Technical Specification Document for Procurement of Basic Symmetric Chamber (BSC) and Horizontal Access Module (HAM) Chamber

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Manufacturing /Fabrication, Testing and Supply of Basic Symmetric Chamber (BSC) and Horizontal Access Module (HAM) Chamber

Technical Specification Covering Scope of Work

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1. Introduction

Laser Interferometer Gravitational-Wave Observatory (LIGO), INDIA is a large-scale physics experiment for the detection of gravitational waves. LIGO detector is a modified Michelson Interferometer having in each perpendicular arms of 4-km length a pair of Fabry-Perot cavity to detect ripples in space with sensitivity less than or equal to 10-24 per square root Hz.

LIGO-India is a collaborative project between LIGO USA and Department of Atomic Energy (DAE) & Department of Science and Technology, Govt. of India, for establishing an Advanced LIGO detector in India. India's major institutes (IPR-Gandhinagar, RRCAT-Indore, DCSEM, Mumbai and IUCAA-Pune) are contributing in installation, commissioning and operation of the Gravitational Wave detector in India.

Institute for Plasma Research (IPR) is primarily responsible for development and procurement of vacuum system for the LIGO-India project. Vacuum system is an integrated system of many vacuum components which comprises of, BSC chamber (6 nos.), HAM chamber (5 nos.) Beam Tube (about 8 km long), Septum plates, Mode cleaner tubes, Spools, Adapters, Baffles, Cryo pump, gate valves and vacuum pumps and associated gauges with controls and instrumentation to control and monitor integrated vacuum system. Entire vacuum

Purpose of BSC and HAM

Basic Symmetric Chamber's (BSC) are used to support core optical components while Horizontal Access Module's (HAM) are used to house auxiliary optics. All major optical components are housed in these two chambers. Both BSC and HAM chambers are provided with demountable cover flanges so that the servicing of the optical components could be carried out whenever needed. These chambers contain seismic isolators and alignment mechanism which support the optical elements and have internal attachment brackets. These brackets will be used to support lightweight optical components. The seals on these cover flanges are designed as double O-rings with a pumped annulus to reduce the gas load due to the permeability of O-rings. A clean air vent and purge system is incorporated to break vacuum and maintain cleanliness of the optical components whenever a chamber is open.

This tender notice is for procurement of prototype one set each of BSC and HAM chamber assembly.

1.1 Basic Symmetric Chamber (BSC) -

'Basic Symmetric Chamber' (referred as 'BSC' hereafter) is a cylindrical metallic enclosure performing the following functions:

- Provide Ultra High Vacuum environment (vacuum better than 1 X 10^{-9} mbar)

- Sustain self-weight, weight of end covers, nozzles & their flanges and operational loads. (Refer Annexure 8)
- Provide the openings for feed-through that are necessary for the attachment of vacuum pump, pressure gauge, Residual Gas Analyzer (RGA), other control instruments installation requirement
- To allow access to inside of the chamber for installation / maintenance and provision for removal of end & upper covers
- **The 'BSC Chamber Assembly' under the scope of this contract includes following:**
    - Basic Symmetric Chamber assembly is made up of upper and lower cylindrical shells, end covers, annulus tubing assembly and its support structure (Refer Drawing VB01-001-R1)
    - BSC support structure (Refer Drawing VB01-002-R1)
    - Lower cylindrical chamber with torispherical dished head (with suitable openings for maintenance access, connection of vacuum pump, and mounting of pressure gauge, RGA, etc.) (Refer Drawing VB01-003-R1)
    - Floor assembly. (Refer Drawing VB01-004-R1)
    - End covers (with suitable openings), detachable from side for mounting as well as for removal of internal components during installation and maintenance phases. (Refer Drawing VB01-005-R1 & VB01-006-R1)
    - Upper cylindrical chamber / cover with torispherical dished head (with suitable openings for mounting pressure gauge and other instrumentations) detachable from top for mounting as well as removal of internal components during installation and maintenance phases. (Refer Drawing VB01-007-R1)
    - Double O-ring flange annulus pumping system (Refer Drawing VB01-008-R1)
    - All the fasteners and required vacuum seals (along with spares mentioned).
    - Spares as specified (Annexure-9)

1.2 Horizontal Access Module (HAM) chamber -

'Horizontal Access Module' (referred as 'HAM' hereafter) chamber is a cylindrical metallic enclosure performing the following functions:

- Provide Ultra High Vacuum environment (vacuum better than 1 X 10^{-9} mbar)

