**Subject: Technology Tie-up for Selective Catalytic Reduction (SCR) DeNOx System.**

## 1) Introduction:

This Expression of Interest (EoI) seeks response from OEMs of SCR System who are meeting the requirements of this EoI and are willing to be associated with BHEL through a License & Technology Collaboration Agreement on long term basis to enable BHEL to design, engineer, manufacture, assemble, quality control, test, supply, erect, commission, repair, service and retrofit the complete SCR DeNOx System for thermal power plants (with high dust flue gases) and for other applications.

### 1.1) About Bharat Heavy Electricals Limited (BHEL):

BHEL is a leading state owned company, wherein Government of India is holding 63.06% of its equity. BHEL is an integrated power plant equipment manufacturer and one of the largest engineering and manufacturing organization in India, catering to the core infrastructure sectors of Indian economy viz. energy, transportation, heavy engineering industry, defence, renewable and non-conventional energy. The energy sector covers generation, transmission and distribution equipment for hydro, thermal, nuclear and solar photo voltaic. BHEL has been in this business for more than 50 years and BHEL supplied equipment account for more than 57% of the total thermal generating capacity in India. BHEL is also listed in Indian stock exchanges. The company has 17 manufacturing units, 4 power sector regions, 8 service centers, 8 overseas offices and 15 regional offices besides host of project sites spread all over India and abroad. The annual turnover of BHEL for the year 2016-17 was US$ 4.45 Billion*. BHEL's highly skilled and committed manpower of approximately 39821 employees, the state-of-the-art manufacturing facilities and latest technologies, has helped BHEL to deliver a consistent track record of performance. To position leading state owned companies as Global Industrial giant and as a recognition for their exemplary performance, Government of India categorized BHEL as "Maharatna Company" in 2013, empowering the company with enhanced autonomy in decision making. With the current order book exceeding US$ 16.2 Billion*, BHEL is poised for excellent future growth. Our ongoing major technology tie-ups include agreements with GE Technology GmbH, Switzerland (for Once through Boilers and Coal Pulverisers); Siemens, Germany (for Steam Turbines, Generators and Condensers); Metso Automation Inc., Finland (for Control & Instrumentation); MHI, Japan (for Pumps); MHPS, Japan (for Flue Gas Desulfurization Systems); Vogt Power International, USA (for HRSG); GENP, Italy (for Compressors); Turbo Lufttechnik, Germany (for Fans), Sheffield Forge Masters International, UK (for Forgings) and Kawasaki Heavy Industries Ltd., Japan (for Stainless Steel Metro Coaches & Bogies). More details about the entire range of BHEL's products and operations are available at www.bhel.com.

### 1.2) High Pressure Boiler Plant (HPBP), Tiruchirappalli:

High Pressure Boiler Plant (HPBP), established in 1965 at southern part of India at Tiruchirappalli in Tamilnadu state is one of the major manufacturing units of BHEL dedicated to production of various kinds of Steam Generators. HPBP has established itself as leading reliable boiler manufacturer with worldwide references in numerous overseas territories including Europe, Middle-East, CIS countries and South-East Asia. HPBP not only manufactures pulverized coal fired boilers but also manufactures CFBC boilers, HRSGs, valves, oil field equipment and many other products of strategic importance for defence sector. HPBP has strong global reference base of various kind of boilers ranging from 30 MWe to 800 MWe. Valves division of HPBP manufactures around 100,000 valves a year.

[*Note: Currency conversion rate considered: 1 US $= Rs. 64.84 as on 31st March 2017]

## 2) Scope of cooperation:

BHEL is seeking Expression of Interest from OEMs for License and Technology Collaboration Agreement for complete SCR system and its integration with boiler to reduce NOx emission for thermal power plants.

Prospective collaborator shall be responsible for transferring necessary know-how & know-why to BHEL for SCR System and also for integration of BHEL supplied catalysts whether manufactured by BHEL in house or bought out from other suppliers with the overall SCR system.

Interested reputed OEMs with proven SCR system are invited to submit their offer in response to this EoI, as per indicative scope of technology transfer given in **Annexure-1**.

SCR system would broadly include reagent unloading and storage system, reagent area safety system, reagent pumping, vaporising, mixing, injection system, SCR reactor, de-dusting system, waste reagent disposal system, flow guiding / straightening system, large particle fly ash removal system at the appropriate places in the flue gas ducting system, electrical and C&I system, other associated systems for successful operation of the SCR DeNOx system as per customer/site requirements.

