



An ISO 9001  
Company

## Bharat Heavy Electricals Limited

(High Pressure Boiler Plant)

Tiruchirappalli – 620014, TAMIL NADU, INDIA

MATERIALS MANAGEMENT / BOI

<b>TITLE</b>  <b>CFBC BOILER REFRACTORY</b>	Phone: +91 431 2574091/2574046 Fax : +91 431 252 0233 / 0525 Email : mshameed@bheltry.co.in
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	<b>Reference Number:</b> <b>MM / BOI / REFRACTORY</b>	<b>Enquiry Date:</b> <b>10.07.2012</b>	<b>Due date for submission of quotation: 10.08.2012</b>
You are requested to quote the Enquiry number date and due date in all your correspondences.			

BHEL/Trichy is looking for ..... Supply of **CFBC BOILER REFRACTORY**

BHEL commercial terms & conditions with Price Bid formats and all annexure can be downloaded from BHEL web site <http://www.bhel.com> or from the Government tender website <http://tenders.gov.in> (public sector units) Bharath Heavy Electricals Limited) under reference "**MM/ BOI / REFRACTORY** "

Tenders should reach us before 14:00 hours on the due date  
Technical bid will be opened at 14:30 hours on the due date  
Tenders would be opened in presence of the tenderers who have submitted their offers and who may like to be present.

Yours faithfully,  
For **Bharath Heavy Electricals Limited**

  
M. Shahul Hameed 10/7/12

SM/ MM/ BOI

## **SPECIFICATION, SCOPE OF WORK FOR CFBC BOILER REFRACTORY**

### **CONTENTS:**

- 1. Specification, scope of work for CFBC Boiler refractory. (36 Pages)**
- 2. Annexure I ( Design Parameters) (4 Pages)**
- 3. Annexure II (Special conditions of contract for application of CFBC Refractory) (2 Pages)**
- 4. Annexure III (Terms of conditions of warranty) (3 Pages)**
- 5. Annexure IV (Schedule of Guarantees) (2 Pages)**
- 6. Annexure V (Checklist of Documents to be submitted) (1 Page)**
- 7. For Detailed arrangement of components of the system refer the following drawings:**
  - i. General arrangement of Boiler – Elevation – 0-00-511-93475-rev03
  - ii. General arrangement of Boiler – Plan – 0-00-511-93476-rev03
  - iii. General arrangement of Boiler Section –AA & BB – 0-00-511-93482-rev00
  - iv. Location of Furnace Openings and Backstays (Back Pass) – 0-00-515-93511-rev00
  - v. Location of Furnace Openings and Backstays (Combustor) – 0-00-515-93510-rev00
  - vi. General arrangement of Ash cooler and Vent Pipe – 0-00-515-93518-rev00
  - vii. Wind Boxes for FBHE, Seal pot & Ash Cooler – 0-00-515-93519-rev00
  - viii. PPA-arrangement of combustor & FBHE – 0-00-521-98300-rev02
  - ix. PPA-arrangement of back pass – 0-00-521-98301-rev03

<b>Prepared</b>	<b>Checked</b>	<b>Approved</b>

**Qualification Criteria:**

This specification consists of detailed scope of work, Design Parameters & Special conditions of contract for application for a CFBC boiler Refractory arrangement.

**VENDORS responding to this enquiry must fulfill the following qualification criteria:**

**“The VENDOR or their principal/collaborator must have supplied, erected & commissioned total refractory to CFBC boilers in India/abroad of minimum 390t/h (or 125 MW) capacity. The same should have been in successful operation for a period of minimum 2 years.”**

VENDOR to submit supporting documents from end user (customer) for above mentioned criteria along with the offer. Offer should not be submitted if above point is not fulfilled by the VENDOR. **Offers without the above supporting document for 2 years successful operation will be summarily rejected without assigning any reason.**

**1. Purpose:**

- 1.1** This Technical Specification defines the minimum requirements with respect to calculation, design, erection and performance of the specified supply and services. In case that information, data, etc. given in this Technical Specification and the corresponding attachments should contradict, those definitions and data are valid which grant the higher standards or the better rights to the BHEL.
- 1.2** **The specifications proposed are indicative only and cannot be quoted by VENDOR as reason for failure during operation. (Read the clause below carefully).**

“The VENDOR is free to propose technically and / or economically advantageous alternatives to the specified supply and services. The specification proposed are indicative only, the VENDOR can propose suitable specification so that ‘**no major repair**’ in the refractory will be necessary for **24 months from date of commissioning with lignite firing and continuous boiler operation**. In case of VENDOR proposing an alternative refractory system, the VENDOR is required to produce proof of 2 years successful operating experience (as mentioned in the qualification criteria) for the alternative also.”

- 1.3** All deviations from this technical Specification have to be announced in writing by VENDOR to BHEL for approval. In any case the BHEL reserves the right, to decide the version to be executed. Modifications from the specified supply and service are only valid, if they are confirmed by an adjustment of this Technical Specification with a new revision.

## **2.0 Brief Description of the Project:**

The project is for **two numbers of 250 MW** of Circulating Fluidized Bed Combustion (CFBC) plant producing 810 t/h of superheated steam for production of electricity. The plant is to be installed at Bhavnagar / Gujarat / India. The CFBC boilers are designed to burn lignite & fuel oil (in Annexure - I)

The fuel is burnt in the combustor in a fluidized form. The bed material is circulating, with solids constantly being carried with the fuel gas, separated by cyclone and re-circulated to the combustor via seal pot. In order to control the temperature in the combustor a separate stream hot circulating ash is directed to the Fluidized Bed Heat Exchangers (FBHE), partially cooled and re-circulated back to the combustor.

## **3.0 Scope of Supply:**

**3.1 VENDOR is responsible for the refractory selection and design, production, testing, packaging, transportation up to site, construction of store at site, storage of refractories (at designated place at site), handling from stores to application point, proper application of refractories including curing & dry heating and round the clock supervision of the same.** The VENDOR is responsible for synchronizing the sequential supply of refractory in tune with the front availability. Particular care to be taken by VENDOR to make sure Just in Time (JIT) availability of shelf life refractory. Any material loss arising due to expiry of shelf life has to be replaced with fresh material free of cost by VENDOR. Upon replacement of fresh material at site, expired material shall be taken back. All the transportation involved in these activities shall be in the scope of the VENDOR.

**3.2 Design and Engineering of refractory for the complete system components in the scope of vendor.**

**3.2.1 VENDOR shall ensure that their design and BOM shall take care of the addition / variation of +5% in surface area as per BHEL drawing/layout. No extra cost will be allowed for the same. However for any modification/ additional requirement which calls for entirely new material not envisaged in the original BOM amendment/additional purchase order will be placed.**

**3.2.2 VENDOR shall ensure their design such that the BOM quoted is sufficient for the entire application as per BHEL enquiry specification and drawings. If any shortage is**

noticed at a later stage or during application, the same shall be supplied by the VENDOR free of cost.

- 3.2.3** The VENDOR will be totally responsible for the supplied materials as requested in this specification. Eventually approval and/or BHEL'S comments concerning the design, data and specific procedures for basic or detailed design do not relieve the VENDOR from his liabilities.

**4.0 Technical Description:** Refractory linings serve the erosion & corrosion protection and insulating purposes in BHEL CFB boilers. The roles of refractory system are multifold:

- Guidance of combustion gas and flue gases through shaping of flow path by maintaining the shapes & contours as envisaged in drawing
- Corrosion and erosion protection respectively
- Thermal insulation

A high level of availability is expected from CFB boiler in view of stringent customer operational requirement. The refractory lining should have a useful life of at least 10 years considering expected 25 year service life of boiler. The refractory lining must not restrict boiler availability during this period of operation. The refractory lining has to satisfy the following requirement to achieve the desired useful life

- Avoiding leakage of gas flows through refractory lining
- Thermal Stability
- Chemical Stability
- Abrasion Resistance
- Dimensional Stability - Thermal Expansion and Shrinkage levels
- Defined thermal conductivity
- Maintain the shapes & contours as envisaged in drawing in both working and insulation linings of a CFBC boiler.

The following components in a CFBC boiler are to be provided with Refractory lining:

#### 4.1 Combustor Water wall-type:

The combustor is refractory lined in the lower part for a height of 11metre (approx) from the nozzle bottom to prevent erosion and corrosion. To reduce heat loss during start-up an insulation layer is applied up to approximately 30mm above the peak of the tube wall. This is followed by the dense refractory castable of approximately 70 mm. For the same reason the nozzle grate is also provided with an insulation layer of 100 mm thickness and with a wear-resistant layer of at least 100 mm. In the area of pant leg CFB combustor the atmosphere is reducing one due to sub-stoichiometric conditions.

In the region of the **flue gas exit to cyclone** the exit is lined with a circumferential refractory collar of refractory castable of at least 100 mm above the peak of the tube wall. For better thermal shock resistance 2% of SS Fibres are to be included in the concrete. In the region of the burner and secondary air nozzles, 100 mm thick refractory castable (**plastic mix**) is to be used.