- Sustain self-weight, weight of end covers, nozzles & their flanges and operational loads. (Refer Annexure 8)
- Provide the openings for feed-through that are necessary for the attachment of vacuum pump, pressure gauge, Residual Gas Analyzer (RGA), other control instruments installation requirement
- To allow access to inside of the chamber for installation / maintenance and provision for removal of access & end covers
- **The 'HAM Chamber assembly' under scope of this contract includes following:**
    - Horizontal Access Module (HAM) is made up of cylindrical vessel with specified openings for maintenance access, vacuum pumping, mounting pressure gauge, RGA and optical requirement. (Refer Drawing VH01-001-R1)
    - HAM support structure (Refer Drawing VH01-002-R1)
    - Cylindrical Part (acting as a main chamber) with suitable openings for maintenance access, connection of vacuum pump, and mounting of pressure gauge, RGA, etc. (Refer Drawing VH01-003-R1)
    - End cover big and small (with suitable openings for optical requirements), detachable from side for mounting as well as removal of internal components during installation and maintenance phases. (Refer Drawing VH01-004 and VH01-006-R1)
    - Cylindrical Part (acting as a beam tube connecting port) with suitable openings for connection of vacuum pump, and mounting of pressure gauge, RGA, etc.) (Refer Drawing VH01-005-R1)
    - Double O-ring flange annulus pumping system (Refer Drawing VH01-007-R1)
    - All the fasteners and required vacuum seals.
    - Spares as specified (Annexure-9)
    - Provision for lifting lugs on all parts as necessary to handle and lift them

2. Overall Dimensions of the BSC and HAM

2.1. Overall Dimensions of Basic Symmetric Chamber (BSC) -

Length: 4820 mm, OD of the chamber: 2680 mm

Overall height of chamber from ground to top in vertical assembled condition: 5210 mm

2.2. Overall Dimensions of Horizontal Access Module (HAM) -

Length: 3032 mm, OD of the chamber: 2165 mm

Overall height of chamber from ground to top in vertical assembled condition: 2918 mm

3. The Scope of work

3.1 Study of the design of "BSC" & "HAM" provided with contract document, in the form of technical specifications and drawings to meet functional requirements (with respect to dimensions, surface finish, weld joints, lifting lugs & its locations) listed in table-1 of section-4 and achieve manufacturing feasibility, and propose necessary changes for purchaser's approval.

Vendor shall propose necessary changes from findings of their design study to purchaser with supporting rationale, for review & necessary approval and subsequently incorporate changes agreed & approved by purchaser and ensure fulfilment of the functional requirements. Documents incorporating final approved and agreed changes shall be transmitted to purchaser at appropriate stage.

Vendor shall be responsible to accomplish functional requirements of BSC / HAM, as defined in subsequent section #4 (which relate to surface finish, dimension and geometrical tolerances, welding, leak rates within acceptable limits, cleanliness) and demonstrate realization of ultimate vacuum in BSC and HAM assembly.

3.2 Preparation and qualification (where necessary) of manufacturing drawings, documents related to quality viz. Manufacturing & Inspection Plan (MIP), Quality Assurance Plan (QAP), Manufacturing Process Sheets (MIS), Manufacturing Procedures, Welding procedures, Assembly procedures, Inspection & Testing Procedures (ITP), Cleaning procedure, packing & transportation procedures including handling and lifting details.

3.3 Procurement of all raw material required for the BSC / HAM manufacturing (including material required for pre-qualifications), set of manufacturing tools, jigs & fixtures (covering all manufacturing activities, handling, assembly), inspection (functional &

dimensional), testing (at factory), packing and loading on transportation, unloading and acceptance inspection at delivery site.

3.4 Scope of work includes packing, loading on transportation at factory, unloading and inspection at delivery site. Forwarding and freight shall be addition scope of work and to be paid at actual basis.

3.5 Establish necessary cleaning setup for cleaning (including procurement of the required equipment(s)) of manufactured / fabricated parts of BSC / HAM chamber.

3.6 Manufacture, fabricate and assemble the BSC / HAM Chamber as per approved manufacturing & assembly drawings, MIP and QAP.

3.7 Design and manufacturing of necessary tools, jigs & fixtures required during handling and lifting for entire scope of work is in the scope of vendor. All these custom tools (with related documents) used during scope of work, shall be supplied to purchaser at IPR, Gandhinagar, Gujarat.

3.8 Design, manufacturing, testing and supply of special transportation structure / fixture and necessary tools for handling of the chambers (BSC & HAM) delivered to purchaser's site at RRCAT, Indore.

3.8.1 The design of packing / transportation structure shall be such that it provides access to delivery supplies for lifting by crane at delivery site to equipment.

