Expression of Interest (EOI) for Consultancy for Review and Vetting of Design of AUSC Steam Turbine

Expression of Interest
for
Consultancy for Review and Vetting of Design of Advance Ultra Super Critical Steam Turbine

Document No BHEL/AUSC/STE/TM/EOI/P1/03

BHARAT HEAVY ELECTRICALS LIMITED
HEAVY ELECTRICAL EQUIPMENT PLANT
HARIDWAR-249403, INDIA
1) **Introduction**

Bharat Heavy Electricals Limited (BHEL), a Government of India undertaking, is the largest Engineering and Manufacturing organization in India and is one of the leading international companies for providing total business solutions in the field of Power Generation & Transmission, Defense, Transportation, Oil & Gas, Telecommunication etc. The company has 17 manufacturing units, 4 power sector regions, 8 service centers, 4 overseas offices and 15 regional offices, besides host of project sites spread all over India and abroad. In FY 2016-17, the company commissioned/synchronized 8,539 MW of power generating equipment. With this, the company’s global installed power generating capacity has gone up to 178 GW. Notably, enhanced focus on project execution has resulted in BHEL achieving a capacity addition of 45,274 MW during the 12th Five Year Plan period (2012-17), surpassing the target of 41,661 MW set by the government for BHEL. With this, BHEL continues to remain the single largest contributor to the country’s power generation capacity addition. With the current order book exceeding Rs. 10,0000.00 crore, BHEL is poised for excellent future growth.

Entire range of BHEL’s products and operations can be obtained by visiting our website www.bhel.com

In the field of Power Generation, the organization is involved in Design, Manufacturing, Erection and Commissioning of Power Plant Equipment with state of the art production facilities. We have more than 50 years’ experience in this field and capacity ranging up to 1000 MW.

A consortium consisting of Indian companies and Institutes has been formed for development of Advance Ultra Super Critical Steam Turbine in India. BHEL is a partner in this consortium. Through the available collective expertise, consortium is working on issues related to material testing, high temperature design, erection, commissioning, plant operation and troubleshooting.

Prior to AUSC, most of the previous turbine designs at BHEL were collaborative efforts with OEMs. The materials used in these sets were Ferritic steels. This is the first time BHEL is independently venturing into turbine design with Nickel Based Alloys and AUSC Parameters. Hence, there is a need for review and vetting of design from an institution/consultancy organization.

BHEL has developed a design of AUSC turbine based on in-house capabilities with
dissimilar metal weld joint wherein Nickel based alloys are welded to 9-10% Chrome steel for High Pressure and Intermediate Pressure turbine. The design shall cater to 800 MW AUSC power plants with steam parameters of 310 kg/cm² / 710 °C / 720 °C.

2) **Present Expression of Interest**

For the purpose of review and vetting of design of AUSC steam turbine BHEL intends to technically shortlist Institution or Consultancy Organization of International Repute based on this EOI.

BHEL shall receive applications pursuant to this EOI in accordance with the terms set forth herein, as modified, altered, amended and clarified from time to time by BHEL, and all applications shall be prepared and submitted in accordance with such terms on or before the date specified in this EOI.

3) **Scope of Work for Prospective Institution/Consultancy Organization**

Scope of work for design review has been described in Annexure-A.

4) **Selection of Prospective Institution/Consultancy Organization**

Based on the information provided under this EOI, the prospective institutions/consultancy organizations shall be technically shortlisted (ref. Annexure-C). The short listed institutions/consultancy organizations will further be evaluated on the basis of terms and conditions defined in the enquiry.

Pre-bid clarification meeting shall be held with the short listed parties regarding scope, confidentiality requirements and deliverables.

5) **Brief Description of EOI Process**

The interested prospective institution/consultancy organization shall ensure that its response in the form of a signed letter comprising the application as per format enclosed at Annexure-B and details requested as per Annexures-A & C of this EOI along with the information and data required as per attachments and supporting
documents thereof, is received by BHEL on or before 07th September 2017. Alternatively, a scanned signed copy of the EOI may be sent by e-mail as advance copy by 07th September 2017, to be followed by original signed copy which should reach BHEL within 7 days of e-mail communication.