Upon receipt of responses against this EoI, BHEL will review the responses to ascertain suitability of the offer and shortlist Prospective Collaborators for further discussions. Detailed discussions on commercial and other terms and conditions to finalise the Technology Collaboration Agreement (TCA) shall be held with shortlisted Prospective Collaborators. The detailed terms and conditions for such a paid-up license agreement shall be mutually agreed upon.

Business sharing option, during the initial period of technology assimilation by BHEL may also be considered.

Representative data on the coal being used and flue gas parameters in a thermal power plant for selection of SCR DeNOx system is provided at **Annexure – 5** for ready reference.

## 3) Prequalification requirements (PQR):

The Prospective Collaborator shall meet following qualification requirements as on the date of submission of EoI:

a) Prospective Collaborator should have at least ten (10) years of experience in designing, engineering, manufacturing, supply, erection, commissioning, performance testing, operation and maintenance of state-of-the-art SCR DeNOx system for Thermal Power Plants. **(To be substantiated by supply reference or any other relevant documentary proof)**

AND

b) Prospective Collaborator should have designed, engineered, manufactured/got manufactured/supplied, erected/supervised erection and commissioned/supervised commissioning of SCR System with at least one (1) no. of anhydrous ammonia as reagent, with NOx reduction efficiency of not less than 75%, operating in conjunction with pulverized coal fired steam generator for 500 MWe or higher capacity unit or having minimum 1500T/hr steaming capacity. Further, such SCR System should have been in successful continuous operation for a period not less than one (1) year as on the date of

closing of this EoI. **(To be substantiated with a performance certificate issued by the end client/customer as documentary proof)**

*AND*

c) Prospective Collaborator should have designed, engineered, manufactured/got manufactured/supplied, erected / supervised erection and commissioned / supervised commissioning of SCR System with at least one (1) no. of aqueous ammonia as reagent, with NOx reduction efficiency of not less than 75%, operating in conjunction with pulverized coal fired steam generator for 500 MWe or higher capacity unit or having minimum 1500T/hr steaming capacity. Further, such SCR System should have been in successful continuous operation for a period not less than one (1) year as on the date of closing of this EoI. **(To be substantiated with a performance certificate issued by the end client/customer as documentary proof)**

*AND*

d) Prospective Collaborator should have designed, engineered, manufactured/got manufactured/supplied, erected/supervised erection and commissioned/supervised commissioning of SCR System with at least one (1) no. of urea as reagent, with NOx reduction efficiency of not less than 75%, operating in conjunction with pulverized coal fired steam generator. Further, such SCR System should have been in successful continuous operation for a period not less than one (1) year as on the date of closing of this EoI. **(To be substantiated with a performance certificate issued by the end client/customer as documentary proof)**

## 4) Brief Description of EoI Process:

The interested Prospective Collaborators shall ensure that their response along with annexures (Broad technical capabilities of Prospective Collaborator and indicative technical features of SCR DeNox System proposed for TCA as per **Annexure-2**, Experience in the field of SCR DeNOx system as per **Annexure-3** and detailed product reference for major supplies in last 10 years as per **Annexure-4**) are received by BHEL on or before **12th September 2017**. The response shall necessarily be accompanied with details on company background, product profile, SCR system proposed along with its technical details, reference list of Customers, performance certificates from customers, product data sheet and annual audited financial reports for last 3 (three) years including auditor's report.

In case any further information is needed, kindly feel free to contact us.

The respondent shall submit their offer with all annexures duly signed. Your response may be sent to the following address:

**Additional General Manager**
**Technology Licensing (TL)**
**Corporate Technology Management**
**Bharat Heavy Electricals Limited**
**BHEL House, Siri Fort**
**New Delhi – 110049, India**
**Phone: +91 11 66337210 / 7218**
**Fax: +91 11 26492974**
**Email: techeoi@bhel.in**

## 5) Miscellaneous:

**5.1.1** Right to accept or reject any or all Applications:

a) Notwithstanding anything contained in this EoI, BHEL reserves the right to accept or reject any Application and to annul the EoI Process and reject all Applications, at any time without any liability or any obligation for such acceptance, rejection or annulment and without assigning any reasons thereof. In the event that BHEL rejects or annuls all the Applications, it may, at its discretion, invite all eligible Prospective Collaborators to submit fresh Applications.

b) BHEL reserves the right to disqualify any Applicant during or after completion of EoI process, if it is found there was a material misrepresentation by any such Applicant or the Applicant fails to provide, within the specified time, supplemental information sought by BHEL.

c) BHEL reserves the right to verify all statements, information and documents submitted by the Applicant in response to the EoI. Any such verification or lack of such verification by BHEL shall not relieve the Applicant of his obligations or liabilities hereunder nor will it affect any rights of BHEL.