3.8.2 Vendor shall guarantee the performance of supplied support structure / fixture.

3.9 Make necessary arrangement for the provision of equipment's (vacuum pumps, gauges, vacuum leak detector etc.) during vacuum leak testing and for demonstration of ultimate vacuum for BSC and HAM. (Refer annexure – 6 & 7)

3.10 Manufacture/ procure and supply of blank off - ConFlat (CF) flanges used in vacuum testing whenever it is performed and seal off the chamber at the time of delivery.

3.11 Make provision of flanged connections to mount gauges, pumps and other control instruments during leak testing and vacuum testing of chambers.

3.12 Supply of temporary support structure (which can be dismantled) to store upper and lower parts of BSC, main cylindrical part and covers of HAM, in stable configuration when chamber is opened for inside access during its functioning at delivery site. These structures may be of carbon steel (with isolation at support locations between SS chamber and CS support structure to avoid direct contact).

3.13 Inspection and testing at identified stages before / during / after manufacturing as agreed in approved QAP / MIP included in relevant sections and annexures and drawings.

3.14 Loading, transportation, safe delivery to RRCAT, handling and unloading shall be done in LIGO Lab at RRCAT, Indore. The chamber shall be handled safely to prevent any

distortion. The parts of BSC / HAM shall not be subjected to other additional loads / stresses not mentioned in this specification.

3.15 Supply specific photographs (@ 25 numbers preferably in 250 x 200 mm size); edited video film (approx. of min. 1 hr. duration) covering complete scope of manufacture, inspection & testing of BSC/HAM with commentary to keep the records.

Each stage, from material procurement till final delivery covering scope of work, shall be recorded additionally in digital form of photograph and video. The digital records shall be provided to purchaser on suitable storage media at the end of scope of supply.

3.16 Complete all checks as a part of factory acceptance tests and prepare reports to accomplish the scope of work of this procurement and arrange for delivery: (as detailed in annexure referred against them)

3.16.1 Raw Material testing and certification (Annexure – 1)

3.16.2 Visual and Dimensional inspection (Annexure – 5)

3.16.3 Helium leak test of all sealing joints / location and welds. (Annexure 6)

3.16.4 Demonstration of specified ultimate vacuum (Annexure-7). Vendor shall provide the procedure to be followed for the purpose of this demonstration, for review and approval of purchaser before taking up demonstration

3.16.5 Cleaning inspection *(As per Annexure 4 of this specification)*

3.16.6 Packing Inspection *(As per section 9 of this document)*

3.16.7 Obtain "Shipping Release" from purchaser (or his authorized representative)

3.17 Complete following checks as a part of onsite acceptance after delivery of supplies:

3.17.1 Check for any physical damage to supplied deliveries during transportation

3.17.2 Visual and dimensional inspection to confirm that distortion and dimensions are within acceptable limits

3.17.3 Checking and verification of reading of gauges / impact sensors mounted on the vacuum sealed equipment(s), packing and merchandises delivered

4. Design and functional / operational requirements of BSC / HAM

Functional / operational requirements of chambers (BSC & HAM) are mentioned in Table-1. Vendor after studying design details provided to them with the tender document shall come out with their suggested changes, which will fulfil functional requirements. During evaluation of the tender bids, vendor should present outcome of

their study to convey purchaser on how they will ensure compliance of manufactured items with each of the specified functional requirement. The presentation

Requirement	Value
Design internal pressure	0.12 MPa (1.2 bar)
External pressure	Atmosphere
Operating Internal Pressure	1.0 X 10^{-9} mbar Ultra-High-Vacuum (UHV)
Demonstration of specified ultimate vacuum	1.0 X 10^{-9} mbar Base vacuum in side chamber when pressure gauge is mounted at far end of chamber from pump location
Vacuum level at Interspace/Annulus (between two O-rings)	10^{-5} mbar (to be pumped by ion pump)
Design Temperature	25^{0} C during operation 200^{0}C during baking
Load condition	Refer: Annexure 8
Number of pressurisation / evacuation cycles (during systems operation life	1000 cycles

Table 1: Design and functional requirement

5. Material Procurement

5.1 The material specification requirements for BSC shall be followed as identified in Table-2 and for HAM as identified in Table-3:

Sr. No.	Part name	Material grade
1.	**(a) Upper part**	
	Shell, F&D head	ASME, SA240, Dual grade SS304/304L
	Port	SS304L
	Stiffener & lifting lugs	ASME, SA479, SS304
	Standard ConFlat (CF) Flange	ASME, SA240, SS316L
	Large custom flange	ASME, SA182, Grade F,SS 304L
2.	**(b) Lower part**	
	Shell, F&D head, port (Dia. 1.5 m)	ASME, SA240, Dual grade SS304/304L
	Internal attachment bracket	ASME, SA240, SS304L
	Port	SS304L
	Stiffener, lifting lugs	ASME, SA479, SS304
	Standard ConFlat (CF) Flange	ASME, SA240, SS316L
	Large custom flange	ASME, SA182, Grade F,SS 304L