The response shall necessarily be accompanied with details of institution/consultancy organization’s background, along with information required as per Annexure-A&C. The responding prospective institutions/consultancy organizations on submission of their response can be contacted/invited for further discussions.

The response may be sent at the following address:

Dy. General Manager
Steam Turbine Engineering (STE-TM)
Bharat Heavy Electricals Limited
HEEP, Ranipur, Haridwar-249403
Uttarakhand, India
Phone: +91-1334-284290; Fax: +91-1334-223954
Email: mbatrani@bhelhwr.co.in

Any request for further information or clarification on the EOI document may be sent by mail to the address mentioned above. BHEL may respond to the queries raised/clarifications sought to the best of its ability. BHEL at its discretion may extend the due date for submission of EOI and the decision of BHEL in this respect would be final and binding on the respondents.

EOI submittals should be in English. Duly authorized representative shall sign on each page of the documents. EOI should be prepared in such a way so as to provide a straightforward, concise description of applicant’s capabilities.

If at any time during the evaluation of EOI, BHEL requires any clarification on the documents submitted by the prospective parties, it reserves the right to request a clarification so as to complete the evaluation.
6) **Miscellaneous**

**Right to accept or reject any or all applications**

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 therefore. In the event that BHEL rejects or annuls all the applications, it may, at its discretion, invite all eligible institutions/consultancy organizations to submit fresh applications.

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.

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.

**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-A

Scope of work for Design Review

Bharat Heavy Electricals Limited (BHEL), a Govt. of India undertaking, is an engineering organization involved in Design, Manufacturing, Erection and Commissioning of Power Plant Equipment with state of the art production facilities. We have more than 50 years’ experience in this field and capacity ranging up to 800 MW.

As part of Govt. of India (GoI) initiative to develop a power plant with Advanced Ultra Super Critical (AUSC) technology a consortium consisting of Indian organizations has been formed. BHEL is a partner in this consortium, and through the available collective expertise, consortium is able to address issues related to material testing, high temperature design, erection, commissioning, plant operation and troubleshooting.

Prior to AUSC design, all the previous turbine designs at BHEL were collaborative efforts with OEMs. The materials used in these sets were Ferritic steels. This is the first time BHEL is independently venturing into turbine design for AUSC Parameters. AUSC power plant will be having steam turbine with components made of Ni-based alloys and having steam parameters much higher than currently used in ultra-supercritical sets of BHEL. In addition, it is envisaged to use cross compounding turbo-generator configuration for the first time in BHEL with HP turbine located separately at higher elevation to reduce the cost of expensive Nickel based alloy piping. Moreover, it will have dissimilar metal welded steam turbine rotors and casings.

Considering the above and so many other complexities and innovations involved, there is a need for independent review, vetting of design and suggestive design improvements, if any, from a consultancy organization or consultant team.

BHEL has developed a HBD for rated load conditions and based on which design of HP and IP turbine cylinders has been performed; which include HP rotor, IP rotor, HP & IP inner and outer casings, valves for HP and IP turbine based on in-house capabilities. The rotors are with dissimilar metal weld joint wherein alloy 617 (M) is welded to 9-10% Chrome steel. Similarly HP and IP casings are with dissimilar weld joint between Cast Alloy 625 and 9-10 % Chrome steel castings. The valve bodies are made of Cast Alloy 625.
Flow path design including blade design of HP and IP turbines has been progressing with the help of commercial software and in-house developed codes. Material of turbine blades is Alloy 617M for initial stages (in high temperature zone) and conventional Chrome Steels for rest of the turbine stages.

Heat balance diagram is prepared with the help of commercial software. Startup cycle is made taking guidance from previous experience and with the help of validation of stresses in the components during transient operating conditions of start-up process.

