SECTION 'C'

TECHNICAL SPECIFICATIONS OF STORES AND DRAWINGS

Fabrication, supply, installation and vacuum testing of Ultra High Vacuum Transmission line (VTL) system along with support structure as per detailed specifications and drawings

Contents:

1.0 INTRODUCTION: In ADITYA-U machine it was proposed to increase the ICRH power level from the present 200 kW to up to 500 kW. For this it was decided to use two separate ICRH transmission line and antenna system to inject power from two separate locations (R15 and R20 ports) of the ADITYA-U machine. The ICRH antenna, which is placed inside the vacuum vessel is fed by a vacuum transmission line (VTL) section which provides smooth transition, line feeding and translation of the antenna. This is essentially a ultra high vacuum (UHV) system which is isolated from the ADITYA-U vacuum with the help of vacuum window. UHV is required in the VTL because of the presence of large number of non-standard RF components, decreased inter-conductor distance and presence of a number of triple points due to use of ceramic supports. The VTL is a very high SWR section, which makes it vulnerable to high voltage breakdown. Presence of vacuum inhibits the breakdown mechanism.

The VTL section consists of two conductors (coaxial) for RF transmission. The RF electrical current flows on the outside surface of the inner conductor (IC) and inside surface of the outer conductor (OC), hence these surfaces require to be smooth, without any discontinuity or sharp edges or transitions in diameter. Sharp edges in these surfaces increases RF electric field and makes it vulnerable to voltage breakdown. The coaxial line is electrically isolated from the vacuum vessel by another vacuum enclose with a ceramic based DC break in between. An edge welded bellow facilitates axial motion of the VTL. The bellow, ceramic disks or supports are available at the IPR and will be provided during site assembly and acceptance.

The detailed design of VTL layout, detailed engineering drawing of all the components are provided here as built to print. The vendors are requested to study it in detail and offer best of their quotations. Any modification in this built to print design if suggested by the vendor MUST be discussed with the IPR and get it approved, since the present system is designed for high

power RF application and any unwarranted modification / alteration may inhibit RF power transmission at high power. The vendor is supposed to be competent enough to deal in UHV component fabrication, handling and testing and does not necessarily required to have an expertise in high power RF transmission technology.

Please note that the indented item is not a commercial item and is intended solely for scientific and research purpose. It is understood that vendor may experience some technical difficulties during fabrication, assembly and testing due to its non-mainstream in nature. Hence the vendor shall be provided technical help during all the stages and our knowledge shall be shared unhindered. It is understood that a sincere mutual cooperation between scientific laboratories and industry can be beneficial for technological advancement in India. Please read this document and drawings carefully and offer your best and competitive quotation.

2.0 SUB-SYSTEM, ITEMS TO BE PROCURED IN THIS WORK CONTRACT

Sr.	Description of Items	**Quantity**
1	Fabrication, testing and supply and installation of vacuum testing of Ultra High Vacuum Transmission line (VTL) system along with support structure as per detailed specifications and drawings mentioned in our enquiry	**2**

3.0 SCOPE OF WORK

3.1. Fabrication [Following is for each of the unit of VTL system]

1	Material	SS304L non-magnetic, UHV compatible , without defects, porosity, impurities etc.
2	Pipe	Seamless
3	Dimensions	as per drawing attached
4	Surface smoothness	better than ∇∇∇ (R_a < 0.8 μ) for inside surface of outer RF conductor and outside surface of inner RF conductor, Standard IS:3073-1967/March 2006 or better to be followed
5	End flanges	Standard and non-standard CF type with metal gasket as per drawing.
6	Welding	All flange joints shall be argon arc welding (TIG) welded from inside. They shall be machined and polished for the required smoothness. Trapped volume should be avoided. Full penetration welds shall be employed.
7	Circlip for Inner Conductor Joints	The component (Drawing no IPR/VTL/A1/16/4026, sheet 9/12, VTL_IC, Part no# 3 & 4, 5 & 6) should be tight fit by hand.

