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GOVERNMENT OF INDIA
BHABHA ATOMIC RESEARCH CENTRE
Uranium Extraction Division

Ref: UED/Pl.13/20/115858

Date: 11.11.2020

Tender No.: BARC/UED/SKS/20070

Due Date: 27.11.2020

Sub: Fabrication, supply, installation, commissioning, testing and warranty of the high temperature box-type resistive furnace System

Sealed quotations are invited for and on behalf of the President of India for the work as described below. Super scribed “**Fabrication, supply, installation, commissioning, testing and warranty of the high temperature box-type resistive furnace System**”, Due Date and Tender No., Party’s Name & Address and Kind Attention “Dr. S. K. Satpati, SO/H, UED” on top of the envelope, Sealed offers should reach the undersigned on or before **DUE DATE: 27.11.2020 TIME: 1600 HRS.** Offers must be sent by INDIA POST (normal, speed etc.) only.

The scope of work, quantity and technical specifications are as given below:

1. SCOPE OF WORK

- i. Design, fabrication, supply and installation of Box type resistance heating high temperature furnace along with its all accessories as per technical specification given in Annexure – A, attached herewith.
- ii. Supply of all suitable sensors needed for the safe operation and control of the furnace, even if it is not mentioned in the annexure.
- iii. Drawing and manuals of furnace with all auxiliaries should be submitted by the vendor at the time of delivery/handover as mentioned in annexure.
- iv. All the fabrication work to be done only after the submission of drawing/QAP of furnace and auxiliaries and obtaining approval from BARC.
- v. Vendor should submit final dimension of furnace for BARC approval. Head room of installation site is 2.5 m. Installation site: 1500mm x 1200mm x 2500mm H.

- vi. Installation of the furnace is in the scope of the vendor and demonstration of coil replacement has to be given by the vendor at the time of installation.
- vii. As applicable, Thermal Fuse protection of the furnace should be provided.

2. ITEMS AND QUANTITY

| Sr. No. | Description | Qty |
|---------|--|----------|
| 1. | High Temperature Electrically heated resistance Furnace System | 1 Set |
| 2. | Graphite reactor of GLMS Grade 1.732gms/cc | 4 nos. |
| 3. | SPARES | |
| 3.1 | Heating coils with coil holders | 1 set |
| 3.2 | Thyristor unit | 1 set |
| 3.3 | B-type duplex Themocouples | 02 nos. |
| 3.4 | PID controller | 01 no. |
| 3.5 | Safety controller | 01 no. |
| 3.6 | Recrystallised Alumina tubes with length 350 mm, OD as per thermocouple OD | 05 nos. |
| 3.7 | Alumina tubes for Ar gas purging | 1 set |
| 3.8 | Digital pirani gauge | 1 set |
| 3.9 | Vacuum pump oil | 1 charge |

The detailed technical specifications of the entire equipment/system is provided in Annexure-A.

Meaning of “set” in spares is as required and provided in furnace system.

- 3. Supplier’s scope:** All the materials to be used for complete system are in supplier's scope. Supplier should be ready to accommodate minor modifications if required, after inspection at no extra cost. The supplier shall dispatch the equipment only after obtaining clearance from the purchaser. Fabrication and inspection/testing should be done as per BARC approved QAP only. QAP should be prepared and submitted by the vendor immediately after accepting the work order to BARC for approval.

4. CONFIDENTIALITY CLAUSE

- 1) **Confidentiality:** No party shall disclose any information to any third party concerning the matters under this contract generally. In particular, any information identified as “Proprietary” in nature by the disclosing party shall be kept strictly confidential by the receiving party and shall not be disclosed to any other third party without the prior consent of the original disclosing party.
- 2) **“Restricted information” categories under section 18 of the Atomic Energy Act., 1962 and Official Secrets” under section 5 of the Official Secrets Act 1923:-** any contravention of the above mentioned provisions by any contractor, sub-contractor, consultant, advisor or the employees of a contractor will invite penal consequences under the aforesaid legislation.
- 3) **Prohibition against use of BARC’s name without permission for publicity Purposes:-** The contractor, sub-contractor, consultant, advisor or the employees engaged by the

contractor shall not use BARC's name for any publicity purpose through any media like press, radio, TV or internet without prior written approval of BARC.