**5.1.2** Governing Laws & Jurisdiction:

The EoI process shall be governed by, and construed in accordance with, the laws of India and the Courts at New Delhi (India) shall have exclusive jurisdiction over all disputes arising under, pursuant to and / or in connection with the EoI process.

**Annexure-1**

## Indicative Scope of Technology Transfer

| | |
|---|---|
| a) | Transfer of up-to-date Technical Information relating to the design, engineer, manufacture, assemble, quality control, test, supply, erect, commission, repair, service and retrofit of the SCR DeNOx system. |
| b) | Training of BHEL Engineers at Collaborator's design office/manufacturing facilities to enable them design, engineer, manufacture, assemble, quality control, test, erect and commission the SCR System in Thermal Power Plants and other applications. |
| c) | Transfer of improvements/modifications/developments/up gradations to meet market requirements and environment norms / statutory requirements during the period of TCA. |
| d) | Transfer of information to enable BHEL to source/procure those items, which the Prospective Collaborator sources from outside (as these are not manufactured by the Prospective Collaborator) for use in the SCR DeNOx systems. |
| e) | Transfer of site feedback and troubleshooting information |
| f) | Transfer of applicable proprietary computer programs including logics and source code |
| g) | Assist BHEL in setting up a test facility for testing of scaled down physical model and also in design and development of models. |
| h) | Assist BHEL in stabilising manufacturing of various critical components in SCR system. Assist BHEL in identifying sub vendors for all the sub systems and bought out items. |
| i) | Provide technical assistance and quality surveillance /supervision during design, engineer, manufacture, assemble, quality control, test, supply, erect, commission, repair, service and retrofit of SCR system. |
| j) | Provide support through engineering services from Collaborator's design office / manufacturing facilities for design vetting of SCR system |
| k) | Deputation of Collaborator's experts either at BHEL's manufacturing facilities or project sites to assist BHEL in assimilating technology for SCR system in Thermal Power Plants and other applications. |

**(SIGNATURE)**

**Annexure-2**

**Broad technical capabilities of Prospective Collaborator and indicative technical features of SCR DeNox System proposed for TCA**

| Sl. No. | Description | Prospective Collaborator's response |
|---|---|---|
| **1.** | Indicate whether Prospective Collaborator has the capability to perform the following to address requirements of new and retrofit SCR system at air pre-heater inlet and also at tail-end (after ESP) in various types of boilers viz. pulverized coal, CFBC boilers, AFBC boilers, HRSGs, Municipal Solid Waste MSW and for other applications: | |
| | a) Capability in preparation of complete arrangement including layout of all equipment starting from Reagent(ammonia/urea) Unloading system up to Air heater inlet/ SCR outlet | |
| | b) P&ID of the SCR System starting form Reagent unloading upto Air Preheater Inlet/SCR outlet. | |
| | c) Design calculations for design and selection of SCR catalyst – size and area, Reagent requirement etc. NOx removal efficiency, actual stoichiometric ratios, space velocity and area velocity, theoretical NOx removal efficiency for $NH_3$ slip determination, catalyst volume, SCR reactor dimensions, estimating reagent consumption and tank size | |
| | d) Computational Fluid Dynamics (CFD) analysis for the ducting system for uniform flow distribution/ Chemical Kinetic Modelling. | |
| | e) Stress analysis and design of the various components and supports in SCR system and also provide basic design and detailed engineering for all components to enable BHEL for in-house manufacturing, even if same is outsourced by Prospective Collaborator | |
| | f) Design basis and selection of various components of the SCR system along with valves, piping & instrumentation and their location and quantum for reagent unloading system, reagent storage tanks & system, reagent area fogging system (safety system in all applicable areas) sprinklers, reagent | |