		Required SS304L circlip to be provided for ensuring good RF contact between them
8	Smooth transition	No sharp edges and abrupt transitions are acceptable. All sharp edges in RF path to be rounded off. The step reducers (Drawing nos # IPR/VTL/A1/16/4026, sheet 9/12, VTL_IC, Part 2/3 and 6) and (Drawing nos # IPR/VTL/A1/16/4026, sheet 8/12, 9VTL_IC, Part 2) to be smoothen out on the RF conducting surface by suitable method. Vendor shall propose and get it approved during drawing approval stage.
9	Perspex Acrylic	Perspex ring and disk (Drawing no # IPR/VTL/A1/16/4026, sheet 4/12-part 2, sheet 6/12-part 3, sheet 2/12-part 4) shall be fabricated and used for leak test and UHV test during factory acceptance test. They will be replaced by original ceramic disks (to be provided by IPR) during the site acceptance test.
10	Support structure	A suitable support structure made of T slot aluminum extrusion channels for supporting VTL to be made as per drawing.
11	CF gaskets	Four sets of matching standard/non-standard copper, Aluminum and Viton gaskets (one set for each type) for all the CF joints to be provided during shipment. One set shall be used at site acceptance test. Required sets (at least 2) of copper gaskets to be prepared extra for factory acceptance test by the vendor. All the gaskets should be prepared as per the respective knife edge as detailed in drawings.
12	Viton O-rings	Four sets of matching Viton O-rings to be provided during shipment. One set shall be used at site acceptance test. Required sets (at least 2) to be prepared extra for factory acceptance test by the vendor. Viton O-rings should be of UHV standard and bakeable up to 150 deg C.
13	Matching nuts, bolts and washers	: Matching Nuts, bolts, washers (spring + Flat) two sets to be supplied during shipment. The fasteners shall be made of SS 304 L/ 316. Vendor may prepare extra set for factory acceptance test,
14	Nylon Bushing assembly	Two sets of Nylon bushing for electrical isolation for component (Drawing no # IPR/VTL/A1/16/4026, sheet 4/12 part 4,5) to be shipped.
15	Heat treatment	All the components should be baked in an inert atmosphere (Nitrogen gas purging), to a temperature of 400 deg.C for 4 to 8 hours after welding for stress removal and for gas desorption from the surfaces. After baking, components are required to be checked for any deformation/distortion if any, before going for final machining.
16	Electro-polish and Ultrasonic cleaning	Standard procedure as defined in section 4.3

3.2. Factory acceptance test

1. Individual components shall be tested for
    a. Dimensional check as per drawing
    b. CF gasket matching test
    c. Viton O-ring check
    d. Surface roughness test by surface profile meter (provided by vendor)
    e. Relative Magnetic permeability test < 1.03 (μ/μ_0), if not available to be done at SAT

2. Each component having CF joints shall individually tested for
    a. Leak rate test by Helium (He) leak detector (provided by vendor) .
    b. Less than $1x10^{-9}$ mbar.l/s for all CF joints, weld joints and body.
    c. Oversized plastic bags to completely enclose the component for global leak rate test to be provided by the vendor
3. Dummy assembly of all the components shall be carried out to rule out finer compatibility issue.
4. Vacuum sections shall be tested for UHV test for an ultimate pressure < $1x\ 10^{-8}$ mbar.
5. The system shall be baked up to 150 deg C with the help of baking tapes, wrapped by fiber clothes and temperature sensors. All the required instruments including Vacuum Gauge, TMP, Rotary and all accessories for the test to be provided by the vendor.

3.3. Site acceptance test

1. The components shall be shipped with adequate packaging safely to IPR and shall be tested.
2. Individual components shall be tested for
    a. Dimensional check
    b. CF gasket matching test
    c. Viton O-ring check
    d. Relative Magnetic permeability test < 1.03 (μ/μ_0)
3. Each component having CF joints shall individually tested for
    a. Leak rate test by He leak detector (provided by IPR) .
    b. Less than $1x10^{-9}$ mbar.l/s for all CF joints, weld joints and body.

4. Assembly of all the components with actual ceramic rings, disks, supports etc. shall be carried out.
5. Vacuum section shall be tested for UHV test for an ultimate pressure < $1x\ 10^{-8}$ mbar. Vacuum Gauge, TMP, Rotary and all accessories for the test to be provided by the IPR.
6. The complete installation and testing shall be supervised by the IPR representatives and all the required assembly and tests shall be carried out by vendor.
7. The complete system shall be checked for electrical continuity (< 0.1 Ω) separately for outer conductor and inner conductor.
8. The complete system should be electrically isolated from its support structures by G10 composite laminate sheet with Teflon/ Nylon bush at the support location to be supplied by the vendor. The DC electrical isolation across the DC break and w.r.t. support shall be tested for 10kV by megger (provided by IPR).