5. INSPECTION AND TESTING

Inspection will be carried out as per approved QAP and technical specifications of the system, Annexure – A.

6. Documentation:

Original and two copies (total 3 nos.) of bounded volumes comprising of all approved documents should be submitted along with the material supply:

- i. QAP
- ii. GAD and component drawings
- iii. Final technical specifications / catalogues of components and system
- iv. Material Testing and calibration certificates/reports
- v. Inspection reports
- vi. O&M manuals for the system including all components like PIC controllers, safety controllers, thyristor modules, panels, furnace etc.

7. Free Issue Material: Not Applicable

No items shall be supplied by BARC and the sole responsibility of procurement of the items rests on the vendor/supplier. However, material storing site, water supply, electricity, light material handling facilities will be made available as required during installation and commissioning at BARC site.

8. PRICE: Offered cost shall be valid for the entire scope of work (materials, fabrication, supply, Installation, taxes, packing & forwarding, transportation etc). Maximum possible break-up price (item wise, spares, transportation, installation, applicable levies etc.) should be given in the offer.

9. VALIDITY: Offer should be firm and valid for **next three months** after due date.

10. TAX: As applicable (Govt. procedure to be followed) shall be indicated clearly and separately.

11. GST Exemption certificate: GST exemption certificate for the work will be provided by BARC on request, which shall be clearly indicated in the offer.

12. GUARANTEE: To give guarantee for complete material and workmanship for at least one year after commissioning at BARC site.

13. COMPLETION PERIOD: 6 weeks from the date of the releasing and acceptance of the work order. The work completion schedule should be strictly adhered with. Any delay which is attributable to the contractor is liable for penalty @ 0.5% per week (max 5 %, or as applicable) on total work order value. In case extension in work completion period is required, request for it with proper and valid justification is to be sent to BARC positively before the expiry of work completion period.

14. INCOME TAX: Income Tax @2% and surcharge, cess on tax or as applicable shall be deducted from vendor's bill.

15. PAYMENT: No advance payment will be made. Full payment will be made by ECS on satisfactory completion of the works.

100% payment including taxes will be made after delivery of material and completion of work and submission of following documents: (a) Delivery Challan (b) Original bill (c) Advance stamped receipt (d) Guarantee Certificate (e) ECS Mandate form (f) GST Undertaking and (g) cancelled cheque.

16. OTHER CONDITIONS:

1. The party should mention their **PAN Number, GSTIN number and HSN code** while submitting the quotation. Failing of the same their quotation will become liable to be rejected.
2. Quotation should be sent by registered/SPEED post only in sealed envelope addressed to **Head, Uranium Extraction Division, BARC, Trombay, Mumbai 400085.**
3. All quotations should be superscripted with (i) the subject, (ii) Tender no., (iii) due date on the top of the envelope.

(S.K. Satpati)
SO/H, Ph. No.: (022) 2559 4550
(For & on behalf of The President of India)

Annexure – A

I. TECHNICAL SPECIFICATIONS

High Temperature box type electrically heated resistance Furnace with MoSi₂ Heaters and maximum Operating Temperature with **1800°C** with a ramp rate of **10°C/min** (minimum) and B-type thermocouple (min. 2 nos.) with vacuum (2-stage rotary pump of suitable capacity) and Ar purging facility (both) of reactor inside furnace.

1. Main Furnace Body: The main furnace body should be made of mild steel casing suitably reinforced to give a rigid structure, the thickness of steel sheets used has to be minimum 6 mm and the channels and angles should be strong enough to carry the load of the furnace. Furnace must be coated with a double coat of high temperature resistant aluminium paint.

All electrical cabling should be done with proper cable trays. All the cables from the heaters, thermocouple etc. should be neatly terminated in a powder coated junction box. The incoming cable for the furnace panel is in the scope of BARC.

Installation of all the cables from the furnace to the control panels and power panels are in the scope of the vendor. The cable sizing should be done on the basis of the switch gear used in the panel.

Furnace should be covered with an outer perforated powder coated shell to cover the element terminals etc.