| Sl. No. | Description | Prospective Collaborator's response |
|---|---|---|
| | forwarding pump system, reagent vaporising system, dilution air system, mixing system, reagent injection system, SCR reactor system including catalyst and rectifier, dedusting system (Soot blowers/Ash sweepers/Sonic horns), waste reagent dilution tank system along with sump to waste treatment system, flow guiding / straightening system and large particle fly ash removal system at the appropriate places in the flue gas ducting system. | |
| | g) Capability in preparing specification for various Bought out Items in each of the system listed in (f) above, and all other items which are required for completeness of the SCR system. | |
| | h) Design of reagent (Anhydrous Ammonia/Aqueous Ammonia/Urea) handling system for various form of reagent (Anhydrous Ammonia / Aqueous Ammonia / Urea) & reagent including reagent unloading, storage tank, safety and statutory regulations, reagent transport from storage to boiler, preparation of reagent for injection to boiler and all other components. | |
| | i) Selection of analysers, electrical equipment, control & instrumentation system (architecture and control logics) for complete SCR system and Integration of SCR system with boiler | |
| | j) Capability in preparation of Design basis for complete SCR system. | |
| | k) Capability in preparation of Hazard and Operability (HAZOP) study for complete SCR system | |
| | l) Manufacturing drawings for the total SCR system | |
| | m) Erection procedure for complete SCR system including SCR catalyst and erection drawings for SCR system. | |

| Sl. No. | Description | Prospective Collaborator's response |
|---|---|---|
| | n) Complete list of equipment required for SCR system for lifting, handling, installation, maintenance and unloading. | |
| | o) Capability in preparation of complete bill of materials for SCR System | |
| | p) Development of catalyst management and replacements system. | |
| | q) Capability to offer generic SCR System design so that any make catalyst (either manufactured by BHEL in house or bought out from market) can be integrated with SCR system | |
| | r) Operation and maintenance of SCR system | |
| | s) Performance guarantee test procedure | |

**(SIGNATURE)**

**Annexure -3**

## Prospective Collaborator's Experience in the field of SCR DeNOx system for Thermal Power Plants & other applications

| Sl. No. | Requirement | Prospective Collaborator's response YES/NO and remarks if any. |
|---|---|---|
| 1) | For how many years, Prospective Collaborator is in business of SCR (Selective Catalytic Reduction) System | |
| 2) | Whether Prospective Collaborator has carried out system design of SCR located between economiser outlet and air pre-heater (high dust) in typical utility boilers (Pulverized coal, Oil, Gas) and CFBC boiler /AFBC boiler. | |
| 3) | Whether Prospective Collaborator has carried out system design of SCR located between Hot ESP and air pre-heater in low dust configuration (Hot ESP is located between Economiser and Air pre heater) in typical utility boilers and CFBC/AFBC boiler. | |
| 4) | Whether Prospective Collaborator has carried out system design of SCR located between ID fan and chimney (Tail end) in typical utility boilers and CFBC/AFBC boiler. | |
| 5) | Whether Prospective Collaborator has carried out system design of SCR for HRSG application. | |
| 6) | Whether Prospective Collaborator has carried out system design of SCR for MSW or WTE application. | |
| 7) | Whether Prospective Collaborator has carried out system design of SCR for other process application. | |
| 8) | Whether the Prospective Collaborator is an original SCR system designer & supplier for high dust and proven for ash content (>25 gm/$Nm^3$) for coal fired power plants. | |
| 9) | Whether Prospective Collaborator has proven operational experience (in 500 MWe or higher capacity unit or with steam generator having minimum 1500T/hr steaming capacity) of minimum 16000 hours without any replacement of Catalyst during the period under high ash environment (>25 gm/$Nm^3$), with NOx reduction efficiency more than > 80 %. | |
| 10) | Whether Prospective Collaborator has supplied any SCR system with Catalyst module of minimum 60,000 hrs. expected mechanical life. | |
| 11) | Whether Company background and its product profile along with technical details of SCR system for Thermal Power Plants which is being offered to BHEL under this EoI enclosed. | |