Sr. No.	Part name	Material grade
3.	(c) Annulus tubing & support	SS304L
4.	(d) Support Structure	ASME, A36 or A500 Gr B Equivalent Indian standard IS 2062
5.	(e) Floor Assembly	ALU SB-308, 6061-T6 & T6511
6.	(f) Fastener	SS 316 Grade A4-70/A4-80 silver plated
7.	(g) O-ring	Perfluoroelastomer
8.	(h) Copper Gasket	Oxygen-Free Electronic (OFE) grade copper (UNS C10100)
9.	(i) **Welding Consumable** Stainless steel to Stainless steel Stainless steel to Carbon steel Aluminum 6061	**Filler Material grade** Stainless steel - SS308L Stainless steel - SS309L Alloy 4043 or 5356

Table 2: Material requirement for BSC

Sr. No.	Part name	Material grade
1.	(a) Cylindrical part (main shell)	ASME, SA240, Dual grade SS304/304L
	Port	ASME, SA240, Dual grade SS304/304L
	Stiffener & lifting lug	ASME, SA479, SS304
	Internal attachment bracket	SS304L
	Standard ConFlat (CF) Flange	ASME, SA240, SS316L
	Large custom flange	ASME, SA182, Grade F,SS 304L
	Bellow & tie rod	SS304L
2.	(b) End Access (Big & small)	
	F&D head	ASME, SA240, SS304L
	Port	SS304L
	Lifting lugs	SS304L
	Standard ConFlat (CF) Flange	ASME, SA240, SS316L
	Large custom flange	ASME, SA182, Grade F,SS 304L
3.	(c) Annulus tubing & support	SS304L
4.	(d) Support Structure	ASME, A36 or A500 Gr B Equivalent Indian standard IS 2062
5.	(e) Fastener	SS 316 Grade A4-70/A4-80 silver plated
6.	(f) O-ring	Perfluoroelastomer
7.	(g) Copper Gasket	Oxygen-Free Electronic (OFE) grade copper (UNS C10100)
8.	(h) **Welding Consumable** Stainless steel to Stainless steel Stainless steel to Carbon steel Aluminium 6061	**Material grade** Stainless steel - SS308L Stainless steel - SS309L Alloy 4043 or 5356

Table 3: Material requirement for HAM

5.2 All material, welding consumable, proprietary items and brought out items including materials for trials, qualifications and test coupons etc., as required for manufacture of BSC / HAM shall be procured and tested in accordance with the specification in Annexure-1. The vendor shall procure all the materials as per relevant specifications from reputed manufacturers and avoid procurement from agents. The source of material procurement should be approved by purchaser as part of quality audit.

All the material used in manufacture shall be marked and traced throughout the procurement to delivery to site time-cycle.

5.3 The vendor shall submit the schedule for the procurement of raw materials and welding consumable by including it in the work schedule.

5.4 MIP, QAP, testing procedure, Non Destructive Examination (NDE) procedure etc. submitted by the procurement source of raw materials, welding consumables and other proprietary & brought out items shall be communicated to the purchaser for approval before effecting delivery material. Approved MIP and QAP shall be strictly adhered thereafter during procurement.

5.5 Material / standard bought out items will be procured under inspection by purchaser (or purchaser's authorized agency). The inspection and testing (as covered in relevant Annexures) of materials will be carried out by the vendor at his cost in a laboratory approved by the purchaser. This testing may be witnessed by Purchaser (as covered in QAP/MIP). Purchaser may ask for the specimen coupons from the procured material for independent testing at his end.

5.6 The vendor shall procure the material in sufficient quantities and appropriate size in single lot taking into account all the necessary allowances required for manufacture, qualification and testing coupons.

5.7 Upon receipt of procured material from raw material source, product analysis shall be carried out by vendor as mentioned in Annexure 1 to ensure the quality and quantity.

6. Welding

6.1 All welding consumables shall meet the applicable specifications stated in Annexure 3. Welding qualification shall be as per clause no.5 and 6 of Annexure 3. The average heat input shall be concluded and reported based on qualified welding procedure.

6.2 The vendor shall give details of storage details, system for issuance and traceability of welding consumables whenever asked for it by purchaser.