The design shall cater to 800 MW AUSC power plants with steam parameters of 310 kg/cm² / 710 °C / 720 °C as targeted by Indian AUSC consortium.

For the purpose of review and vetting of the above detailed design of turbine, BHEL intends to engage consultancy organization or a team led by a Lead Consultant in collaboration with suitable partners as deemed necessary (Lead Consultant having the prime responsibility of coordination with other experts as needed) in line with the broad scope detailed below, which is a preliminary outline of the work envisaged, and shall be finalized after detailed discussions further on.
1 **Concept of steam turbine design**: Review of basic concept of the cross compounded turbine which include following

1.1 Concept of cross compounding turbine where both TG trains are operating at different heights; this will include the overall cross-section/configuration of the TG trains. Various system of both TG trains and control system philosophy

1.2 External cooling arrangement of balance piston area in HP turbine along with overall sectional arrangement

1.3 Overall cross sectional arrangement of IP turbine

1.4 Pre-warming concept of steam turbine to shorten the start-up time

2 **Thermodynamic design of TG Set**: Review of following is required in the area of thermodynamic design:

2.1 Existing HBD (rated conditions) being used for design

2.2 Thermal data used for design of steam turbine. (Such as balance piston diameters, shaft seal design, blade design and NRV design data etc.)

2.3 Axial thrust calculation for both TG trains (HP+Generator+exciter and IP+LP1+LP2+Generator+exciter)

2.4 Seal and leak-off steam quantities and related thermal parameters for different operating regimes

2.5 Thermal parameters of steam at different terminal points of turbine worked out at transient condition during different start-up regimes

3 **HP and IP Turbine Flow path/Blading**: Review of following is required in the area of flow path/blading design:

3.1 Aero-thermodynamic design of HP blade-path.

3.2 Aero-thermodynamic design of Turbine Side (TS) IP blade-path.

3.3 Aero-thermodynamic design of Generator Side (GS) IP blade-path.

3.4 Mechanical design of Guide and Moving Blades, Lock blades, Locking Screws, Rotor Claw, Seals and caulking pieces.

3.4.1 Material properties and Factor of safety used for the design.

3.4.2 Review of load cases used and types of static and dynamic loads considered for blade design.

3.4.3 Verification of various Blade Stresses along with Material Allowable Stress for four blades. One Double T-Root and one Single T-Root blades with IN617 material and two Single T-Root blades with alloy Steel (either of HP or IP flow path).
3.4.4 Verification of various stresses involved in design of Blade grooves.
3.4.5 Review of design of Rotor Claw and Claw stress.
3.4.6 Review of design of Lock blades, and locking screws.
3.4.7 Review of mechanical design of Seals and Caulking pieces.
3.4.8 Axial and Radial clearances in overall blade Plan.
3.4.9 Relative blade twist and other blade assembly criteria.

4  **Turbine Start-up**: In turbine start-up following needs to be reviewed

4.1 Startup curves for various types of start-up i.e. hot, warm and cold start-up.
4.2 Determination of allowable steam and metal temperature difference and its implementation in Control and Instrumentation.

5  **Mechanical Design of HP/IP Rotor of Steam Turbine**: Review of following areas in mechanical design of HP/IP rotor:

5.1 Design loads and boundary conditions
5.2 Identified failure modes as per BHEL design documents and identifying the missing failure modes if any vis-à-vis HP/IP rotor design
5.3 Verification of intended factor of safety (FOS)/allowable limits for each identified failure mode
5.4 Estimated heat transfer coefficients for thermal analysis for establishment of temperature profile under various operating conditions of start-up and steady state for evaluation of secondary stresses in HP/IP rotor of turbine
5.5 Analysis/calculation procedure, post processing of FEA results and factor of safety obtained.
5.6 Allowable temperature margin i.e. allowable temperature difference between surface and mean temperature of HP/IP Rotors.
5.7 Rotor dynamics of both Turbo Generator trains which include bending/torsional critical speed, unbalance response, catenary generation etc.
5.8 Calculations of Lube-oil & Jacking-oil quantity of Bearings and Hydraulic Turning Motor used of barring.