| Sl. No. | Requirement | Prospective Collaborator's response YES/NO and remarks if any. |
|---|---|---|
| 12) | Whether product data sheet has been enclosed | |
| 13) | Whether information on market share has been enclosed | |
| 14) | Whether Prospective Collaborator's detailed reference list has been enclosed | |
| 15) | Whether Prospective Collaborator's annual audited financial reports including auditor's report for last 3 years has been enclosed | |
| 16) | Whether the SCR system with high dust burden (>25 gm/$Nm^3$) in Thermal Power Plants offered for technology transfer is the latest being marketed by the Prospective Collaborator | |
| 17) | *"Prospective Collaborator should have at least ten (10) years of experience in designing, engineering, manufacturing, supply, erection, commissioning, performance testing, operation and maintenance of state-of-the-art SCR DeNOx system for Thermal Power Plants."*<br><br>Whether Prospective Collaborator meets above PQR and requisite supply reference or any other relevant documentary evidence to substantiate the above PQR has been submitted. | |
| 18) | **"***Prospective Collaborator should have designed, engineered, manufactured/got manufactured/supplied, erected/supervised erection and commissioned/supervised commissioning of SCR System with at least one (1) no. of anhydrous ammonia as reagent, with NOx reduction efficiency of not less than 75%, operating in conjunction with pulverized coal fired steam generator for 500 MWe or higher capacity unit or having minimum 1500T/hr steaming capacity. Further, such SCR System should have been in successful continuous operation for a period not less than one (1) year as on the date of closing of this EoI.***"**<br><br>Whether Prospective Collaborator meets above PQR and requisite performance certificate issued by the end client/customer as documentary proof to substantiate the above PQR has been submitted. | |
| 19) | "Prospective Collaborator should have designed, engineered, manufactured/got manufactured/supplied, erected/supervised erection and commissioned/supervised commissioning of SCR System with at least one (1) no. of aqueous ammonia as reagent, with NOx reduction efficiency of not less than 75%, operating in conjunction with pulverized coal fired steam generator for 500 MWe or higher capacity unit or having minimum 1500T/hr steaming capacity. Further, such SCR System should have been in successful continuous operation for a period not less than one (1) year as on the date of closing of this EoI." | |

| Sl. No. | Requirement | Prospective Collaborator's response YES/NO and remarks if any. |
|---|---|---|
| | Whether Prospective Collaborator meets above PQR and requisite performance certificate issued by the end client/customer as documentary proof to substantiate the above PQR has been submitted. | |
| 20) | *"Prospective Collaborator should have designed, engineered, manufactured/got manufactured/supplied, erected/supervised erection and commissioned/supervised commissioning of SCR System with at least one (1) no. of urea as reagent, with NOx reduction efficiency of not less than 75%, operating in conjunction with pulverized coal fired steam generator. Further, such SCR System should have been in successful continuous operation for a period not less than one (1) year as on the date of closing of this EoI."*<br><br>Whether Prospective Collaborator meets above PQR and requisite performance certificate issued by the end client/customer as documentary proof to substantiate the above PQR has been submitted. | |
| 21) | Whether the prospective collaborator has supplied SCR system with $SO_2$ Oxidation rate of ≤ 1% and Ammonia slip < 3ppm | |
| 22) | Whether Prospective Collaborator's dedusting system is equipped with soot blowers or Sonic horn or Ash sweeper | |
| 23) | Whether only soot blowers can be offered (if required) for dedusting system. | |
| 24) | Whether only sonic horn/ash sweepers can be offered (if required) for dedusting system as per Prospective Collaborator's technology. | |
| 25) | Whether Prospective Collaborator's SCR system can be offered with vaporiser. | |
| 26) | Whether Prospective Collaborator's SCR system can also be offered without vaporiser | |
| 27) | Whether Prospective Collaborator's SCR system can be offered with reagent forwarding pumps | |
| 28) | Whether Prospective Collaborator's SCR system can also be offered without reagent forwarding pumps | |
| 29) | Whether Prospective Collaborator's SCR system can be offered with accumulator | |