4.0 WORKS PROCEDURE /GUIDELINES

4.1. Drawing and verification

1. The vendor should study the detailed drawings provided and generate fabrication / shop floor drawings. Any suggested modification in drawings and detailed fabrication procedure MUST be discussed with IPR and final approval MUST be taken before fabrication. Soft copy of drawing submitted herewith may be provided to successful bidder upon request at the sole discretion of IPR.
2. All the final drawings should be submitted to IPR both in soft copy and hard copy.

3. Material test certificate from Govt. Approved laboratory must be submitted before fabrication. Relative Magnetic permeability test < 1.03 (μ/μ_0) for sample from same batch should also be sent to IPR.
4. IPR representatives reserves the right to visit with prior intimation and inspect the progress of the job.
5. A final Factory acceptance test (FAT) at factory shall be carried out before shipping.
6. All the components should be properly packed and transported to IPR's premises and special care should be taken to avoid contamination of vacuum surfaces or damage to CF knife edges.
7. All the knife edges should be protected by gaskets and end flanges should be covered with plastic cap.

4.2. Fabrication

1. The vendor shall procure all the raw materials and obtain material test certificate from Govt. approved laboratory.
2. All raw materials should be surface cleaned for removing oil / grease before fabrication process to avoid contamination.
3. All the inner conductor pipe should go tight fit with the IC joint for very good electrical contacts.
4. All the sharp edges on RF current surface should be adequately rounded off.
5. All the vacuum components shall be adequately cleaned with Acetone / Isopropyl alcohol to remove any dust, finger spots, oil, adhesives etc. This is required to obtain UHV during testing.
6. The individual components (Sr# 1 to 5 of Table 1) should be super scribed with a component name tag (Metal tag, size approx. 1cm x 6cm) as per the drawing table submitted. The vendor may put only one sticker of his company name in the VTL system / Support with a size not exceeding 3cm x 10 cm.
7. Where ever blind tapping are made, corresponding bolts should have slot to pump out trapped gases. Slot should be of 1 mm wide by 1 mm deep along the length of the bolt.
8. Interruption during welding should be reduced to minimum possible extent.
9. All welds should be ground smooth and flush with adjoining surfaces with convex curvature with adjoining wall everywhere.
10. For two matched flanges of adjacent components, holes should be drilled together in order to avoid error in PCD making.
11. Tolerance should be strictly followed as given in the drawings.
12. Uniform gap within ± 0.1 mm is required between three concentric parts i.e. inner conductor, outer conductor and outermost conductor.
13. Fixtures should be used during welding, machining and heat treatment to avoid ovality to the conductors.
14. Radiography test shall be carried out on all weld joints.

4.3. Post-fabrication Cleaning for UHV compatibility

All the SS304L components shall be cleaned and treated for UHV compatibility as per the following procedure.

1. All the tapes, adhesives, inks should be removed with acetone
2. Components should be cleaned with water.
3. They should be cleaned with mild nitric acid 5% V/V (HNO3) followed by cleaning with water.
4. Components should be cleaned with detergent followed by de-mineralized water.
5. Electro polishing should be done for every component for surface finish (Electro polish electrolyte and current/time shall be confirmed by the vendor).
6. After electropolish they should be rinsed in de-mineralized water immediately followed by rinsing in mild alkali solution like NaOH .
7. Cleaning with de-mineralized water should follow.
8. Ultrasonic cleaning in trichloroethylene (Power and duration shall be confirmed by the vendor) followed by cleaning with de-mineralized water.
9. Drying with hot air shall be done.
10. Pack with aluminum foil or plastic bag**.**

5. INFRASTRUCTURE AND EQUIPMENTS AVAILABLE AT SITE

1. Vendor may use some of the facility at IPR's site without any cost subject to availability and as per rules.
2. Crane with 5T load capacity to move, position VTL sections and components.
3. Equipment to test electrical continuity and isolation.
4. Upright drill machine 20mm for minor job which require in situ modification.
5. He leak detector, TMP, Rotary, vacuum gauge, He cylinder and spray pistol, hose pipes and connectors.