6  **Governing System**: Review of following is required in the area of turbine governing

6.1 HP valve w.r.t the valve sizing calculations
6.2 IP valve w.r.t the valve sizing calculations
6.3 Overload valve w.r.t the valve sizing calculations
6.4 Governing philosophy

7 Control and Instrumentation: Review of following topics of control philosophy
7.1 Operational and control philosophy of steam turbine
7.2 Additional protection criteria for Steam Turbine due to elevated steam temperature, pressure and new material being used for steam turbine design
7.3 Finalized material and design of root valves for Turbine area which will be used for higher parameters of AUSC cycle.
7.4 Design of Thermocouples to be used for elevated steam Temperature in MS /HRH line and HP/IP Turbine.
7.5 Additional measurement /Instrumentation for Steam Turbine

8 Foundation loads and Integral Piping: Review of following in the area of foundation loads and turbine integral piping
8.1 Calculations of load on TG Foundation at 51 meter and 17 meter height
8.2 Turbine Integral Piping system P&ID along with its equipment and Valves design for the following systems:
   8.2.1 Lube Oil system for TG Bearings
   8.2.2 Turbine Oil Module system
   8.2.3 Seal Steam System for Turbine glands and valve spindle leak-off
   8.2.4 Turbine drainage system
   8.2.5 Control fluid system for ESVs, IVs, Overload Valve and LP Bypass valve
   8.2.6 Condensate Spray system for LP Turbine, Flash tank & LP Bypass line
   8.2.7 Overload valve piping system
   8.2.8 HP, IP & LP Turbine system
8.3 Working parameter i.e., Pressure, Temperature and Flow along with Maximum short term parameter at all the design section for above Turbine Integral systems.
8.4 Pressure drop calculation and allowable pressure drop for Seal steam system and Lube oil system.
8.5 Piping and valve materials & its mechanical properties at room temperature & higher temperature.
8.6 Turbine integral piping design (Layout & stress analysis) for seal steam system, turbine drainage system and overload piping system.

9 Expected outcome of Expert review

Consultant will submit a detailed report of review which shall include the following

9.1 Suggestions/comments on the overall concept of the present AUSC cross-compounded turbine including benefits and drawbacks of this system

9.2 Comments against each section of the design report submitted by BHEL along with rationale behind each comment

9.3 Any missing failure criteria for reliable design; which are not taken care in the design report

9.4 Comments upon methodology followed by designer in each section of the report submitted by BHEL. Reviewer will verify its correctness and suggest the possible improvements

9.5 Comments upon the correctness of assumptions/estimation taken in the course of design. Reviewer's opinion on possible tolerance in the assumed/estimated parameter taken by design team

9.6 Overall recommendation of reviewer from performance, safety and operational reliability of the components/systems

9.7 Suggestion for further improvement in the design for better reliability of the component
10 Methodology of expert review

10.1 BHEL will submit the reports of design of various components and systems to expert team and team will review the design of components at their works. During review at their works consultant may need to interact with the team of BHEL through VC/ live meeting.

10.2 In case any information is required by the consultant for effective review against any of the sections 1 to 8 in addition to details provided in the report submitted by BHEL, consultant may ask the same from BHEL.

10.3 Sharing of final observation of review will be done by relevant expert at works of BHEL, Haridwar, India against each section 1 to 8 which will require one or more visits.

10.4 Expert team need to take care of their travel, boarding and lodging at BHEL, Haridwar, India. BHEL will provide a suitable office space to facilitate the discussions.

10.5 Reviewer team need to submit charges of review based on per hour basis and the man hours required against each section of the scope of review.

10.6 In case of utmost requirement consultant may need to visit BHEL, Haridwar during the course of discussions prior to visit against clause 10.3. Reviewer is requested to provide additional offer for such visit on man-hour basis along with travel, boarding and lodging charges at BHEL Haridwar.