Quantity per plant: 1 (Pant Leg Configuration)

<b>Fluidized bed area (up to Bottom Secondary Air Nozzle Entry)</b>	
Operating Temperature	850 ± 50°C
Operating Pressure	200 mbar
Excess air coefficient	0.49 to 1.0
Gas velocity	Max 6.0 m/s
Particle loading	Dense fluidized bed (1000 to 1500 kg/nm <sup>3</sup> )
<b>Upper part area</b>	
Operating Temperature	850 ± 50°C
Operating Pressure	0 to 100 mbar
Excess air coefficient	0.73 to 1.2
Gas velocity	Max 7.0m/s
Particle loading	20 kg/nm <sup>3</sup>

<b>Material specification for refractory castable</b>	
Bulk density	2.28 t/m <sup>3</sup> (min)
Cold crushing strength (N/mm <sup>2</sup> )	1000°C -130 N/mm <sup>2</sup> (min)

Abrasion resistance 800 <sup>0</sup> C	ASTM – Test C 704 </=10cm <sup>3</sup>
Base material	Fireclay
Type of bonding	Hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> = 45%,(min)SiO <sub>2</sub> = 47%,(max) Fe <sub>2</sub> O <sub>3</sub> =0.6%,(max)

<b>Material specification for insulation refractory castable layer 1.</b>	
Bulk density	0.95 t/m <sup>3</sup> (max)
Cold crushing strength	820°C -2.07 N/mm <sup>2</sup> (min)
Base material	Fireclay low in iron
Type of bonding	Hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> = 44%(min),SiO <sub>2</sub> = 40%(max) Fe <sub>2</sub> O <sub>3</sub> =1%(max), TiO <sub>2</sub> = 1%(max)

<b>Material specification for refractory castable (Plastic mixes) in burner area &amp; Secondary air openings.</b>	
Bulk density	2.75 t/m <sup>3</sup> (min)
Maximum service temperature	1650°C
Cold crushing strength	1200°C –60 N/mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 </=10cm <sup>3</sup>
Type of bonding	chemical ceramic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =82%, (min) Fe <sub>2</sub> O <sub>3</sub> =1.3%(max),P <sub>2</sub> O <sub>5</sub> = 4.5%(max)

#### 4.2 Ducting system:

The refractory thickness shall be designed by a heat transfer calculation in that way that the The outside surface temperature shall **not exceed 60°C at 30°C ambient air temperature and still air condition.**

##### 4.2.1 Duct from combustor to cyclone

Quantity per plant: 2

Operating Temperature	900 ± 50°C
Operating Pressure	-10 to 20 mbar
Excess air coefficient	1.2
Gas velocity	28 m/s
Particle loading	15 kg/nm <sup>3</sup>

### Wall structure

Wear protection layer approximately 160 mm

Insulation layer 1 approximately 175 mm

Insulation layer 2 approximately 75 mm

<b>Material specification for self flowing castable (Target &amp; Non – Target Wall)</b>	
Bulk density	2.72 t/m <sup>3</sup> (min)
Cold crushing strength	850°C -80 N/mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 <=/=10cm <sup>3</sup>
Base material	Fireclay low in iron, Corundum
Type of bonding	Hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =70% (min),SiO <sub>2</sub> =17%(max) Fe <sub>2</sub> O <sub>3</sub> =0.6%(max),TiO <sub>2</sub> =9.5%(max)
<b>Material specification for insulation refractory castable layer 1.</b>	
Bulk density	0.95 t/m <sup>3</sup> (max)
Cold crushing strength	820°C -2.07 N/mm <sup>2</sup> (min)
Base material	Fireclay low in iron
Type of bonding	Hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> = 44%(min),SiO <sub>2</sub> = 40%(max) Fe <sub>2</sub> O <sub>3</sub> =1%(max), TiO <sub>2</sub> = 1%(max)

<b>Material specifications for calcium silicate block, insulation Layer 2.</b>	
Bulk density	0. 23 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -1.8 N/mm <sup>2</sup> (Minimum)

Base material	calcium silicate
Type of bonding	Chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> = 0.2%(min), SiO <sub>2</sub> = 45%(max) Fe <sub>2</sub> O <sub>3</sub> =0.2% (max), CaO =45% (max) MgO =0.7%(max), K <sub>2</sub> O =0.2% (max) Na <sub>2</sub> O = 0.1%(max)

### Ceiling structure

Wear protection layer approximately 200mm

Insulation layer 1      approximately 175 mm

Insulation layer 2      approximately 75 mm

<b>Material specification for self flowing castable</b>	
Bulk density	2.72 t/m <sup>3</sup> (min)
Cold crushing strength	850°C -80 N/mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 <math>\leq 10\text{cm}^3</math>
Base material	Fireclay low in iron, Corundum
Type of bonding	Hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =70% (min),SiO <sub>2</sub> =17%(max) Fe <sub>2</sub> O <sub>3</sub> =0.6%(max),TiO <sub>2</sub> =9.5%(max)
<b>Material specification for insulation refractory castable layer 1.</b>	
Bulk density	0.95 t/m <sup>3</sup> (max)
Cold crushing strength	820°C -2.07 N/mm <sup>2</sup> (min)
Base material	Fireclay low in iron
Type of bonding	Hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> = 44%(min),SiO <sub>2</sub> = 40%(max) Fe <sub>2</sub> O <sub>3</sub> =1%(max), TiO <sub>2</sub> = 1%(max)

<b>Material specifications for calcium silicate block insulation layer 2</b>	
Bulk density	0.23 t/m <sup>3</sup> (max)
crushing Cold strength	110°C -1.8 N/mm <sup>2</sup> (min)

Base material	calcium silicate
Type of bonding	Chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =0.2%(min),SiO <sub>2</sub> =45%(max) Fe <sub>2</sub> O <sub>3</sub> =0.2%(max),CaO=45%(max) MgO=0.7%(max),K <sub>2</sub> O=0.2%(max) Na <sub>2</sub> O=0.1%(max)

**Bottom structure**

Wear protection layer approximately 160 mm

Insulation layer 1 approximately 175 mm

Insulation layer 2 approximately 75 mm

<b>Material specification for fireclay brick for bottom</b>	
Bulk density	2.22 t/m <sup>3</sup> (min)
Cold crushing strength	110°C - 60 N/mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 <= 14 cm <sup>3</sup>
Base material	low-iron fireclay brick
Type of bonding	ceramic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =35%(min), SiO <sub>2</sub> =60%(max) Fe <sub>2</sub> O <sub>3</sub> =1.2%(max), TiO <sub>2</sub> =1.0%(max) Na <sub>2</sub> O=0.1%(max), K <sub>2</sub> O=1.7%(max) CaO = 0.6%(max), MgO = 0.4%(max)
<b>Material specification for insulation brick, insulation layer 1.</b>	
Bulk density	0.70 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -2.1 N/mm <sup>2</sup> (min)
Base material	vermiculite
Type of bonding	Hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> = 13%(min),SiO <sub>2</sub> = 35%,(max) Fe <sub>2</sub> O <sub>3</sub> =2.5–3.5%,CaO=22.5 – 23%,MgO = 10%(max)

<b>Material specification for calcium silicate block, insulation layer 2</b>	
Bulk density	0.23 t/m <sup>3</sup> (max)

Cold crushing strength	110°C -1.8 N/mm <sup>2</sup> (min)
Base material	calcium silicate
Type of bonding	chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =0.2%(min),SiO <sub>2</sub> =45%(max) Fe <sub>2</sub> O <sub>3</sub> =0.2%(max),CaO =45%(max) MgO =0.7%(max),K <sub>2</sub> O=0.2% (max) Na <sub>2</sub> O = 0.1%(max)

### 4.3 Cyclone:

Solids entrained together with flue gas from the combustor are separated from the flue gas in a one-stage recycling cyclone. Four parallel recycling cyclones are installed.

**The outer wall, which is a tangent to the cyclone, is especially exposed to wear due to function and geometry of the inlet duct to the cyclone.** Here an appropriate material with high erosion resistance and simultaneously good thermal shock resistance is to be selected. The console (retainer plates, brick holder etc..) distances have to be carefully checked concerning height and diameter. To obtain a sufficient stability in the masonry the thickness of the bricks has to be carefully selected.

Temperature	950 ± 50°C
Pressure	-25, + 40 mbar
Excess air coefficient	1.2
Gas velocity	6.0 – 28.0 m/s
Particle loading	1-15 kg/Nm <sup>3</sup>

Quantity per plant: 4

#### Wall structure (cylinder and cone)

Wear protection layer approximately 160mm

Insulation layer 1 approximately 175mm

Insulation layer 2 approximately 75mm

<b>Material specification for refractory bricks target wall and 25% (0-90°) of target cylinder wall</b>	
Bulk density	2.57 t/m <sup>3</sup> (min)

Cold crushing strength	110°C -80 N/mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 <7 cm <sup>3</sup>
Base material	high alumina brick
Type of bonding	Andalusite, Corundum
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =58.5%(min), SiO <sub>2</sub> =36%(max)Fe <sub>2</sub> O <sub>3</sub> =0.8%(max), P <sub>2</sub> O <sub>5</sub> = 2.6%(max)
<b>Material Specification for insulation brick, insulation layer 1</b>	
Bulk density	0.70 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -2.1 N/mm <sup>2</sup> (min)
Base material	Vermiculite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =13%(min),SiO <sub>2</sub> = 35%(max) Fe <sub>2</sub> O <sub>3</sub> =2.5 – 3.5%,MgO = 10%(max) CaO = 22.5-23%(max)
<b>Material specification for calcium silicate block, insulation layer 2</b>	
Bulk density	0.23 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -1.8 N/mm <sup>2</sup> (min)
Base material	calcium silicate
Type of bonding	chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =0.2%(min),SiO <sub>2</sub> =45%(max) Fe <sub>2</sub> O <sub>3</sub> =0.2%(max),CaO = 45%(max) MgO = 0.7%(max),K <sub>2</sub> O = 0.2%(max) Na <sub>2</sub> O = 0.1%(max)

<b>Material specification for fireclay brick cylinder wall, cone and bottom (270<sup>0</sup>)</b>	
Bulk density	2.22 t/m <sup>3</sup> (min)
Cold crushing strength	110°C -60 N/mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 </=14cm <sup>3</sup>
Base material	low-iron fireclay brick
Type of bonding	ceramic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =35%(min),SiO <sub>2</sub> =60%(max)

	Fe <sub>2</sub> O <sub>3</sub> =1.2%(max),TiO <sub>2</sub> =1.0%(max) Na <sub>2</sub> O=0.1%(max),K <sub>2</sub> O=1.7%(max) CaO = 0.6%(max),MgO = 0.4%(max)
<b>Material specification for insulation brick, insulation layer 1</b>	
Bulk density	0.70 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -2.1 N/mm <sup>2</sup> (min)
Base material	Vermiculite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =13%(min),SiO <sub>2</sub> =35%(max) Fe <sub>2</sub> O <sub>3</sub> =2.5– 3.5%, CaO = 22.5 -23%,MgO =10%(max)
<b>Material Specification for calcium silicate block, insulation layer 2</b>	
Bulk density	0, 23 t/m <sup>3</sup> (max)
Cold crushing strength	110°C – 1.8 N/mm <sup>2</sup> (min)
Base material	calcium silicate
Type of bonding	chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =0.2%(min),SiO <sub>2</sub> = 45%(max) Fe <sub>2</sub> O <sub>3</sub> =0.2%(max),CaO=45%(max) MgO = 0.7%(max),K <sub>2</sub> O = 0.2%(max) Na <sub>2</sub> O = 0.1%(max)

**Ceiling structure**

Wear protection layer approximately 200mm  
 Insulation layer 1 approximately 175mm  
 Insulation layer 2 approximately 75mm

<b>Material specification for self flowing castable</b>	
Bulk density	2.72 t/m <sup>3</sup> (min)
Cold crushing strength	850°C -80 N/mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 <=/=10cm <sup>3</sup>
Base material	Fireclay low in iron, Corundum
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =70%(min),SiO <sub>2</sub> =17%(max) Fe <sub>2</sub> O <sub>3</sub> =0.6%(max),TiO <sub>2</sub> = 9.5%(max)