6.3 The vendor shall submit Shop Weld Plan (SWP) consisting of weld joints indicating seam nos. for respective weld joints, applicable Welding Procedure Specification (WPS), Weld Procedure Qualification Record (PQR) and NDE to be carried out, with corresponding drawing number, for review and approval to the purchaser.

6.4 The weld seam shall be staggered wherever required as per the joint design requirements.

6.5 To approve welder and weld samples Vendor shall submit a Procedure Qualification Record (PQR) on welder and weld samples, prior to starting production welding

7. Inspection and Testing

7.1 The vendor shall inspect all the machined parts, sub-assemblies, final assemblies etc., in full compliances with Annexure 5 and approved drawings as per agreed procedures.

7.2 All the tolerance dimensions / features of individual parts, sub-assemblies and the assembled chamber shall be inspected by applicable procedures. All the threaded fasteners shall be checked by the thread gauges and ensure fasteners shall be interchangeable.

7.3 Dimensional check for the individual components and the completed chamber shall be carried out at a uniform temperature (25^0 C) as per the approved procedure and shall meet the functional requirements specified in the approved drawing.

7.4 All the dimensions given in the drawing are at 25^0 C. Measurement carried out at other temperature shall be compensated and corrected to 25^0 C before comparing with dimensions in the drawing. Value of co-efficient of thermal expansion at various temperatures shall be obtained from material producer.

7.5 The inspection and testing shall be done as per specifications and in a manner acceptable to purchaser. If deemed necessary purchaser will have right to specify additional inspection / testing other than specified here in this specification and cost of such test / inspection will be borne by the purchaser. The records of all the tests and inspection shall be maintained by the vendor and the same will be submitted to the purchaser.

7.6 Quality surveillance as well as quality audit by the purchaser or his authorized representative shall not relieve the vendor from the responsibility of meeting the specification or the inspection duties.

7.7 The inspection shall be in compliance with MIP prepared by the vendor and approved by the purchaser. However depending on the manufacturing procedure, quality assurance system of the company and manufacturing and inspection facilities available with the vendor, some additional checks may also be necessary on and above approved MIP. Such checks shall be incorporated and implemented by the vendor without any extra financial implications to the purchaser.

7.8 Change request: If vendor requires raising any change deviation to specification provided and approved for acceptance to purchaser, it has to get it approved before implementing if change is necessary. Change request procedure shall be mutually decided and agreed upon between vendor and purchaser.

8. Cleanliness, storage and workmanship

8.1 Surface treatment procedure shall be prepared in line with the Annexure-4 of this document and submitted to purchaser for approval.

8.2 Clean condition and good workmanship shall be maintained at all the stages of storing, handling, fabrication, inspection and packing as acceptable to purchaser.

8.3 Care should be taken to avoid contact of stainless steel with carbon steel at any time.

8.4 SS fabrication area shall be shielded from neighboring areas by metallic screens to prevent contamination from the machining area, weld spatter and fumes, grinding dust etc.

8.5 The raw material, subassemblies and finished components shall be sufficiently covered with polythene sheets to avoid contamination during storage.

8.6 Separate storage facility for S.S. material away from C.S material shall be used and identification of all material and their cut offs (like heat no, plate no., rolling direction etc.) shall be maintained by transferring the same to other location before cutting.

9. Handling, Packing and Delivery

9.1 The vendor shall provide details of floor space layout, handling facilities available at the place of manufacture, testing and assembly of BSC / HAM parts at the time of bidding. Vendor shall obtain detail of cleanliness class (class 100000 which is ISO 8 equivalent) for the area where final clean components are stored, assembled and are prepared for packing before dispatch.

9.2 The vendor shall ensure that all the chamber parts / assemblies are protected against any corrosion or surface damage during all stages of manufacture, inspection, handling, storage and transport. The packing shall be suitable and rigid enough to ensure safety of chamber during all stages of shipping to delivery site, loading, stacking and storage. Adequate number of silica gel packets shall be kept inside carte along with a copy of shipping release document.

9.3 All the openings shall be protected to prevent entrance of dirt and moisture during shipment, storage and assembly.

9.4 The package shall be stenciled in bold character with indelible paint, protected with shellac to indicate shipping mark, package numbers, dimensions and gross weight in kilos, the purchase order number and any other necessary data to identify the equipment and relate it to the contract.

9.5 Packing list shall be clearly visible and include package number, package contents, dimensions and net, legal and gross weight of each package and handling instructions if any. If more number of items are placed in a package, the net weight for each item shall be specified apart from gross package weight.

9.6 The shipment of equipment shall not be effected until and unless written “Shipping Release” is obtained from purchaser. The same will be issued by the purchaser or his authorized representative after satisfactory completion of “Factory acceptance test”

before release for delivery. The vendor shall dispatch the entire lot of supplies to purchaser's site after receipt of shipping release certificate.