- a. **Maximum Chamber Size:** 500 mm (L) X 500 mm (W) X 750 mm (H); to be made according to the size of the reactor as described. (Effective hot zone inside the furnace = Maximum dimensions of crucible = 400 mm dia. x 600 mm height)
- b. **Furnace atmosphere:** Air
- c. **The maximum weight of the charge and reactor to be loaded** inside the furnace is 100 kg (approx.)
- d. The furnace will operate as a **single zone furnace**.
- e. Furnace heat loss should be kept minimum possible. External wall temperature of the furnace should not be more than 50 deg. C.
- f. **Desired ramp rate: 10°C/min or higher throughout the operating range of the furnace.**
- g. **Maximum operating Temperature: 1800°C**
- h. **Power Rating:** To be decided by the vendor as per our required technical specification (~65 KW), should be designed based on furnace specification as given.
- i. Distance between the furnace and the control panel for instrumentation cable is 50mtrs.
- j. Distance between the furnace and the transformer is 15mtrs.
- k. The furnace front door should be of double swivel type hinged on suitable high temperature bearings. The furnace door would initially traverse forward/reverse and later traverse horizontally. This would give adequate insulation projection into the furnace to keep the door at low temperatures. A view port should be provided on the front door of the furnace for inspection of the sample inside the furnace.
- l. The insulation should be such that to completely seal the door and provide good thermal insulation. The door operation should be in interlock with the heating. Leak tightness should be ensured.

2. MoSi₂ Heating Elements: Suitably rated Molybdenum di-silicide heating elements should be provided on either side of the chamber vertically. The heating elements should be of high

density with superior quality so as to work up to temperature of 1800°C on continuous basis. All the clamping of the heaters should be done on the roof of the furnace. All clamps used should be made of high-quality stainless steel with high current rated aluminium flexible braids interlocked into the clamps. The clamping ceramic holders should be made of minimum 98% alumina content. The braids should be connected using spring washers etc. onto copper buss bars located on the roof of the furnace. All buss bars are to be mounted on high temperature porcelain holders on the roof. The outer roof of the furnace is to be covered with a steel shell which would be perforated to allow air circulation for cooling the top of the furnace.

3. Refractory Lining: The furnace should be lined with suitable refractory lining to work up to a temperature of 1800°C. The refractory lining should be a suitable combination of ceramic fibre boards and high alumina bricks. The hearth (floor) of the furnace should be lined with high alumina bricks so as to take abrasion and take on the weight of the charge. The **side walls** should be a minimum thickness of **225 mm** and the **roof** will be a minimum thickness of **200mm**. Thermocouple should be provided on the top of the furnace from the roof. The insulation design should be such that the outside skin temperature should not exceed 50°C.

4. Reactor / Crucible: The reactor material suitable for the working temperature range is in the scope of the vendor. Suitable lining may be provided on the inside to prevent reaction between charge and the crucible material. A cylindrical-conical-cylindrical type reactor, with top diameter in the range 330-370 mm and bottom diameter about 100 mm and overall height 380-570 mm with suitable tight-fitting lid for leak tightness is required. The detailed drawing will be furnished by the indenter after placing the order.

As the furnace atmosphere is air, suitable inlet and outlet connections to this reactor vessel must be provided for evacuation as well as inert gas purging. The entire heating operation is to be carried out under flowing argon atmosphere, with a flow rate about 4-5 lit/min.

5. Thyristor Drive: Phase Angle Firing Thyristor Drive along with PID Controller of Eurotherm/Silcarb or any equivalent make, should be provided along with furnace to maintain the temperature of $\pm 1^\circ\text{C}$ of the set value. The Thyristor drive should be firing onto a Dry transformer (Low Tesla Transformer). The Thyristor drive should be specially designed for MoSi_2 heating elements application where the resistance of the heater is inversely proportional to the temperature of the heater.

The Thyristor drive will have an inbuilt current limit as well as a separate voltage limit pot. Current rating of the drive would be suitably overrated by 30% to have a sufficiently big heat sink to keep the diodes in safe operating temperatures. Fast acting fuses would be provided onto the drive to safeguard the modules. All modules will be from Semicron. The thyristor drive should be in a single module.