| Sl. No. | Requirement | Prospective Collaborator's response YES/NO and remarks if any. |
|---|---|---|
| 30) | Whether Prospective Collaborator's SCR system can also be offered without accumulator | |
| 31) | Whether the Prospective Collaborator owns the Intellectual Property Rights for the technology being proposed for transfer under the Technology Collaboration Agreement (TCA) or have an unencumbered right from the owner of the Intellectual Property Rights to sub-license the technology, if applicable.<br><br>If yes, whether list of such Intellectual Property Rights enclosed. | |
| 32) | Whether Prospective Collaborator has confirmed their design & performance of SCR as per the indicative fuel analysis and flue gas parameters provided in Annexure-5. | |
| 33) | Whether the Prospective Collaborator has any experience in establishing a new manufacturing, testing and assembly facilities, if so please specify. | |
| 34) | Maximum Unit Size or Capacity (MWe rating) with urea as reagent supplied by Prospective Collaborator. (Name of the Plant with details) | |
| 35) | Whether Prospective Collaborator has offered technology license to any other company in the world for supply of SCR system for Thermal power plants. | |

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**Annexure -4**

**Reference List:** The Prospective Collaborator shall furnish a summary of their product reference as detailed below for major supplies in last 10 years

| Sl No | Customer/ Country | Ash % | Unit Rating MWe | No of units | Type of Boiler: PF (Tower / Two pass) CFBC / BFBC/ MSW | Type of fuel | Supply type: New / Retrofit | Date of order | Commissioning Date | Location of SCR between (Economizer & APH / APH & ID fan / ID fan & chimney ) | Steaming capacity, t/h | Dust concentration at SCR inlet g/Nm3 | Inlet NOx mg/ Nm3 (at 6% O2 dry) | Outlet NOx mg/ Nm3 (at 6% O2 dry) | NH3 slip, ppm | SO2 to SO3 conversion, % | Type of Catalyst | Catalyst Supplier | Reagent Type | NOx reduction efficiency % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | |
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| Description | Design (Yes / No) | Engineering (Yes/No) | Manufactures/Got Manufactured /Supply | Erection / Supervised Erection | Commissioning / Supervised Commissioning |
|---|---|---|---|---|---|
| Reagent unloading system | | | | | |
| Reagent storage tank system | | | | | |
| Regent fogging and spray system | | | | | |
| Reagent vaporizing system | | | | | |
| Reagent pumping system | | | | | |
| Reagent mixing and dilution system | | | | | |
| Reagent injection system | | | | | |
| Dedusting system | | | | | |
| SCR Reactor Ducting, Catalyst support, Guide Vanes and Flow Straightners and supporting structures | | | | | |
| Static Mixers, Large Particle Ash screen | | | | | |