9.7 Transshipment in transit shall be avoided and vendor shall arrange specially hired transport for direct delivery to purchaser specified delivery site.

9.8 The vendor shall do the road survey of route through which shipment is to be transported up to the unloading / installation location. Purchaser may join vendor in this activity. Moving supplies up to installation location is responsibility of vendor when specified.

9.9 When necessary, to obtain required clearance from statuary bodies for transportation of supplies responsibility lies within the scope of the vendor. The purchaser has no obligation in this regards. Wherever possible purchaser will put efforts to try to sort out issue but that doesn't relieve vendor from responsibility.

10. Technical documentation and progress reports

10.1 Drawings

The following drawings are provided to vendor with tender document of BSC / HAM chamber which shall be used as reference basis.

SL. No.	DRAWING Name	DRG No.	No. of Sheets
1.	BSC ASSEMBLY	VB01-001-R1	03
2.	BSC SUPPORT ASSEMBLY	VB01-002-R1	02
3.	BSC LOWER PART	VB01-003-R1	09
4.	FLOOR ASSEMBLY	VB01-004-R1	04
5.	BSC END COVER TYPE 1	VB01-005-R1	03
6.	BSC END COVER TYPE A11	VB01-006-R1	01
7.	BSC UPPER PART	VB01-007-R1	03
8.	BSC ANNLUS TUBING ASSEMBLY	VB01-008-R1	02
9.	STANDARD FLANGES	VO01-001-R0	05

Table 4: Drawing reference for BSC

SL No.	DRAWING Name	DRG No.	No. of Sheets
1.	HAM ASSEMBLY	VH01-001-R1	03
2.	HAM VESSEL SUPPORT	VH01-002-R1	02
3.	HAM CYLINDRICAL PART (DIA 84.25" ID)	VH01-003-R1	06
4.	HAM END COVER (BIG)	VH01-004-R1	04
5.	PORT CYLINDRICAL PART (DIA 60.5" ID)	VH01-005-R1	08

SL No.	DRAWING Name	DRG No.	No. of Sheets
6.	HAM END COVER (SMALL)	VH01-006-R1	03
7.	HAM ANNLUS TUBING ASSEMBLY	VH01-007-R1	04
8.	STANDARD FLANGES	VO01-001-R0	05

Table 5: Drawing reference for HAM

10.2 Verification, preparation of manufacturing drawings and as built drawings & 3D Model -

The 3D CATIA Model in .stp; format and 2D drawings derived from them covering the chamber assembly and its support structure will be supplied by the purchaser. The vendor shall prepare manufacturing drawings from them respecting design code compliance, manufacturability, fabrication, handling, access / effectiveness of inspection & testing and functional requirements.

Vendor shall perform Structural design verification of all the applicable parts as per ASME Section- VIII, Div-1.

The vendor shall incorporate changes if any in the 3D model as per the final manufacturing drawings approved by purchaser. The new 3D model / 2D Drawings shall be submitted to purchaser in '.stp' format compatible to CATIA V5 / SOLIDWORKS (preferably SOLIDWORKS) for review and approval.

At the end of manufacturing the vendor shall prepare 'as built' 3D model / 2 D Drawings of equipment in CATIA or equivalent and supply it to purchaser in the format compatible to CATIA V5 / SOLIDWORKS for record as a part of delivery of supplies.

If vendor wants to make suggestion to use CAD software other than SOLIDWORKS, he shall seek approval before its use. Approval to use other CAD software lies with purchaser and do not relieve vendor of his responsibility.

10.3 Preparation of manufacturing drawing

Preparation of manufacturing drawings (based on drawings / models supplied with tender document) and seek purchaser's review and approval is in the scope of vendor. This step is prior to beginning of the manufacturing stage.

The vendor shall ensure necessary care in preparation of manufacturing drawings in specifying all the dimensions with tolerances for each of the individual components, sub-assemblies and final assemblies. Progressive tolerances shall be implemented at intermediate stages from manufacturing to assembly in order to achieve the final requirements specified in the purchaser's assembly drawings. Drawings for jigs, fixtures

and tooling required to cover the scope of work, shall be prepared by the vendor and submitted to the purchaser for information & record.

The shop drawings shall include all details covering surface finish, weld details, method of inspection / examination, surface finish, bill of materials, allowances for cutting, machining including final finish besides other relevant information and details.

Vendor shall prepare all drawings in approved CAD software and provide in appropriate CAD and pdf format along with one hard copy for review.