<b>Material specification for insulation refractory castable for casting and gunning, insulation layer 1</b>	
Bulk density	1 t/m <sup>3</sup> (max)
Cold crushing strength	110°C –7 N/mm <sup>2</sup> (min)
Base material	light fireclay, pearlite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =38%(min),SiO <sub>2</sub> =36%(max) Fe <sub>2</sub> O <sub>3</sub> =2.6 %(max), Na <sub>2</sub> O = 1.0%(max) K <sub>2</sub> O = 1.4%(max)
<b>Material specification for calcium silicate block, insulation layer 2</b>	
Bulk density	0.23 t/m <sup>3</sup> (max)
Cold crushing strength	110°C –1.8 N/mm <sup>2</sup> (min)
Base material	calcium silicate
Type of bonding	chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =0.2%(min),SiO <sub>2</sub> =45%(max) Fe <sub>2</sub> O <sub>3</sub> =0.2%(max),CaO = 45%(max) MgO = 0.7%(max),K <sub>2</sub> O=0.2%(max) Na <sub>2</sub> O = 0.1%(max)

**Bull nose area**

<b>Material specification for self flowing castable with SS fibres</b>	
Bulk density	2.72 t/m <sup>3</sup> (min)
Cold crushing strength	850°C –80 N/mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 </=10cm <sup>3</sup>
Base material	Fireclay low in iron, Corundum
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =70%(min),SiO <sub>2</sub> = 17%(max) Fe <sub>2</sub> O <sub>3</sub> =0.6 %(max),TiO <sub>2</sub> =9.5%(max)

<b>Material specification for insulating refractory castable for casting and gunning, insulation layer 1</b>	
Bulk density	1 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -7 N/mm <sup>2</sup> (min)
Base material	light fireclay, perlite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =38%(min),SiO <sub>2</sub> =36%(max) Fe <sub>2</sub> O <sub>3</sub> =2.6%(max),Na <sub>2</sub> O = 1.0%(max) K <sub>2</sub> O = 1.4%(max)
<b>Material specification for calcium silicate block, insulationlayer2</b>	
Bulk density	0.23 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -1.8 N/mm <sup>2</sup> (min)
Base material	Calcium silicate
Type of bonding	chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =0.2%(min),SiO <sub>2</sub> = 45%(max) Fe <sub>2</sub> O <sub>3</sub> =0.2 %(max),CaO = 45%(max) MgO = 0.7%(max),K <sub>2</sub> O=0.2%(max) Na <sub>2</sub> O = 0.1%(max)

#### 4.4 Seal pot and connecting duct to the combustor:

The seal pot serves as a non-mechanical pressure seal on the one hand between the cyclone working under ambient pressure and the lower section of the combustor working under a slight overpressure and on the other hand between the cyclone and FBHE, working under an overpressure as well.

It is fluidized through a nozzle grate to ensure an even air distribution to assist the flow of solids from the cyclone into the combustor and if foreseen also into the FBHE.

Operating Temperature	950 ± 50°C
Operating Pressure	250 mbar
Gas velocity	0.5 - 1.5 m/s
Particle loading dense	fluidized bed

**Quantity per Plant: 4****Wall structure**

Wear protection layer approximately 160mm

Insulation layer 1 approximately 125mm

Insulation layer 2 approximately 125 mm

<b>Material specification for refractory castable</b>	
Bulk density	2.27 t/m <sup>3</sup> (min)
Cold crushing strength	800°C - 90 N/mm <sup>2</sup> (min))
Abrasion resistance	ASTM – Test C 704 $\leq 8 \text{ cm}^3$
Base material	Fireclay
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =51%(min),SiO <sub>2</sub> =42%(max) Fe <sub>2</sub> O <sub>3</sub> =0.75%(max),CaO = 4.0%(max)

<b>Material specification for insulating brick, insulation layer 1</b>	
Bulk density	0.49 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -2.5 N/ mm <sup>2</sup> (Minimum)
Base material	Vermiculite
Type of bonding	chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =9%(min), SiO <sub>2</sub> = 48%(max) Fe <sub>2</sub> O <sub>3</sub> =5.0-6.0%, MgO = 25%(max)

<b>Material specification for insulation brick ,insulation layer 2</b>	
Bulk density	0.43 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -1.3 N/ mm <sup>2</sup> (min)
Base material	perlite

Type of bonding	ceramic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =14.8%(min),SiO <sub>2</sub> =66.5%(max)Fe <sub>2</sub> O <sub>3</sub> =4.1%(max),CaO = 5%(max)

### Nozzle Grate Structure (Seal Pot)

Wear protection layer                      approximately 160 mm

Insulation layer                              Approximately 250 mm

<b>Material specification for refractory castable</b>	
Bulk density	2.27 t/m <sup>3</sup> (min)
Cold crushing strength	800°C - 90 N/ mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 <math>\leq 8\text{ cm}^3</math>
Base material	Fireclay
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =51%(min),SiO <sub>2</sub> =42%(max) Fe <sub>2</sub> O <sub>3</sub> =0.75%(max),CaO = 4.0%(max)

<b>Material specification for insulating refractory castable</b>	
Bulk density	0.74 t/m <sup>3</sup> (max)
Cold crushing strength	110°C - 0.76 N/ mm <sup>2</sup> (min)
Base material	Vermiculite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =32%(min),SiO <sub>2</sub> =29%(max) Fe <sub>2</sub> O <sub>3</sub> =7.9%(max), CaO= 21%(max)

### 4.5 Fluidized bed heat exchanger (FBHE):

Part of the heat to be generated in the combustion system can be transferred in the FBHE by feeding it with a controlled side stream of the hot circulating ash from the sealpot.

The hot ash extracted from the seal pot by means of special equipment called spieß- valve. This spieß-valve is equipped with a spear like head sitting in an orifice. By adjusting the width of the ring opening the amount of ash flowing into the FBHE is controlled.

The ash stream flowing into the FBHE is cooled by flowing through successive chambers: from the last chamber the cooled ash is sent via outlet chamber and a fluidized duct back to the combustor.

Temperature empty chamber	900 ± 50°C
Temperature 1.bundle chamber	850 ± 50°C
Temperature 2.bundle chamber	700 ± 50°C
Temperature outlet chamber	600 ± 50°C
Operating Pressure	350 mbar
Gas velocity	0.3 – 15 m/s
Particle loading	fluidized bed

Quantity per plant: 4

### Walls

Wear protection layer approximately 150mm

Insulation layer approximately 250mm

<b>Material specification for high fireclay brick A 30 t. for all bundle chambers</b>	
Bulk density	2.2 t/m <sup>3</sup> (min)
Cold crushing strength	800°C -45 N/ mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 <math>\leq 12</math> cm <sup>3</sup>
Base material	Fireclay
Type of bonding	chemical ceramic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =33.3%(min),SiO <sub>2</sub> =60.4%(max)Fe <sub>2</sub> O <sub>3</sub> =1.9%, (max)

<b>Material specification for insulating brick, insulation layer 1</b>	
Bulk density	0.49 t/m <sup>3</sup> (max)
Cold crushing strength	110°C - 2.5 N/ mm <sup>2</sup> (min)
Base material	Vermiculite
Type of bonding	chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =9.0%(min),SiO <sub>2</sub> =48.51%(max) Fe <sub>2</sub> O <sub>3</sub> =5.0-6.0%,MgO = 24.0-27.0%

<b>Material specification for insulating brick, insulation layer 2</b>	
Bulk density	0,43 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -1.3 N/ mm <sup>2</sup> (min)
Base material	perlite
Type of bonding	ceramic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =14.8% (min),SiO <sub>2</sub> =66.5% (max)Fe <sub>2</sub> O <sub>3</sub> =4.1% (max),CaO = 5% (max)

### Material specification for empty chamber

Wear protection layer approximately 150mm

Insulation layer approximately 250mm

<b>Material specification for refractory castable</b>	
Bulk density	2.27 t/m <sup>3</sup> (min)
Cold crushing strength	800°C -90 N/ mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 </=8 cm <sup>3</sup>
Base material	Fireclay
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =51% (min),SiO <sub>2</sub> = 42% (max) Fe <sub>2</sub> O <sub>3</sub> =0.75% (max),CaO = 4.0% (max)

<b>Material specification for insulating refractory castable</b>	
Bulk density	0.74 t/m <sup>3</sup> (max)
Cold crushing strength	110°C - 0.76 N/ mm <sup>2</sup> (min)
Base material	Vermiculite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =32% (min),SiO <sub>2</sub> =29% (max) Fe <sub>2</sub> O <sub>3</sub> =7.9% (max), CaO= 21% (max)

**Partition wall to the 1.bundle chamber**

Wear protection layer approximately 150mm

Insulation layer approximately 250mm

**Partition wall to the 2.bundle chamber**

Wall protection layer approximately 125mm

Insulation layer approximately 175 mm

<b>Material specification for refractory castable</b>	
Bulk density	2.27 t/m <sup>3</sup> (min)
Cold crushing strength	800°C -90 N/ mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 </=8 cm <sup>3</sup>
Base material	Fireclay
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =51%(min),SiO <sub>2</sub> = 42%(max) Fe <sub>2</sub> O <sub>3</sub> =0.75% (max),CaO = 4.0%(max)

<b>Material specification for insulating refractory castable</b>	
Bulk density	0.74 t/m <sup>3</sup> (max)
Cold crushing strength	110°C - 0.76 N/ mm <sup>2</sup> (min)
Base material	Vermiculite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =32%(min),SiO <sub>2</sub> =29%(max) Fe <sub>2</sub> O <sub>3</sub> =7.9%(max), CaO= 21%(max)

**Ash inlet**

Wear protection layer approximately 120mm

Insulation layer approximately 230mm

<b>Material specification for refractory castable</b>	
Bulk density	2.27 t/m <sup>3</sup> (min)
Cold crushing strength	800°C -90 N/ mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 </=8 cm <sup>3</sup>

Base material	Fireclay
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =51%(min),SiO <sub>2</sub> = 42%(max) Fe <sub>2</sub> O <sub>3</sub> =0.75% (max),CaO = 4.0%(max)