The information shared under the project shall be governed by the conditions of a Non-Disclosure Agreement to be signed with the Consultant during Pre Award stage/Post Award stage/Later stage, as applicable. The schedule of work shall be decided as per mutual agreement between the consultant and BHEL. It will depend on the overall project timelines involving other partners who are also responsible for providing interface information to BHEL for finalization of HP and IP turbine design and availability of funds.

Taking cognizance of the above stated objectives, it is requested to submit a brief Approach paper mentioning the broad methodology to be followed along with the prospective collaboration with additional resource persons (experts) if needed.
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Annexure-B

Expression of Interest Letter
(To be submitted on the letter head of the party submitting the EOI)

To,
Dy. General Manager
Steam Turbine Engineering (STE-TM)
Bharat Heavy Electricals Limited
HEEP, Ranipur, Haridwar-249403
Uttarakhand, INDIA
Telephone: +91-1334-284290
Telefax: +91-1334-223954
Email: mbatrani@bhelhwr.co.in

Subject: EOI for being Consultancy Provider for Review & Vetting of Design of AUSC turbine

With reference to your EOI document Ref. No BHEL/AUSC/STE/TM/EOI/P1/03 Rev.00 dated __________, we have examined the EOI document and understood its contents and hereby submit our application for pre-qualification for the aforesaid project.

1. We acknowledge that BHEL will be relying on the information provided in the application and the documents accompanying such application for the aforesaid consultancy work, and we certify that all information provided in the application and Annexure-A & C are true and correct; nothing has been omitted which renders such information misleading; and all documents accompanying such application are true copies of their respective originals.
2. We confirm to make available to BHEL, within the stipulated time, any additional information it may find necessary.
3. We agree and undertake to abide by all the terms and conditions of the EOI document.

In witness thereof, I / we submit this application under and in accordance with the terms of the EOI document.

Yours faithfully,
(Signature, name and designation of the Authorized Signatory
Name and seal of the Applicant)
Annexure-C

Mandatory information required for technical evaluation of the institutions/consultancy organizations by BHEL to be furnished along with EOI.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>DESCRIPTION OF REQUIREMENT</th>
<th>Relevant Document Attached (Yes/No)</th>
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| 1       | Experience in number of years of design of high temperature steam turbine components of rating 500MW or above. Which shall include  
1.1 Thermal design  
1.2 Flow path design  
1.3 Transient operation of turbine  
1.4 Mechanical design  
1.5 Turbine governing  
1.6 Control and instrumentation  
1.7 Piping system integral to turbines  
1.8 Foundation load calculations  
Experience profile along with academic/industry background of experts in related areas. |                                                                                   |
| 2       | List of design of steam turbines performed/reviewed/vetted for rating 500MW or above of USC parameters (Pressure 270 bar; temperature 600°C) or above |                                                                                   |
| 3       | Experience in design of welded steam turbine rotor configuration including weld zone analysis |                                                                                   |
| 4       | List of the OEMs of Steam turbine to whom already consultancy services provided along with the brief nature of consultancy work |                                                                                   |

Desirable information required for technical evaluation of the institutions/consultancy organizations by BHEL to be furnished along with EOI.

1 Experience in design of components made of Nickel based alloy which should include design of rotors of any MW rating operating above temperature of 600°C
Disclaimer

The information contained in this Expression of Interest document (the “EOI”) or subsequently provided to Applicant(s), whether verbally or in documentary or any other form, by or on behalf of BHEL or any of its employees or advisors, is provided to Applicant(s) on the terms and conditions set out in this EOI and such other terms and conditions subject to which such information is provided.

This EOI is not an agreement and is neither an offer nor invitation by BHEL to the prospective Applicants or any other person. The purpose of this EOI is to provide interested parties with information that may be useful to them in the formulation of their application for qualification pursuant to this EOI.

BHEL also accepts no liability of any nature whether resulting from negligence or otherwise howsoever caused arising from reliance of any Applicant upon the statements contained in this EOI.

The issue of this EOI does not imply that BHEL is bound to select and shortlist Applicants for next stage of the Project.