If appropriate, the purchaser may ask the vendor for comments on new drawing versions. If new versions are viewed by purchaser or the vendor as significantly affecting interfaces, functionality or costs, a mutually agreed procedure between purchaser and the vendor will be followed.

The purchaser reserves the right to make minor dimensional changes during the period of contract, such changes shall be considered within the scope of the specified work and shall not be considered extra; the necessary agreement for the quantum of such changes shall be mutually agreed upon.

The vendor shall prepare the 'as built' drawing after completion of scope of work and submit them to the purchaser for records as a part of deliverable compatible with SOLIDWORKS.

10.4 Applicable code and standards covering scope of work of procurement of BSC / HAM

- ASME Boiler and Pressure vessel code Section II Part A
- ASME Boiler and Pressure vessel code Section II Part C
- ASME Boiler and Pressure vessel code Section II Part D
- ASME Boiler and Pressure vessel code Section V
- ASME Boiler and Pressure vessel code Section VIII Div. 1
- ASME Boiler and Pressure vessel code Section VIII Div. 2
- ASME Boiler and Pressure vessel code Section IX
- ASTM E498-Standard Test Methods for Leaks Using the Mass Spectrometer leak Detector
- Standard of Expansion Joint and Manufacturer's Association (EJMA)
- ISO Standard 2861-Flange standard
- ISO Standard 14644-1 for cleanroom

Latest edition of above codes shall be used.

10.5 Applicable Specification –

Detailed specifications applicable to scope of work are included in the number of annexures listed below and form the part of tender specifications applicable to BSC / HAM Chambers:

Sr. No.	Description	Annexure No.
1.	Specification for Material	Annexure 1
2.	Specification for rolling, machining and manufacturing	Annexure 2
3.	Specification for welding and welding qualification of the austenitic stainless steel	Annexure 3
4.	Specification for cleaning and cleanliness	Annexure 4
5.	Specification for inspection and testing	Annexure 5
6.	Specification for vacuum leak tightness and leak testing	Annexure 6
7.	Specification for Vacuum requirement	Annexure 7
8.	Various parts details & Load specification for BSC / HAM	Annexure 8
9.	List of deliverables	Annexure 9

Table 6: Applicable Annexure / Specification

10.6 In case of conflict between this specification and other specification mentioned elsewhere at other document /places, the vendor shall contact purchaser for guidance and the purchaser's decision shall be considered as final.

10.7 Details of documents to be prepared and provided for approval of purchaser at all stages of manufacturing, fabrication, inspection and testing of BSC / HAM Chamber :

Document to be provided by vendor	Provider	Milestone*
2D manufacturing drawing, BoM	Vendor	Within 30 days from the KOM
Follow-up documents (Quality Assurance Plan and Manufacturing & Inspection Plan) identifying Purchaser hold points	Vendor	
Material / welding consumables / Equipment tracing - identification and marking procedure	Vendor	
Deviation Request (If Applicable)	Vendor	BS

Document to be provided by vendor	Provider	Milestone*
Material documentation (incl. Procurement specification, material certificates, test and examination results)	Vendor	BS
List of contractor's sub-suppliers/sub-contractor	Vendor	BS
Welding Data Package (WPS, PQR, WPQ and Shop Weld Plan), welder qualification	Vendor	BS
NDE procedures along with the credentials of qualified NDE personnel	Vendor	BS
Cleanroom specification for the areas of storage, manufacturing, assembly, testing and packing	Vendor	BS
Assembly and fabrication procedures	Vendor	BS
Leak Testing Procedures along with the credentials of qualified testing personnel	Vendor	BS
PWHT – Dimension Stability Procedures (wherever applicable)	Vendor	BS
Cleaning procedures along with details of cleaning agents	Vendor	BS
Packing and Transportation procedures	Vendor	BS
Forming procedure (if applicable)	Vendor	BS
Non Conformance Report (If applicable)	Vendor	BS Throughout period of scope of work
Documents to be supplied before final acceptance of BSC / HAM in the factory		
Inspection reports (dimensional check, visual inspection, vacuum leak tests outcome (covering magnitude and location of leak recorded), NDE results (Annexure 3, 4 & 5)	Vendor	AC
Vacuum performance (demonstration of ultimate vacuum as per specification) (Annexure-6 & 7)	Vendor	AC

Document to be provided by vendor	Provider	Milestone*
End of manufacturing report (Release Note) including as-built drawings for BSC / HAM chamber assembly and its parts. The end of manufacturing report file is progressively built up during manufacture of the component(s) assembly & testing.	Vendor	EF

Table 7: Document submission list throughout scope of work

*** AC: After completing of activity

EF: End of the factory acceptance

*BS –Before start (of Manufacturing or procedure)

10.8 The vendor shall record all deviations incorporated after due approval, which necessitated throughout the manufacturing, inspection and testing stages. Standard forms shall be used by the vendor for raising Deviation Requests (DRs) supplied by purchaser.