<b>Material specification for insulating refractory castable</b>	
Bulk density	0.74 t/m <sup>3</sup> (max)
Cold crushing strength	110°C - 0.76 N/ mm <sup>2</sup> (min)
Base material	Vermiculite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =32%(min),SiO <sub>2</sub> =29%(max) Fe <sub>2</sub> O <sub>3</sub> =7.9%(max), CaO= 21%(max)

**Nozzle grate structure**

Wear protection layer approximately 150 mm

Insulation layer approximately 250 mm

<b>Material specification for refractory castable</b>	
Bulk density	2.27 t/m <sup>3</sup> (min)
Cold crushing strength	800°C -90 N/ mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 </=8 cm <sup>3</sup>
Base material	Fireclay
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =51%(min),SiO <sub>2</sub> =42%(max) Fe <sub>2</sub> O <sub>3</sub> =0.75%(max),CaO = 4.0%(max)
<b>Material specification for insulating refractory castable</b>	
Bulk density	0.74 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -0.76 N/ mm <sup>2</sup> (Minimum)
Base material	Vermiculite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =32%(min),SiO <sub>2</sub> =29%(max) Fe <sub>2</sub> O <sub>3</sub> =7.9%(max),CaO = 21%(max)

**Ceiling structure**

Wear protection layer approximately 120mm  
 Insulation layer 1 approximately 200mm

<b>Material specification for self flowing castable</b>	
Bulk density	2.72 t/m <sup>3</sup> (min)
Cold crushing strength	850°C -80 N/mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 </=10cm <sup>3</sup>
Base material	Fireclay low in iron, Corundum
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =70%(min),SiO <sub>2</sub> =17%(max) Fe <sub>2</sub> O <sub>3</sub> =0.6%(max),TiO <sub>2</sub> = 9.5%(max)

<b>Material specification for insulation refractory castable for casting and gunning, insulation layer 1</b>	
Bulk density	1 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -7 N/mm <sup>2</sup> (min)
Base material	light fireclay, pearlite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =38%(min),SiO <sub>2</sub> =36%(max) Fe <sub>2</sub> O <sub>3</sub> =2.6 %(max), Na <sub>2</sub> O = 1.0%(max) K <sub>2</sub> O = 1.4%(max)

**4.6 Ash cooler**

Bottom Ash from the combustor and ash from the FBHE is used for the differential pressure control in the combustor and is cooled in an ash cooler for further transport. The refractory materials especially in the inlet and outlet chamber must have excellent thermal shock resistance and high wear resistance. The ash flow is discontinuous.

Temperature empty chamber	850 ± 50°C
Pressure	250 mbar
Gas velocity	0.3 – 20 m/s

Particle loading	fluidized bed
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Quantity per plant: 4

### Walls

Wear Protection layer                      approximately 125 mm

Insulation layer                                approximately 175mm

<b>Material specification for refractory castable</b>	
Bulk density	2.27 t/m <sup>3</sup> (min)
Cold crushing strength	800°C -90 N/ mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 </=8 cm <sup>3</sup>
Base material	Fireclay
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =51%(min),SiO <sub>2</sub> =42%(max) Fe <sub>2</sub> O <sub>3</sub> =0.75%(max),CaO = 4.0%(max)

<b>Material specification for insulating brick, insulation layer 1</b>	
Bulk density	0.49 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -2.5 N/ mm <sup>2</sup> (min)
Base material	Vermiculite
Type of bonding	chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =9.0%(min),SiO <sub>2</sub> =48-51% Fe <sub>2</sub> O=5.0-6.0%, MgO=24.0-27.0%

### Ceiling :

Wear protection layer                      approximately 100 mm

Insulation layer                                approximately 100 mm

<b>Material specification for self flowing castable</b>	
Bulk density	2.72 t/m <sup>3</sup> (min)
Cold crushing strength	850°C -80 N/ mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 </=10 cm <sup>3</sup>
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =70%(min),SiO <sub>2</sub> = 17%(max) Fe <sub>2</sub> O <sub>3</sub> =0.6%(max), TiO <sub>2</sub> = 9.5%(max)

<b>Material specification for insulating refractory cast able for casting and gunning,</b>	
Bulk density	1 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -7 N/ mm <sup>2</sup> (min)
Base material	light fireclay, perlite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =38% (min),SiO <sub>2</sub> =36% (max) Fe <sub>2</sub> O <sub>3</sub> =2.6 % (max), Na <sub>2</sub> O = 1.0% (max) K <sub>2</sub> O = 1.4% (max)

#### 4.7 Flue gas duct between cyclone and back pass

Expecting a high stability the circular part of the flue gas duct should be lined with bricks. Intersections from circular to rectangular and straight walls and ceilings should be refractory lined with casting materials. The bottom can be lined with bricks again.

Temperature	850 ± 50°C
Pressure	-50 + 30 mbar
Excess air coefficient	1.2
Gas velocity	30 m/s
Particle loading	0.1 kg/Nm <sup>3</sup>

Quantity per plant: 2

#### **Walls, bottom and circular ducts**

Wear protection layer            approximately 160mm  
Insulation layer 1                approximately 175 mm  
Insulation layer 2                approximately 75 mm

<b>Material specification for high fireclay brick A30 t</b>	
Bulk density	2.2 t/m <sup>3</sup> (min)
Cold crushing strength	110°C -60 N/ mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 <=/=12 cm <sup>3</sup>
Base material	Fireclay
Type of bonding	chemical ceramic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =33.3% (min),SiO <sub>2</sub> =60.4% (max) Fe <sub>2</sub> O <sub>3</sub> =1.9% (max)

<b>Material specification for insulating brick, insulation layer 1</b>	
Bulk density	0.7 t/m <sup>3</sup> (max)
Cold crushing strength	110°C -2.1 N/ mm <sup>2</sup> (min)
Base material	Vermiculite
Type of bonding	Chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =12.0% (min),SiO <sub>2</sub> = 35% (max) Fe <sub>2</sub> O <sub>3</sub> =3% (max),CaO = 23% (max)
<b>Material specification for calcium silicate block, insulation layer 2</b>	
Bulk density	0.23 t/m <sup>3</sup> (max)
Cold crushing strength	110°C – 1.8 N/mm <sup>2</sup> (min)
Base material	calcium silicate
Type of bonding	chemical
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =0.2% (min),SiO <sub>2</sub> =45% (max) Fe <sub>2</sub> O <sub>3</sub> =0.2% (max),CaO = 45% (max)

### Ceilings

Wear protection layer approximately 160mm

Insulation layer 1 approximately 175mm

Insulation layer 2 approximately 75 mm

<b>Material specification for self flowing castable</b>	
Bulk density	2.72 t/m <sup>3</sup> (min)
Cold crushing strength	850°C -80 N/ mm <sup>2</sup> (min)
Abrasion resistance	ASTM – Test C 704 <math>\leq 10\text{ cm}^3</math>
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =70% (min),SiO <sub>2</sub> = 17% (max) Fe <sub>2</sub> O <sub>3</sub> =0.6% (max), TiO <sub>2</sub> = 9.5% (max)

<b>Material specification for insulation refractory castable for casting and gunning, insulation layer 1</b>	
Bulk density	1 t/m <sup>3</sup> (max)
Cold crushing strength	110°C – 7 N/ mm <sup>2</sup> (min)



<b>Material specification for insulation refractory cast able for casting and gunning, insulation layer</b>	
Bulk density	1 t/m <sup>3</sup> (max)
Cold crushing strength	110°C – 7 N/ mm <sup>2</sup> (min)
Base material	light fireclay, perlite
Type of bonding	hydraulic
Chemical Analysis	Al <sub>2</sub> O <sub>3</sub> =38.0%(min), SiO <sub>2</sub> =36%(max) Fe <sub>2</sub> O <sub>3</sub> =2.6%(max), K <sub>2</sub> O = 1.4%(max)

#### **4.9 Material for Anchors and Retainer Plates:**

All anchors and retainer plates and any other metallic items required while refractory lining are to be made of 253 MA quality only.

##### **4.9.1 Anchor Spacing:**

- Combustor water wall – type

77 – 84 anchor /m<sup>2</sup>

-Flue gas duct from cyclone to backpass

Brick refractory wall 8 anchor / m<sup>2</sup>

Castable refractory wall 16 anchor / m<sup>2</sup>

Ceiling 20 anchor / m<sup>2</sup>

-Cyclone

Brick refractory wall 8 anchor / m<sup>2</sup>

Cast able refractory wall 16 anchor /m<sup>2</sup>

Ceiling 25 anchor /m<sup>2</sup>

-Fluidized bed heat exchanger

Brick refractory wall 8 anchor / m<sup>2</sup>

Cast able refractory wall 16 anchor / m<sup>2</sup>

Ceiling 20 anchor / m<sup>2</sup>

#### **4.10 Other Design & Technical parameters (refer Annexure I)**

**5.0 Rules, Regulation, Standards:** The refractory must be designed, manufactured and erected according to the most recent internationally recognized relevant codes, standards (as given below), accident prevention regulations, legal regulations and local rules and regulations appropriate to the duty, operational requirements, statutory obligations and environmental conditions specified.

1. Regulations of local authorities
2. Internationally accepted standard are
  - ANSI: American National Standard Institute.
  - ASTM: American Standard for Testing Material.
  - ASME: American Standard of Mechanical Engineers.
  - AWS: American Welding Society.
  - ISO: International Organization for Standardization.
  - ASA: American Standard Association.
  - DIN: Deutsche Industries Normen
  - VDI :VereinDeutscherIngenieure.

## **6.0 General Conditions**

### **6.1 Transient operating conditions:**

- a) Warming up to operating temperature following a longer boiler shutdown(> 60 h)
- b) Warming up to operating temperature after a short interruption to boiler operations (<60 h)
- c) Cooling down (through heat losses ) on short interruptions to operations ( < 60 h )
- d) Shutting the boiler down ( deliberately ) within 10 h
- e) Burner air purge ( after failure of the burner for a renewed start of the system )

For the above points from (a) to (e) the following interruptions to operations must be planned for commissioning and normal operations:

Commissioning operations	pilot operations / normal
a) Approximately 10 x per year b) Approximately 10 x per year c) Approximately 10 x per year d) Approximately 10 x per year e) Approximately 10 x per year	a) Approximately 5 x per year b) Approximately 5 x per year c) Approximately 5 x per year d) Approximately 5 x per year e) Approximately 5 x per year

### 7.0 Price bid submission :

**7.1** Separate offer shall be submitted for the supply of all materials including selection engineering & design, procurement, manufacturing, quality assurance, supply, documentation, packing and transportation to BECL site.