6. MATERIAL TO BE PROVIDED BY IPR

1. IPR will provide following components (of 99.5% Al2O3 ceramic) at IPR during the site acceptance test. However, the vendor shall fabricate those components made of Nylon/ Perspex as per given drawing for Factory acceptance test.
    a. Ceramic for DC break (Drawing no# IPR/VTL/A1/16/4026, Sheet 4 of 12, part 2 , Component name # VTL_03_DC_CER)
    b. Ceramic disk for vacuum window (Drawing no# IPR/VTL/A1/16/4026, Sheet 6 of 12, part 3, Component name # VTL_05_VW_CER)
    c. Ceramic coaxial support (Drawing no# IPR/VTL/A1/16/4026, Sheet 2 of 12, part 4, Component name # VTL_01_OUT_CER)
    d. Edge welded bellow assembly with end flanges (Drawing no# IPR/VTL/A1/16/4026, Sheet 3 of 12, complete component, Component name # VTL_02_BL)
    e. Brass I/C finger joint (Drawing no# IPR/VTL/A1/16/4026, Sheet 9 of 12, part 7, Component name VTL_IC_01_ICJ3)

7. PERFORMANCE GUARANTY

1. The vendor shall guarantee for a period of ONE year from the date of acceptance,
    a. the quality of material provided and certified copy of material test certificate from Govt. approved test laboratory.
    b. Mechanical integrity of the assembled system
    c. Weld joints for all the flanges for leak tightness
    d. Leaks from metal body due to material defect or porosity.

8. DELIVERY AND INSTALLATION SCHEDULE

1. The FAT, Delivery at IPR and SAT shall positively be finished within FOUR months from the date of PO. The vendor MUST consider this schedule to expedite.
2. SAT can be started immediately after the delivery at IPR.

3. The vendor MUST bring all the equipment and accessories/tools required for assembly and test except that have been mentioned in sr. 5& 6. All other specialized tools and accessories shall be brought by vendor. This list must be finalized before coming to SAT to avoid any delay.

9. ELIGIBILITY CRITERIA:

1. Bidder must be established in India for last 5 years from the date of publication of this tender.
2. The bidder should be a fabricator/manufacturer of medium to big sized (1 L to 500 L) UHV components and chambers of SS304, SS304L etc. The bidder should have expertise of fabricating, handling and testing of different size of CF flanges (35 CF to 200 CF) including non-standard flanges.
3. Bidder should have his own workshop with facility or access to facility of CNC, milling, facing, welding, brazing etc.
4. The bidder should have He leak detection facility with leak rate that can be measured less than 1E-9 mbar.lit/sec.
5. The bidder should have facility or access to surface roughness measurement to qualify the component.
6. Vendor must have executed similar type of works with a single Purchase Order of minimum Rs.25 lacs and above in the past 3 financial years. (2012-13 to 2014-15).
7. Bidder should have average annual turnover of at least Rs.90 Lacs for last 3 financial years (2012-2013 to 2014-2015).

Annexure I

List of Enclosed Drawings & Related Notes

Table-1

Sr.	Drawing Number / Part No.	Description
1	IPR/VTL/A1/16/4026, sheet 2/12, VTL_01_OUT	VTL Outermost Conductor assembly
2	IPR/VTL/A1/16/4026, sheet 4/12, VTL_03_DC	VTL DC Break assembly
3	IPR/VTL/A1/16/4026, sheet 5/12, VTL_04_OUT	VTL Outermost conductor assembly
4	IPR/VTL/A1/16/4026, sheet 5/12, VTL_05_VW	VTL Vacuum Window assembly
5	IPR/VTL/A1/16/4026, sheet 7/12, VTL_06_OC	VTL Outer conductor assembly
6	IPR/VTL/A1/16/4026, sheet 8/12, VTL_OC	VTL Outer conductor assembly with a step reducer
7	IPR/VTL/A1/16/4026, sheet 9/12, VTL_IC	VTL Inner conductor assembly. Note: part 7 (VTL_IC_01_ICJ3) to be supplied by IPR during SAT
8	IPR/VTL/A1/16/4026, sheet 10/12, VTL_IC	VTL Inner conductor detail part drawings of the assembly in Sr#7.
9	IPR/VTL/A1/16/4026, sheet 11/12, VV_RP	Vacuum Vessel Radial port assembly
10	IPR/VTL/A1/16/4026, sheet 12/12, VV_RP	Vacuum Vessel Radial port detail parts
11	IPR/VTL/A1/16/4026/1, sheet 1-4, ADITYA-U_ICH_VTL_ASSY	VTL Support structure