6. Thermocouple: B-Type Duplex Thermocouple of Pt30%Rh–Pt-6%Rh of a minimum length of 330mm should be used in the furnace. The gauge of the B-type thermocouple would be a minimum 0.3 mm. The thermocouple would be covered in a high alumina tube of minimum 99.70 percent alumina capable of operating up to 1800°C without deforming. We require 02 nos. B-type duplex thermocouples for PID control and safety control as a part of furnace system.

7. Control Panel Cabinet: Design, fabrication, supply and installation of Low Tesla transformer and control panel for controlling temperature in the furnace.

All electrical components will be housed in a powder coated stand-alone cabinet. The panel will house a main switch fuse unit which will isolate the electrical from the incomer. The panel

will consist of a PID controller which will give an output of 4-20mA to the Thyristor drive to feed the power to the heaters. The panel will also consist of vacuum pump control (Start, Stop, and Emergency Stop). The panel should also indicate the vacuum level.

The input will be from the thermocouple. Panel will have ammeters, voltmeter, and a heater on/off switch. The transformer will be housed in the same cabinet as the Thyristor drive. All connections between the Thyristor drive and the transformer will be done using electrical grade copper buss bars. Control panel specifications are as under:

- a. Input for the panel is 3Ph, 415V
- b. The panel should be powder coated and oven dried.
- c. The heating operation is to be interlocked with the door position, limit switches for the same are in the scope of the vendor.
- d. Blind controller for the safe operation of the furnace should be provided.
- e. Blind controller should be compatible with the sensor used.
- f. Temperature sensors should be duplex B type thermocouple.
- g. The furnace temperature control should be PID control.
- h. Temperature recorder for monitoring the profile should also be provided.
- i. The line diagrams, wiring diagrams and GA drawings have to be prepared and fabrication should be done after approval.
- j. Manual for all the controllers, sensors and panel should be provided at the time of handover.
- k. Ammeter, voltmeter and energy meter should be provided on the panel.
- l. The panel should have indication of heating ON/OFF and R Y B indication.

Note: All the electrical components of the control panel should be of reputed make viz. L&T, MECO, SUDARSHAN, SALZER, SIEMENS, LEGRAND, SCHNEIDER, ZENITH, SIGMA, TOHO, MAXAIR, EIC, JAINSON, PASSOLITE.

8. Cabling and bus bar installation:

All necessary cabling including for high current from the panel to the furnace are in the scope of the vendor. If the current rating is more than 200Amps, insulated copper bus bars should be used in place of cables. All the instrumentation cabling that involves low voltage signal, shielded cable with PVC coating should be used. All other power cable to be installed should be armored PVC cable or suitable capacity. Customer will provide the main incoming cabling into the panel board.

- a. Electrical grade copper bus bar with minimum 5 mm thickness should be used between the transformer and the furnace.
- b. The bus bar should be properly insulated and clamped to the fixed surface.
- c. FRLS shielded cable should be used for all low voltage signals like thermocouples.
- d. The thermocouples should be industrial type with high temperature insulation. The length of the thermocouples should be sufficient to measure the temperature of the reactor vessel placed inside the furnace.
- e. All accessories for the installation of the cable, including supports, saddles, lugs gland etc are all in the scope of the vendor.
- f. The cable should not be saddled directly on the wall; necessary support structure has to be provided for the cable.
- g. If a sub-contract for the same is issued it will be solely the responsibility of the vendor to ensure the job is done as per BARC standards and requirement.
- h. All the cables supplied by the vendor, for the furnace, should be FRLS, and proper test certificate for the same should be submitted.
- i. All the cable should be metal armored.

- j. Supply and installation of thermocouple cable from the control panel to the furnace and from the furnace and to the centralized control room.
- k. All the installed cables should be properly labeled and should have clear reference in the approved drawing.

9. Vacuum & Ar purging System: Design, fabrication, supply and installation of Ar purging system as well as vacuum system (Both arrangement), and its accessories for reactors in the furnace. System will be designed so that internal flushing (inside the reactor) can be done for different sizes of graphite reactors. The system will include entire vacuum system including pumps, filters etc. for the reactor. System will be designed so that change from vacuum to inert atmosphere inside the reactor can be done smoothly and easily.

The vacuum system should be provided with a two stage rotary pump of suitable capacity. The pump should be from reputed manufacturers. The rotary pump should be provided with accessories viz. fore-line trap, dust pre filter, inlet moisture trap (silica gel type with metallic body) and outlet oil mist filter.