**7.2** Separate offer shall be submitted for application package which includes storage, issue of materials, handling, application, curing & drying of refractory with expert supervision including complete facility of labour, equipment, accessories, consumables, tools and tackles. The application of refractory in CFBC boiler can be carried out either by VENDOR themselves or by engaging a third party refractory erector/contractors. **Simultaneous erection/application of refractory is to be carried out in both the boilers at BECL. Hence VENDOR must engage TWO SEPARATE ERECTION CONTRACTORS (one for each boiler).** In either case the VENDOR/third party erection contractors should have successful prior experience of total refractory application of CFBC boiler of minimum 390 t/h (or 125 MW) capacity. Credentials confirming the same has to be furnished in TECHNICAL BID ITSELF by VENDOR to BHEL. The VENDOR shall mention in bid the list of prospective third party erectors/contractors whom they may deploy for application with their supporting credentials for application experience desired by BHEL. No intermediate/partial repair experience will be accepted by BHEL. The application experience must be in totality for a CFBC boiler of 390 t/h (or 125 MW) capacity. Offer without the above experience mentioned will summarily be rejected.

**7.3** Separate offer shall be submitted for maintenance of refractory for two years from the date of expiry of the warrantee inclusive of supply & application of refractory (optional and will be used as required).

**7.4** Separate offer for intermediate repair works has to be submitted along with initial offer itself based on the following repair details in **7.4.1**.

**7.4.1 (I) Intermediate Repairs during Warranty Period:** Refractory repair works may be required during the warranty period due to reasons both attributable and non-attributable to the VENDOR. The list of reasons for refractory failures not attributable to VENDOR are as follows:

- a) Tube Failure
- b) Casing failure other than over heating
- c) Damage of refractory during Clinker removal

Any other failures in refractory other than mentioned above is deemed as a failure due to VENDOR only and such failures must be repaired free of cost under warranty period. Any kinds of mechanical or erection defects if observed by VENDOR must bring to the notice of BHEL so that those issues are sorted out beforehand to refractory erection. Vendor must understand the operations involved in a BHEL designed CFBC boiler and design refractory accordingly for the boilers. **Post commissioning / dry out, any claims by VENDOR on refractory failures due to operational conditions will not be accepted by BHEL.** The refractory repair works must be carried out free of cost under warranty conditions only.

**(II) Repair Work Plan:** BHEL will intimate VENDOR about refractory lining failure. Representatives from VENDOR in any case must be present at site within 72 hrs from date of intimation of failure by BHEL. Repair procedure and schedule must be mutually discussed and agreed upon by both BHEL & VENDOR so that the boiler is restored into operation at the earliest. This is applicable for any type of refractory failure. Any delay in this regard will not be entertained by BHEL considering importance of restoring boiler into operation by recourse. Also a minimum stock of refractory materials must be stored at site to carry out repairs on time.

However for cases of refractory repair work for reasons (only the 3 reasons listed above) not attributable to VENDOR, BHEL will pay for the repair.

**(III) Bid Submission for Intermediate Repair:** VENDOR to submit a separate offer for Intermediate repair for failures not attributable to VENDOR along with price bid. VENDOR must submit in a separate bid covering the unit rate for all kinds of refractory materials (as in BOM) and the application rate / ton for the same. The price quoted will remain firm and will be exercised by BHEL for repair payment purposes within warranty period. No new/change price will be allowed by BHEL in supply and/or in application.

Paid refractory repair works also must be covered under warranty conditions in line with initial refractory lining.

## **8.0 Design, Engineering Supply and Application Requirements:**

**8.1** General arrangement drawings for the refractory lined components are given along with this specification for estimation of bill of materials during offer stage. Fabrication drawings of all components with detailed dimension required for preparation of refractory installation drawing will be provided by BHEL after ordering. All detailed information in the indicative drawings such as e.g. wall structure, material specification, arrangement of the brickwork, anchors, retainer plates, expansion joints, etc., must be checked taking account of the design parameters and, where necessary, reset in conjunction with BHEL. The complete contract must be accompanied by a quality assurance system in accordance with the **ISO 9000** series. The appropriate QA documentation must be submitted to BHEL. The supplier guarantees that the detail engineering is correct and complete. It must be carried out in accordance with the state of the art.

**8.2 Material selection and Configuration Details:** The responsibility for the choice of refractory material and lining scheme is with **VENDOR** based on indicative specification provided in this document which **VENDOR** is expected to meet or alternately offer superior material (meeting trouble free operation experience).

**8.3 Heat flow calculation:** Heat Transfer Calculation of the wall structure and the individual layer thicknesses for determining the heat losses and metal shell temperatures taking account of the technical values of the selected materials and the operating and ambient conditions shall be submitted.

## **8.4 Expansion calculations:**

**8.4.1** The calculations of reversible and irreversible expansion / shrinkage of the refractory lining are required to determine construction dimensions (e.g. expansion joints). The reversible and irreversible expansion of the refractory lining must be calculated and submitted to BHEL for approval.

**8.4.2** The expansion of adjoining surfaces shall be taken into consideration.

**8.5 Drawings of Refractory lining:** Drawings and documentation shall cover the following:

**8.5.1** General arrangement drawing of refractory lined components.

**8.5.2** True-to-scale representation of refractory lining for the various components of boiler, showing sufficient details so as to ensure proper refractory erection work.

The drawing should consist of :

- Details of quality grades and /or type designation of bricks, monolithic including castable, mortar etc., anchors and construction aids.
- Item code of bricks and various other refractory materials.
- Reference to standard brick sizes and shapes.
- Identification of different material qualities on the basis of material list and specifications.
- 3D drawings for all openings in the combustor.

**8.5.3** Detailed representation of refractory lining.

**8.5.4** Representation of standard bricks and special shapes, inclusive of dimensional details and tolerances for manufacturing purposes, as well as identification of location code according to the material list and brickwork drawing.

**8.5.5** Drawings of anchoring devices on load-bearing part, complete with guidelines for the attachment of anchors& retainer plates (eg., welding specification).

**8.5.6** Representation of form and size of anchoring devices (anchors and retainer plates) showing location code as per material list and refractory arrangement drawing.

**8.5.7** Drawings and documentation for the detailed engineering must be submitted to BHEL for approval and release. All documents must be submitted in **FOUR HARD COPIES and TWO set of soft copy in CD**. The Supplier must submit the document for inspection in good time so that the delivery date can be complied with in any case. For this purpose the supplier must submit a deadline assurance schedule for detailed engineering, material procurement, erection and drying to BHEL within 2 weeks of the award of the contract. The supplier must also take possible changes into account. Amended drawings must be resubmitted to BHEL for approval. **The approval of the drawings by BHEL does not relieve the VENDOR from his contractual obligations and guarantees.** The final documentation includes “as built” drawings.

**8.6 Material Properties:** The following are physical and chemical properties are to be complied in form of technical/material data sheets and submitted along with offer.

- Chemical composition of refractory (inclCaO content in castables)
- Refractoriness (Pyrometric Cone Equivalent)
- Bulk density and porosity
- Refractoriness under load and application limit
- Permanent Linear Change (PLC)
- Application temperature
- Thermal Expansion (Reversible)
- Cold crushing strength at 110<sup>0</sup>C, 800<sup>0</sup>C & 1200<sup>0</sup>C
- Thermal conductivity values at 300<sup>0</sup>C, 500<sup>0</sup>C& 800<sup>0</sup>C
- Linear Shrinkage
- Abrasion resistance in accordance with **ASTM C 704**
- CO resistance in accordance with **ASTM C 288**
- Setting time of castables used.
- Water requirement in % for casting.
- Shelf life of monolithic and other applicable items. **(with a minimum requirement of 6 months for dense castable and 9 months for insulation castable)**
- In case of Fireclay bricks only Machine pressed bricks are to be supplied. Handmade bricks are not acceptable.

**8.7 Bill of Materials:** List of all material quantities and qualities for the refractory lining of **each component and for the overall installation** must be submitted by the **VENDOR**, so that a correct and continuous supply of the refractory materials is done. The following must be mentioned in the BOM

- Position number
- Brick format or special-shaped firebricks number
- Material quality with specification numbers
- Material quantities in numbers of items / units and weights.

The quantity information must be subdivided into:

- Installation quantity
- Installation weight
- Reserve quantities / spraying and other losses
- Total weight

**8.8 Erection Guidelines for Refractory Lining:** Guideline for refractory lining work with detailed explanation of the work sequences and information on particular conditions required for any specific type of material used, the operational requirement and the local situation must be submitted by VENDOR after PO stage. It should contain:

- Storage instructions
- Material processing instructions
- Necessary machinery, appliances and special tools
- Personnel schedules
- Work sequence schedules
- Quality management plans
- Test plans for monitoring construction and erection

**8.9 Anchoring and Welding Instructions:** A guideline containing detailed explanation of the sequences and information on the welding work to be carried out should be submitted. Also procedure should explain the required testing needed to be carried out on the weld work before the refractory material is installed.

**8.10 Drying Instructions for Refractory Lining:** The engineering services cover guidelines and instructions on drying and heating up process, properly coordinated with the quantities and qualities of the brickwork used. Appropriate temperature curves for the drying and heating up periods in conformity with the heat generator types and their output should be indicated in the instruction. In addition, a plan must be drawn up showing the arrangement of the hot gas generators that are to be used, their output and the necessary temperature measuring points.

The following must be determined:

- Cooling down of the refractory – without forced cooling on a plant standstill of 1 to 10 days
- Firing curve on a cold start
- Firing curve on a warm start after cooling
- Determining basic values for the design of the burners for drying (oil / gas, air ratio, number of burners required)
- Maximum metal shell temperature in the area of retainer plates/brackets, anchors.

**8.11 Transport, Storage and packing Instructions:** An Instruction must be submitted for storing on site in accordance with the material type, taking account of local and

seasonal weather conditions and the planned work sequences and transportation internally in site. The instructions must stipulate the packing according to material type and also taking account of the loads in the applicable packing considering expected transport and storage.

**8.12 Refractory Maintenance Instructions:** The maintenance instructions should mention the inspection, test activities and preparation of the measurement records during annual plant shutdowns. The repair and maintenance instructions of refractory lining should be mentioned including that for the expansion joints which are expected to be regularly required must be described.

**8.13 Erection of Refractory:** The erection covers all measures for the erection of the refractory lining. This includes essentially:

**8.13.1** Blasting of the wall surface where necessary and welding holding fixtures and pins, including testing the welds.

**8.13.2** Providing the necessary erection appliances, machinery and tools, lifting gear, vehicles and transport means, workplace lighting, erection aids, resources and supplies.