**(SIGNATURE)**

**Annexure -5**

## TYPICAL COAL ANALYSIS

| **Description** ( Source / Type ) | | | | | | |
|---|---|---|---|---|---|---|
| **Proximate Analysis** | Coal - 1 | Coal - 2 | Coal - 3 | Coal -4 | Coal - 5 | Range of adequacy coal |
| Fixed carbon % | 24 | 20 | 30.5 | 40 | 29 | 19.25 - 40 |
| Volatile matter % | 22 | 19 | 24 | 30 | 45 | 18.75 - 45 |
| Moisture % | 14 | 17 | 11.5 | 20 | 16 | 10 -17.5 |
| Ash % | 40 | 44 | 34 | 10 | 10 | 32 - 44.5 |
| Total % | 100 | 100 | 100 | 100 | 100 | |
| HHV kcal / kg | | | | | | |
| LHV kcal / kg | | | | | | |
| Ash kg / $10^6$ kcal | | | | | | |
| **Ultimate Analysis** | | | | | | |
| Carbon % | 34 | 30 | 41.65 | 56.4 | 62.4 | 28.85 - 62 |
| Hydrogen % | 3.1 | 2.3 | 3.4 | 4.5 | 4.9 | 2.3 - 4.9 |
| Sulphur % | 0.4 | 0.6 | 0.35 | 0.9 | 0.8 | 0.35 - 0.8 |
| Nitrogen % | 1.2 | 0.9 | 1.23 | 0.9 | 0.5 | 0.57 - 1.23 |
| Oxygen % (by difference) | 7.3 | 5.2 | 7.87 | 7.3 | 5.4 | 5.41 - 9.17 |
| Total Moisture % | 14 | 17 | 11.5 | 20 | 16 | 10 - 20 |
| Carbonates % | ---- | ---- | ---- | 0 | 0 | ---- |
| Phosphorous % | ---- | ---- | ---- | 0 | 0 | ---- |
| Ash % | 40 | 44 | 34 | 10 | 10 | 32 - 44.5 |
| Total | 100 | 100 | 100 | 100 | 100 | |
| Hard Grove Index | 50 | 45 | 70 | 45 | 60 | 45-70 |
| YGP Index (mg/kg) | 75 | 80 | 70 | 100 | 70 | 65-100 |
| GCV Kcal/Kg | 3500 | 3000 | 4200 | 5800 | 6500 | 2900-6500 |
| **Ash Characteristics (Under reduced atmosphere)** | | | | | | |
| IT - Initial deformation temp. °C | 1150 | 1100 | 1200 | 1100 | 1250 | 1100-1200 |
| ST - Softening temp. H = W °C | - | - | - | | | - |
| HT - Hemispherical temp. H = W/2 °C | 1300 | 1250 | 1350 | 1300 | 1350 | 1250-1350 |
| FT - Fusion temp. °C | 1400 | 1350 | 1400 | 1400 | 1400 | 1350-1400 |
| **Ash Constituents** | | | | | | |
| A - $S_i O_2$ % | 58.59 | 56.81 | 60.2 | 32.74 | 34.94 | 56.29-60.42 |
| A - $Al_2 O_3$ % | 26.77 | 27.42 | 26.1 | 30.5 | 28.43 | 25.9-30.5 |
| B - $Fe_2 O_3$ % | 8.8 | 9.8 | 7.8 | 18.2 | 15.2 | 7.6-18.2 |
| B - MgO % | 1 | 1.13 | 0.97 | 1.83 | 1.93 | 0.92-1.93 |
| B - CaO % | 1.39 | 1.48 | 1.32 | 6.12 | 7.62 | 1.28-7.62 |
| B - $Na_2 O$ % | 0.2 | 0.08 | 0.4 | 0.3 | 0.4 | 0.08-0.5 |
| B - $K_2 O$% | ---- | ---- | ---- | ---- | ---- | ---- |
| A - $TiO_2$ % | 1.66 | 1.78 | 1.56 | 1.56 | 1.76 | 1.52-1.86 |
| $P_2O_5$ % | 0.19 | 0.1 | 0.24 | 0.44 | 0.54 | 0.08-0.54 |
| Sulphuric Anhydride% | 0.05 | 0.04 | 0.1 | 6.95 | 7.65 | 0.04-7.65 |
| Alkalies (by difference) | 1.35 | 1.36 | 1.31 | 1.36 | 1.56 | 1.36-1.56 |
| Total | 100 | 100 | 100 | 100 | 100.03 | |

**TYPICAL FLUE GAS PARAMETERS**

| Sl. no | Description | Units | Case - 1 | Case - 2 | Case - 3 | Case - 4 |
|---|---|---|---|---|---|---|
| 1 | Flue gas flow at Economiser Outlet | kg/hr | 2730000 | 2730000 | 3304000 | 3304000 |
| 2 | Typical range of Flue gas temperature entering SCR | deg C | 300-360 | 300-360 | 300-360 | 300-360 |
| 3 | Flue gas temperature entering SCR | deg C | 324 | 324 | 324 | 324 |
| 4 | Total Volumetric Gas Flow at Sl No 3 | m3/hr | 4640000 | 4640000 | 5620000 | 5620000 |
| 5 | Total Volumetric Gas Flow | Nm3/hr | 2122000 | 2122000 | 2572000 | 2572000 |
| 6 | Flue gas constituents, Wet Basis - % By Weight | | | | | |
| i | $CO_2$ | % | 21.852 | 21.852 | 21.852 | 21.852 |
| ii | $N_2$ | % | 68.913 | 68.913 | 68.913 | 68.913 |
| iii | $O_2$ | % | 3.458 | 3.458 | 3.458 | 3.458 |
| iv | $SO_2$ | % | 0.174 | 0.174 | 0.174 | 0.174 |
| v | $H_2O$ | % | 5.603 | 5.603 | 5.603 | 5.603 |
| 7 | Inlet Particle Dust Concentration | gm/Nm3 | 73.9 | 73.9 | 73.9 | 73.9 |
| 8 | NOx concentration to SCR Inlet | mg/Nm3 | > 300 | > 750 | > 300 | > 750 |
| 9 | NOx required at Chimney | mg/Nm3 | < 90 | < 90 | < 90 | < 90 |

**(SIGNATURE)**