1. Vacuum Plumbing Lines:

The vacuum plumbing lines should be fabricated out of stainless steel SS-304 with necessary bellow adaptors to arrest vibration.

2. Direct Drive Rotary Pump: 1 no.

Double stage Direct Drive Rotary Pump should be having quiet & vibration free operation. It should be compact & light weight, effective gas ballast, low oil charge, air cooled & high-water vapour handling capacity with free air displacement.

- a. Capacity : 250 lpm (15 m³/hr)
- b. Ultimate vacuum when measure on a McLeod Gauge with Gas ballast closed: $>1 \times 10^{-3}$ mbar; and when opened: $>5 \times 10^{-2}$ mbar
- c. Inlet Connection: KF 25
- d. Motor
- e. Single Phase: ½ hp
- f. A compound gauge of 4" dial having a measuring range from -1 to 0 to 2 bar (absolute) should be provided on the furnace chamber to measure the initial rough vacuum and pressure
- g. Stabilized Digital pirani gauge with two pirani gauge heads is provided to independently monitor the roughing and backing pressure. Vacuum in the job or pipeline can be seen on the gauge display using a selector switch. This pirani gauge can measure vacuum level from atm. to 0.001mbar.

10. Other Important Points:

- a. Element rating 1900°C will be of Kanthal or Silcarb or equivalent reputed make (BARC approved) with original manufacturer test certificate need to be produced.
- b. Furnace will be capable of operating continuously under oxidizing atmosphere in 1800°C. While the graphite reactor is under inert atmosphere (argon), the external of the graphite reactor will work under oxidizing atmosphere.

11. Standards to be followed:

- i. Control panel protection – IP 54 or higher
- ii. Panel wiring and cabling should be as per I.S-692, IS-7098, IS-1554 (Part-I) 1964 and IS 694-1990 or latest.
- iii. Furnace fabrication should be as per IS 15562

iv. Furnace refractory should be as per ASTM F1312, IS 1528.

12. Inspection and Testing:

- a. All major materials used for the equipment should have test/performance certificates.
- b. The furnace is to be tested for full design temperature for the full time period of 60hrs as mentioned in the technical specification (without reactor or Process Heat load) at the time of inspection/testing at vendor site as well as after installation and demonstration at BARC site.
- c. The furnace system will be tested with the required Heat load as actual during commissioning at BARC site.
- d. Uniformity of the temperature inside the furnace should be assured.
- e. Vacuum / Ar purge line should be qualified for leak-test at min. 60 mm Hg (g) with holding time min. 30 mint.
- f. All the features of the control panel i.e. alarms, set points; interlocks will be tested at the time of installation and demonstration at BARC site; and should be up-to the satisfaction of the user.
- g. The coil resistance, current in each zone should be as per the BARC approved design document submitted prior to the fabrication of the furnace.
- h. Certificate for the furnace casing material, coil material and their composition. Calibration certificate of all instruments and recorders.
- i. The vendor has to make the furnace as per the approved drawings.

13. Warranty: At least 12 months after commissioning.

14. End-Use-Certificate / inspection: *Not Applicable and available for system and components.*

15. Tender/Offer acceptance Criteria: This should be submitted as check list separately along with the offer with remark, if any **variation:**

- a) Complete technical details of the equipment being offered along with the basic sketch of the conceptual furnace indicating approximate dimensions should be furnished.
- b) Material specifications of various fabrication and bought out items should be provided viz. Basic details of the pumps, gauges, electrical items with details of make etc.
- c) Quotation /offer should be submitted as per technical specification (Annexure – A) and tender of the furnace system. The all bought out material should not have any compatibility issue.
- d) List of customers to whom similar high temperature furnaces have been supplied especially to DAE / Govt. organizations along with company profile and capability supporting document (facilities for drawing, fabrication, testing, demonstration etc.) should be submitted.
- e) Work completion period should be strictly 6 weeks.
- f) The furnace dimensions should not be larger than 1500mm x 1200mm x 2500mm

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Quotations submitted without the above details are not likely to be considered for evaluation. The purchaser shall have the right to visit and evaluate fabrication facilities of the supplier and his sub-contractors especially coil manufacturer.

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