**8.13.3** Monitoring construction and erection which includes:

- Monitoring and coordinating site work
- Progress chasing
- Erection progress reports
- Inspection at different stages of installation
- Records (dimensions, incl. material qualities)
- Responsibility for site security
- Complete erection of the refractory lining through to a condition ready for use in accordance with the appropriate erection instructions including provision of all shuttering, scaffoldings, lifting and transport gear, mixing tools, injection machinery, etc. and the necessary weatherizing or winterizing, where applicable. Also providing all necessary scaffolding arrangements during erection stage and during inspections and repair works post commissioning in warranty period.
- Containers for demolition material, if required through own erection.
- Removal of rubble/debris.
- Welding holding fixtures and pins, including testing the welds.

- **Stage-wise protocol for completeness of refractory work as per approved drawing must be jointly signed by BHEL site and Vendor representatives.**

#### **8.13.4 For special conditions of erection of refractory refer Annexure II**

#### **8.14 Dry Out of refractories:** The scope of performance includes:

- 8.14.1** Dry heat setting of the installed refractory lining in accordance with the dry heat setting diagrams submitted to and agreed with BHEL.
- 8.14.2** Provision of the pre-heaters and heaters including tanks for oil gas heating.
- 8.14.3** The required fuel for dry heat setting must be provided by VENDOR. Prior to usage of fuel information on Volume is required to be furnished to BHEL so that fuel consumption will be monitored during dry heating.
- 8.14.4** The dry heat setting takes place basically in accordance with the standards in the detail engineering. Continuous monitoring is necessary during this period. The dry heat setting equipment, including the supply lines and the monitoring devices in the installation, must be provided.
- 8.14.5** A drying report must be drawn up on conclusion of the work.

#### **9.0 Material Testing / Inspection:**

**9.1 Testing at Manufacturer's works:** Testing of all the materials required for lining will be inspected by BHEL / BHEL approved inspection agency at VENDOR's works as per the approved material data sheet. The supplier must inform BHEL in due time about quality inspection dates so that BHEL will participate in these inspections. **The presence and participation of the BHEL / BHEL approved inspection agency during the inspections does not reduce the supplier's responsibility and contractual obligations.**

**9.2 Testing at BECL site:** The following test will be done at site especially for monolithic upon receipt :

Bulk density, cold crushing strength (CCS) and abrasion resistance after fire at 800°C

In the event of negative results from the above tests, the quality of the received lot in question must be marked clearly so that the following shall apply:

- i) If the material has already been installed: The applied monolithic has to be removed and re-installed with fresh material.
- ii) If the material is unused: Clearance will not be given for usage of the lot and must be replaced with new supply.

**10.0 Packing And Transport:**

**10.1** Sea worthy packing, marking and transportation from **VENDOR Works to M/s.BECL's site** shall be included in the scope of service of the **VENDOR**.

**10.2** BHEL / customer will provide space at site for construction of stores for refractories storage. **VENDOR** must construct stores according to their requirement and store all the materials. While vacating site after completion of all activities, Vendor must dismantle store constructed by them and return the space back to BHEL / Customer in as given condition.

**10.3** Shifting of materials from Vendor store at site to application point in any part of boiler is also under the scope of **VENDOR**.

**10.4** In the event of rejection of material at site due to shelf life, test fail etc., fresh lot of the material must replace rejected material free of cost. In this case either ways transportation of material is in the scope of the **VENDOR** and free of cost to BHEL.

**10.5** All parts shall be protected against damage, vibration, rain, dirt and corrosion. For the same the following packing conditions shall be followed:

**10.5.1** Bricks are to be stacked in pallets with corner protection so as to prevent any physical damages like edge chipping, transit breakage/cracks; handling breakages while storage and application or any other.

**10.5.2** Monolithic are to be packed in 25Kg HDPE polythene bags and thereafter are to be palletized in 1MT pallet. Each monolithic item must be packed in unique colored HDPE bag for proper and easy identification at site while application.

**10.5.3** For all shelf life items date of manufacturing, batch no. & date of expiry shall be legibly stenciled on the bag itself. BHEL/ BHEL approved agency has the right to verify the date of manufacturing from the records at Vendor's manufacturing premises.

**10.6** The **VENDOR** has the obligation to mark all individual parts clear and durable to allow easy identification during erection works. All individual items contained in one packing are to be listed in the respective packing list.

**10.7** Each piece shall be clearly marked and identified. Codes shall also be marked on part list and erection drawing.

Steel anchors in box pallets

Refractory bricks on pallets

Refractory castable/mortars/concretes on pallets

Small equipment in wooden boxes

**11.0** Terms of Warranty conditions : Refer Annexure III

**12.0** Schedule of Guarantees : Refer Annexure IV

**13.0** Checklist of Documents to be submitted : Refer Annexure V

**Annexure-A**

**Additional points to note by the vendors for this Tender**  
**(CFBC Boiler Refractory requirement for BECL-1&2 (5316 &5317) projects)**

1. The scope of supply shall be as per the tender enquiry specification No. PCPS:33:1203:Rev00.
2. All drawings and annexures as per page 1 of 36 of the above specification are enclosed. Vendor to acknowledge the receipt of these documents.
3. Complete technical details, data sheets and relevant drawings along with point wise confirmation to our specifications shall accompany the offer (in duplicate).
  - a) For all the materials selected by the vendor, detailed specification, catalogues (all duly signed) shall be enclosed for evaluation.
  - b) All documents as per specification shall be submitted for evaluation.
  - c) Technical offer shall contain detailed Bill of Materials showing various area of location with specifications, quantity, total weight in each quoted item & cumulative total weight shall be clearly indicated for evaluation.
  - d) Shelf Life and Non Shelf Life approximate quantity of materials shall be indicated in the technical bid.
  - e) Incomplete offer leads to rejection.
4. Vendors willing to submit offers against this Web Tender shall essentially participate in the Pre Bid discussions organized by BHEL, Tiruchy tentatively around end July'12 which will be informed to vendors through separate corrigendum.

The specifications and annexure enclosed along with the offer are to be studied by vendor upon receipt. A time period of 15 days shall be given for the same.

After studying the enquiry specification the bidder shall attend PRE-BID conference at BHEL-Trichy to deliberate on the specification before submitting their technical bids. Bidder shall submit list of clarifications on enquiry specification to BHEL-Trichy 2 (two) days prior to the date of PRE-BID conference.

This Pre bid conference is conducted to bring clear understanding to the bidder on the proposed specifications. Furthermore clarifications after PRE BID conference will not be entertained by BHEL.

5. All vendors shall submit offers in 2 Parts, viz., (1) Techno Commercial Bid & unpriced price bid in a separate sealed cover and (2) Price Bid for (a) material Part – Material delivery upto site & (b) application part - from unloading, storage to till dry out in separate sealed cover. The above 2 parts in sealed covers shall be put in another single sealed cover and submitted. All covers shall bear NIT reference and Techno Commercial Bid with unpriced price bid, Price Bid shall be legibly indicated on the respective covers.
6. Techno-commercial bid will be opened on the due date and after detailed evaluation, the price bids of the technically suitable offers will be opened at a later date and shall be informed separately.

7. Integrity Pact is applicable for this web tender is enclosed. All the vendors shall execute Integrity Pact Agreement as per the format. Offers from vendors who do not execute Integrity Pact as per format enclosed will be liable for rejection.

The INTEGRITY PACT-Independent External Monitor (IEM) detail will be included in the Tender, later.

8. The Price (FOR/Site) shall be clearly indicated only in the price bid for all scope of supply as per for the enclosed format Annexure-B copy of un price-bid shall be enclosed along with technical offer for evaluation.
9. All cost associated with activities referred in clause 3.1 of Page no. 3 of 36 of specification no. PCPS: 33:1203:Rev00 will be considered as total cost to BHEL for ranking purpose.
10. Successful bidder in the event of placement of order shall execute manufacturing and dispatch (after Inspection) of the materials after BHEL's clearance only.
11. Delivery: FOR/BECL project site (site will provide required space only. Vendor has to take care of constructing covered shed, unloading of materials, proper storing of materials, internal movement of refractory materials etc). Foreign vendors have to quote with two options with respect to customs import duty structure i.e. (a) with NIL duty (b) merit duty (duty structure will be informed during price bid opening which shall be paid by BHEL but will be loaded in their price intimation for ranking purpose).
12. Payment Terms: No advance payment shall be made and is applicable for supply portion. Our payment terms shall be 100% against material receipt at site & acknowledgement and against 10% PBG.
13. Validity: Your offer shall be valid for a period of 120 days from the date of Technical Bid opening or 60 days from the date of Price Bid opening whichever is later. From the date of placement of order all the prices shall be kept firm for another 3 years (minimum).
14. PBG: You have to confirm furnishing Performance Bank Guarantee for 10% of order value (on prorata basis) valid for the warrantee period as per specification.
15. Liquidated Damage Clause shall be applicable for the delayed deliveries @0.5% per week subject to maximum of 15%. Confirmation required.
16. Refractory materials shall be made available tentatively 120 days from the date of Purchase Order, at site.
17. Vendors fulfilling the qualification criteria (page 2 of 36 of specification no. PCPS:33:1203:Rev 00 and Vendors who are not registered vendors of BHEL, Trichy have to submit the filled in "Supplier Registration Forms" (available in [www.bhel.com](http://www.bhel.com) website) along with the technical bid. Based on this and other conditions, as well as capacity and capability and approval by customer vendor will be shortlisted.

Following will be the criteria for short-listing the vendors

- Evaluation of dully filled Supplier Registration Forms.
- Availability of minimum manufacturing, handling, testing and measuring facilities as detailed in the Supplier Registration Form.
- BHEL will have the right for spot assessment of the facilities.
- Meeting our techno-commercial requirements of the enquiry.

- Customer approval for the vendors before ordering.
  - Accepting & entering in to Integrity Pact (IP).
18. Based on technical evaluation & suitability, BHEL has the right to process this tender through reverse auction option also.
  19. Inspection- Vendors have to submit their Quality Plan (QP) for approval and the Testing, Inspection, etc shall be as per the approved Quality Plan.
  20. O&M Manuals- The successful vendor should submit O&M Manual immediately after document approval.
  21. Risk Purchase: Alternatively, the purchaser at his option will be entitled to terminate the contract and to purchase elsewhere at risk and cost of the seller either the whole of goods or any part which the seller has failed to deliver to dispatch within the time stipulated as aforesaid or if the same were not available, the best and nearest available substitute therefore. The seller shall be liable for any loss which the Purchaser may sustain by reason of such risk purchase in addition to liquidated damage at the rates mentioned above.

  
10/7/12  
SM/Purchase/PCPS

Ref: BECL Refractory

## Price-Bid Submission Format

**Design, Supply, Application, Curing and Drying of Boiler Refractory for BECL-1&2 (5316 & 5317) projects****1.0- Supply Part and Bill of Materials (As per specification clause No.7.1)**

Scope Serial Number	Material Specification/Size (BOM)	Quantity in Supply unit (for one boiler)	Total weight in Kgs. (to be indicated for one boiler for each item)	Unit Rate in Rs.(FOR BECL site basis inclusive of packing & Frieght)	Total value in Rs.	Applicable Duties, Taxes	Exworks Place (to be very clearly indicated for each item)
1.1							
1.2							
1.3							
1.4							
...							
...							
...							
1.n							
Net Total for one boiler requirements (FOR/BECL site basis)							
Net Total for two boiler requirements (FOR/BECL site basis)							

**2.0- Complete Application, Curing & Drying with expert supervision (As per specification clause No.7.2)**

Scope Serial Number	Description	Lumpsum Value in Rs.	Any other Price elements
2.0 (2.1)	Complete Application, Curing & Drying with expert supervision as per specification clause		

**3.0- List of Spares for 2 years Beyond Warrantee Period (optional & will be utilised if required)(As per specification clause No.7.3)**

Scope Serial Number	Material Specification/Size (BOM)	Quantity in Supply unit (for both boilers)	Total weight in Kgs. (for both Boilers)	Unit Rate in Rs.	Total value in Rs.	Applicable Duties, Taxes and any other Price elements	Exworks Place (to be very clearly indicated for each item)
3.1							
3.2							
3.3							
3.4							
...							
...							
...							
3.n							
Net Total							

3.1 Application cost in Lumpsum/ Ton

4.0 Intermediate repair works ( As per specification clause 7.4)

4.1 Unit rate /cost as per BOM

4.2 Application cost Lumpsum/ Ton (For repair works)

**DESIGN PARAMETERS-**

1. Surface Temperature : The outside surface temperature shall not exceed 60°C at 30 ° C ambient air temperature and still air condition.

**2. Flue gas parameters**

- 2.1. Flue gas quantity : 462567 Nm<sup>3</sup>/hr  
 2.2. Flue gas density : 1.2 to 1.3 kg/Nm<sup>3</sup>

**3. Fuel Ultimate analysis (%by weight):**

Sl No.	Description	Unit	Design	Worst	Best
3.1.	Carbon	%	26.00	21.46	29.25
3.2.	Hydrogen	%	2.13	1.42	2.40
3.3.	Sulphur	%	1.90#	4.00#	2.14#
3.4.	Oxygen (by diff)	%	7.93\$	7.93&	8.91@
3.5.	Nitrogen	%	0.54	0.61	0.61
3.6.	Moisture	%	44.00	44.0	37.0
3.7.	Ash	%	17.50	20.58	19.69

**Note:**

Lignite size maximum 10 mm

Lignite ash softening temperature - > 1400°C

\$ - Includes Chlorine of 0.1%

& -Includes Chlorine of 0.13%

@- Includes Chlorine of 0.11%

# - Combustible sulphur	1.64%	3.46%	2.14%
Ash considering above combustible sulphur	17.76	21.12	19.69

**Fuel oil (For start-up low load carrying)**

Particulars	Unit	Data	Data
Type	-	Heavy Fuel Oil as per IS 1953,1982 (Grade - HV)	LDO
Viscosity max	Cst	370 @ 50 ° C	2.5 – 15.7 @ 40 ° C
Density @ 15 ° C max	Kg/m <sup>3</sup>	890 - 950	850 - 870
Flash point	°C/min	66	66 min

Pour point	°C/max	20	12 for winter 21 for summer
Water content by volume	%max	1.0	0.25
Sediments by weight	%max	0.25	0.10
Sulphur by weight	%max	4.5	1.8
Ash content by weight	%max	0.1	0.02
Approximate GCV	kcal/kg	10000	10000

4. **Bed Material:**

**Type:** Crushed refractory grog or river sand

**Size:** maximum 1mm

**Bulk Density (in Kg/m<sup>3</sup>):** 1500-1800

5. **Flue gas & Ash analysis (% by weight)**

SI No.	Description	Unit	Value
5.1	SO <sub>2</sub> in flue gas	mg/Nm <sup>3</sup> dry	160-380
5.2	Ca/S	mol/mol	3.6
5.3	HCl/HF in flue gas	mg/Nm <sup>3</sup>	85 - 400/0
5.4	Cl/F-integration	%	25/90
5.5	CO/NO <sub>2</sub> in flue gas	mg/Nm <sup>3</sup>	200/350
5.6	H <sub>2</sub> O in flue gas	%	14 – 26.2
5.7	O <sub>2</sub> in flue gas wet	%	2.6 – 11
5.8	O <sub>2</sub> in flue gas dry	%	3.5 – 13
5.9	CaO in ash	%	11 – 18
5.10	CaSO <sub>4</sub> in ash	%	26 – 31
5.11	NaCl and Na <sub>2</sub> SO <sub>4</sub>	%	19 – 34
5.12	KCl and K <sub>2</sub> SO <sub>4</sub>	%	0.34 -0.6
5.13	C in ash	%	0.9 – 5.3
5.14	Flue gas quantity	Nm <sup>3</sup> /hr	462567 - 1156373

## 6. Typical Chemical Ash analysis (%by weight) Value

Sl No.	Description	Design	Worst
6.1.	Silica SiO <sub>2</sub>	21.00	21.00
6.2.	Aluminum oxide Al <sub>2</sub> O <sub>3</sub>	15.00	15.00
6.3.	Iron oxide Fe <sub>2</sub> O <sub>3</sub>	23.00	23.00
6.4.	Titanium oxide TiO <sub>2</sub>	4.00	4.00
6.5.	Calcium oxide CaO	14.00	14.00
6.6.	Magnesium oxide Mgo	1.50	1.50
6.7.	Sodium oxide Na <sub>2</sub> O	2.20	2.20
6.8.	Potassium oxide K <sub>2</sub> O	0.20	0.20
6.9.	Sulphate SO <sub>3</sub>	19.0	19.0
6.10.	Phosphorous pent oxide P <sub>2</sub> O <sub>5</sub>	0.05	0.05
6.11.	Others	0.05	0.05

## 7.Site Data:

Ambient temperature	: 43.5°C (Range: 7.7 to 43.5 °C)
Relative humidity	: 62% (Range: 44 to 62%)
Site Elevation	: 42m (Range 34 to 42m)(above mean sea level)
Site location	: BECL, BHAVNAGAR OF GUJARAT

## 8. Temperature profile

The temperatures at various location of the boiler system are given below. For heat transfer calculations the operating temperatures shall be used and the selected material shall be able to withstand the design temperature of 1000°C

Sl	Operating Data	Temp.°C	Pr. mbar	Velocity m/s	Particle Loading kg/nm <sup>3</sup>
8.1	Combustor - Lower	850 ± 50	200	6	Fluidised bed(1000 to 1500)
8.2	Combustor-Upper( >3m from grate)	850 ± 50	0-100	7	20
8.3	Combustor to cyclone	900 ± 50	-10 to +20	28	15
8.4	Cyclone	950± 50	-25 to +40	6 to 28	1to15
8.5	Cyclone to Back Pass	850 ± 50	-50 to + 30	30	0.1
8.6	Seal pot to combustor	950 ± 50	250	0.5 to 1.5	Fluidised bed

8.7	FBHE Empty Chamber	900 ± 50	350	0.3 to 15	Fluidised bed
8.8	FBHE Bundle Chamber - I	850 ± 50	350	0.3 to 15	Fluidised bed
8.9	FBHE Bundle Chamber - II	850 ± 50	350	0.3 to 15	Fluidised bed
8.10	FBHE Exit Chamber	600 ± 50	350	0.3 to 15	Fluidised bed
8.11	Ash cooler Empty chamber	850 ± 50	250	0.3 to 20	Fluidised bed
8.12	Ash cooler Bundle chamber - I	850 ± 50	250	0.3 to 20	Fluidised bed
8.13	Ash cooler Bundle chamber - II	850 ± 50	250	0.3 to 20	Fluidised bed

**Note:**

1. Pressure fluctuations of ± 10 mbar at a frequency of 1.2 – 1.5 Hz can occur in the installed components.
2. Provision for future spieess valve to be given in FBHE SH 11 & 12 chamber to ash cooler.
3. Refractory may include up to 2% of metal pins in order to reduce thermal shock resistance.
4. The profile at refractory interface is to overlap metal spray interface by at least 100mm.

**SPECIAL CONDITIONS OF CONTRACT FOR APPLICATION OF CFBC REFRACTORY**

1. Vendor to arrange for his labor colony and staff residential including transport to site.
2. Construction power shall be provided at one point which can be approximately 500 m away from work front. Distribution of power from common point to work to be arranged by vendor.
3. Vendor to inform requirement of construction power for his use. The construction power will be provided free of charge. Taxes and Duties which are applicable is to be borne by Contractor.
4. Construction water shall be provided at site free of charge. Normalization of water, if any for specific use in refractory application work to be carried out by vendor.
5. Office space shall be provided in the vicinity of site free of charge. Construction office to be built by the vendor.
6. Safety standards for application of refractory and working at height to be strictly followed, implemented and demonstrated at site by the vendor.
7. Vendor to furnish his safety plan for safe execution of his work at site.
8. First aid provisions to be maintained at site by the vendor.
9. Vendor to inform fully himself regarding site conditions, infra structures, availability of local labor, local materials, consumables, other resources etc. for his requirement by visiting site before award of work. Certificate to this effect to be provided by the vendor.
- 10. BECL, Bhavnagar Energy Company Ltd site is located in Padva, Bhavnagar of Gujarat State.**
11. Erection rates to quote on lumpsum basis. However payments shall be regulated on pro rata tonnage of application basis, on certification by the Engineer in-charge.
12. 10% Performance Bank Guarantee (PBG) shall be paid on completion of guarantee period. No advance money is payable by BHEL.
13. Supply of refractory material to site to be coordinated by the vendor with BHEL site office to ensure uninterrupted erection of refractory at site.
14. Taking delivery, lifting of material from store, transportation to work spot, safe storage and preservation till application is the responsibility of vendor.
15. The vendor shall ensure sequential supply and ensure shelf life of materials supplied.

16. Necessary scaffolding, moving platform/T&P are to be arranged by vendor during erection stage and during subsequent inspections and repair works post commissioning in warranty period. All the T&P needed at site to be tested by agencies approved by Gujarat Factories Inspectorate and Certificate to be furnished to BHEL/Customer.
17. Necessary insurance, labour licences are to be arranged by vendor and copy to be submitted to customer. Gate passes will be issued to labour by customer only on production of above documents to customer.
18. The vendor shall be bound by all statutory rule/regulations as applicable at Site.
19. Field QP for all the type of Refractory installation to be submitted and got to be approved by customer.
20. Daily Labour report/Progress report to be submitted to BHEL.

### TERMS OF WARRANTY CONDITIONS

- 1 The VENDOR is under obligation to BHEL, upon written request by BHEL before expiration of the warranty, to rectify at VENDOR's expense any defect (except those attributable to BHEL specified in **clause 7.4.1** of main specification) to the refractory lining that arises during the period of warranty.
- 2 The VENDOR will take back and replace free of charge any inappropriate spare material/ equipment which BHEL bought from VENDOR to construction site or on VENDOR's recommendations. Unsuitable materials stored by the VENDOR will be taken back by VENDOR free of costs including transportation involved.
- 3 Costs incurred for the rectification of damage caused by refractory lining failure under terms of warranty shall be borne by the VENDOR. The costs incurred for scaffolding, cleaning, disposal of byproducts / bed material, renewal of inert solids in case of failure due to refractory has to be borne by VENDOR.
- 4 The warranty commences from the date of first firing for power generation or latest six months from completion of refractory lining. VENDOR and BHEL will keep record the date and time of starting of warranty. The completeness of refractory work has to be jointly agreed.
- 5 The CFB boiler is expected to have a service life of around 25 years. The design and choice of materials to be made that major renewal (area of replacement exceeds 20% of component area or damages affecting functional performance of refractory lining) will become necessary only after 10 years or 75000 hours of operation.
- 6 **The term of warranty expires after 24 months from date of commissioning with lignite firing and continuous boiler operation.**
- 7 The warranty period is deemed to have ended on completion of transient operation specified in clause 6.1 of main specification before the term of warranty expiry. Any stops on account of refractory lining damage will not be accounted in this cycles.
- 8 VENDOR has recourse to conduct inspections, testing and checks without affecting operational availability of CFB boiler in agreement with BHEL. In case of refractory failure during warranty period, VENDOR representative should be available for joint assessment within 72 hours of notice failing which BHEL assessment for failure is deemed to be utilized for future reference. In case of unresponsive Vendor/ non – availability of Vendor for repair works with in stipulated time of 72 hrs, BHEL or Customer (BECL) shall carry out the repair job at the risk and cost of the VENDOR (which includes material and repair cost).

- 9 Warranty for replaced materials will be extended by same period starting from time of operation of the CFB Boiler after replacement.
- 10 During overall operating period of five years subsequent to the end of warranty period, any damage occurs which can be proved due to the interchange of material applied, the VENDOR will replace the defective part free of charge including disassembly and re-installation. In addition, the VENDOR will carry out checking over the area where such interchange material is suspected.
- 11 In case of faulty refractory lining not meeting guaranteed quality, BHEL reserves following right without forgoing further claims.  
Corrective Changes: The VENDOR will repair or deliver new and replace all those parts which within period of warranty have proved to be deficient or do not possess the prescribed properties due to circumstances caused / responsible by VENDOR. The extent of the part to be replaced is not limited and may be even comprise of total replacement. Defects on account of faulty design or workmanship will be renewed by fundamental alterations free of cost by VENDOR.
- 12 If the VENDOR, upon receiving the notification of defects, expresses his inability to improve the situation under the given circumstances, or if the changes made by him do not confirm compliance with the warranty, or fails to remedy the defect within, BHEL is entitled to reject the refractory lining in part or totally.
- 13 If warranties agreed here, cannot be attained through corrective action changes or replacement deliveries, BHEL reserves right to claim compensation.
- 14 In the event of changes or repair / maintenance work being executed improperly by BHEL or third parties without prior consent of the VENDOR, the latter is exempt from warranty liabilities and any consequences arising.
- 15 In urgent cases or unresponsive VENDOR / non-availability of VENDOR representatives, BHEL reserves the right to have necessary changes or repair/maintenance work properly performed by a third party in accordance with VENDOR instructions. In such case, the original liability of the VENDOR will continue to exist on information of performance of such work to VENDOR and inability of VENDOR to carry out the tasks himself on schedule. BHEL will be responsible for the repair work alone.
- 16 Right of Rejection: BHEL shall have the right of rejection either wholly or in part, if:

- a) **VENDOR** exceeds the contractually agreed delivery dates even though no fault on exists on **BHEL** side, nor existence of **FORCE MAJURE** conditions and a reasonable extension of time granted by **BHEL** has expired ( even though no fault of **BHEL**), provided that **BHEL**, upon granting the extension, has stated that it reserves the right of rejection
- b) Adequate extension granted to the supplier for rectifying defect in refractory lining lapses through **VENDOR**'s fault.
- c) an individual part of refractory failing to meet the operational, functional and economic requirements specified in the contract. If modification or replacement of a defective part, acceptance of which initially had been refused by **VENDOR**, proves to be impossible and the contractual requirements thus cannot be met, **BHEL** is entitled to reject the refractory lining, either in part or wholly, if further operation with the defective part is considered unreasonable in the long run.

ACCEPTANCE TO TERMS OF WARRANTY CONDITIONS AS STIPULATED ABOVE  
IN PAGES 1 to 3

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AUTHORIZED SIGNATURE OF VENDOR WITH SEAL

**SCHEDULE OF GUARANTEES:** The following items need to be guaranteed for fulfilling the intent of the specification:

SI No	Guarantee Conditions	Acceptance by Vendor	Remarks
1	<p><b>Operational Availability (OA):</b> The boiler should not be shut down on account of defects of refractory lining during the warranty period and provide availability of at least 90% as per formulae given below</p> <p>Operating Availability (OA)</p> $\% \text{ during warranty period} = \left\{ \frac{[(PH-PM) - FOH]}{(PH-PM)} \right\} \times 100$ <p>Where, PH = Total Operating hours = 24 X 365 = 8760 / year.</p> <p>FOH = Total Forced Outage Hours in a year due to reasons of refractory failure attributable to vendor.</p> <p>PM = Repair/ Maintenance hours in a year for reasons not attributable to refractory.</p>		
2	<p><b>Resistance to wear , abrasion and chemical attack</b> – Refractory will withstand erosive attack, chemical attack within the warranty life. This requirement is considered proved if anchor tips are not found exposed in any portion of castable lining.</p>		
3	<p><b>Thermal Insulation/heat losses:</b> The outside surface temperature shall not exceed 60°C at 30°C ambient air temperature and still air condition. Vendor shall submit correction curves to be used for the variation in ambient temperature and air velocity from the specified values as above, while demonstrating the guarantees.</p>		
4	<p><b>Gas Tightness &amp; structural stability:</b> The brickwork setting shall be suitably designed and constructed to avoid destructive effects through gas leakage flows along wall / roof of any part and the structure stability is not affected by the dead weight nor by interaction between refractory lining and steel casing work. The above guarantee is considered met if no hot spots are observed at any time and at any location during the entire warranty period.</p>		

**Demonstration of guarantees:**

- For SI no. 1: If vendor fails to demonstrate operational availability as per above the warranty period will get extended in which the vendor has to prove the availability of 90%.
- For SI no. 2 & 3: Vendor has to demonstrate the guarantees at three stages
  - Immediately after commissioning
  - After 1 year of operation.
  - After 2 years of operation and End of warranty period.
- Vendor shall conduct guarantee tests and produce protocols signed by BHEL and end customer M/s. BECL in fulfillment of above points on performance guarantees.
- Notwithstanding the above guarantees, damages like loosening of bricks, any uneven erosion of castable and bricks etc., noticed during any unit shutdown during warranty period shall also be rectified by the vendor.

5. In case of non-compliance of the above vendor has to set right the defective area with same / modified design and workmanship in the immediate shutdown provided by the customer to meet the above points of guarantee with a consequential extension of warranty period.
6. Vendor will be given chance to set right any non compliance for 2 times; In case of failing to do so, BHEL reserves the right to set right with a third party at risk and cost to the vendor.

**ACCEPTANCE TO SCHEDULE OF GUARANTEES AS MENTIONED ABOVE**

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**AUTHORIZED SIGNATURE OF VENDOR**

### **Checklist of Documents to be submitted**

The following table contains the list of technical documents required by BHEL. Vendor is required to fill-in as much data as possible to provide a clear and concise representation of their bid. Failure to do so may result in non-consideration of bid. More detailed responses may be supplemented after award of contract.

SI No	<b>Documents to be submitted in Technical Bid along with offer</b>
1	Credentials confirming qualification criteria as stipulated in “Qualification Criteria”
2	Credentials for refractory erection services of Vendor/third party erector
3	Codes and standards followed in design, manufacture and testing of refractory
4	Test facilities available at manufacturing works for carrying out tests as per recognized standards
5	Time schedule for design, manufacture, delivery and application of refractory
6	M/s. BECL specific refractory lining arrangement drawings including anchor pitching detail, retainer plates locations, thickness of various layers of material proposed at different locations.
7	Consolidated Bill of materials
8	Component wise bill of materials.
9	Heat Transfer Calculation
10	Refractory material Data sheet
11	Quality plan
12	Terms of warranty conditions – Duly signed
13	Schedule of Guarantee – Duly signed
14	Any other information which is necessary to fully understand the offer both technically and commercially.
15	An undertaking must be given by vendor confirming submission of documents required by BHEL after P.O. The documents to be furnished by Vendor after P.O are listed below in SI no. 1 to 11.
SI No	<b>Documents to be submitted after Purchase Order (P.O) within 4 weeks from date of P.O</b>
1	M/s. BECL project specific drawings (including 3D drawings for combustor openings) for refractory installation showing details of anchor spacing, retainer plate and expansion provisions etc. for BHEL approval
2	Heat Transfer Calculation
3	Expansion calculation
4	Refractory material Data sheet for BHEL approval
5	Quality plan for BHEL approval
6	Application procedure
7	Dryout procedure for BHEL approval
8	Refractory Lining Inspection procedure
9	Maintenance Procedure
10	Repair Procedure
11	Operation Manual and Maintenance Manual
12	Guarantee test procedure for BHEL approval