10.9 The vendor shall prepare detailed monthly progress reports on the works performed and submit soft and hard copy for each month to the purchaser by mutually agreed dates/week of succeeding month.

10.10 As this work is a prototype in nature (Manufacture and assembly of BSC / HAM), Vendor shall prepare and submit a comprehensive note on the manufacturing experience, covering all the activities highlighting the salient features. Specific difficulties / problems faced, if any, and the methods by which they were resolved shall be included with necessary details. All deviation requests approved shall be part of this note.

11. Delivery

Supply of scope of work specified under this contract shall be completed within 9 (nine) months from the date of approval of manufacturing drawings.

Delivery of supplies shall be made at RRCAT, P. O. CAT, Indore - 452013, Madhya Pradesh, India. Contact details at RRCAT, Indore shall be provided in contract documents

Goods shall be unloaded inside LIGO lab, RRCAT. The Project Coordinator, LIGO Activities, RRCAT shall be the contact person in RRCAT. In case situation arise, the unloading location may be changed due to unavoidable circumstances but it shall remain within the premises of RRCAT, Indore.

12. Guideline to vendors on Notification and Hold points for Purchaser

Activity	Purchaser	Comment
Structural design verification of all the applicable parts as per ASME Section- VIII, Div-1	N	Assessment of structural integrity before commencement of scope of work
Approval of Procurement related documentation (includes QAP, MIP, Manufacturing drawings with BOM, Manufacturing procedure and Inspection stages & Test results etc.)	H	
List of Contractor's sub-suppliers	H	Approval of sub-contractor shall be subjected to clearance of quality audit by purchaser
Kick off Meetings between Contractor and Purchaser	H	
Material procurement, Procurement of Welding consumables.	N	
Raw Material receipt inspection Material identification marking	H	Product analysis, Check test, Material Test Certificate and Identification
Design of Jigs, fixture, Tooling and manufacturing	N	Contractor to provide details of Jigs, Fixture and tooling to be used.
Marking And Cutting of Material	N	
Machining and Drilling of parts (as applicable)	N	
Dimensional inspection of Parts before taking up for fabrication	H	
Welding Qualification (Procedure & Welders)	H	
Commencement of fabrication	H	
Special Fixture for fabrication (as applicable)	N	
Visual & Dimensional inspection of chamber	H	
Non Destructive Examination of welds	H	
Cleaning of chamber	H	
Leak testing of chamber	H	
Ultimate Vacuum test	H	
Factory Acceptance Test	H	
Preparation of End of Manufacturing report	N	

Activity	Purchaser	Comment
Packing & Transportation	H	
Shipment release clearance by purchaser (or purchaser's representative)	H	

Table 8: Guideline on Notification and Hold points for Purchaser

H: Hold Point

N: Notification Point

This table is guideline to contractor for preparing detail MIP.

The notification / hold points may be added or deleted by purchaser before / during / after manufacturing as per the need and criticality of the activity.

13. Guidelines to interested Vendors

13.1 Currency used in pricing in bids

Vendors shall quote all the prices in their bids in Indian Rupees (INR)

13.2 Roadmap for the tender process

Guidelines to vendor indicating the procedural steps that will be followed for tender notice of procurement of BSC-HAM chambers are listed below in table – 9

Sr. No.	Tender Step	Action	Due date
1.	Notice Inviting Tender	Paper notification	T=T0
2.	Pre Bid meeting with vendors	Meeting at IPR	T0 + 2 weeks
3.	Clarification to the vendors	Communication with clarification to queries raised by them	T0 + 4 weeks
4.	Two part Bid submission	Bid submission by vendors	T0 + 9 weeks
5.	Opening of Part-I (Techno-commercial) of bids by vendors	Bid opening post due date	T0 + 9 weeks
6.	Qualification of bidders	Scrutiny of vendors based on essential qualification criteria	T0 + 11 weeks
7.	Meeting with shortlisted eligible bidders	Meeting at IPR	T0 + 13 weeks
8.	Evaluation of Part-I bids	Techno-commercial Scrutiny of vendors based of submission and presentation during meeting	T0 + 17 weeks

Sr. No.	Tender Step	Action	Due date
9.	Shortlisting of vendors for opening of part-II bids	Selection and intimation to successful vendor of shortlisting of their bid in opening of part-II of bids	T0 + 18 weeks
10.	Opening of Part- II (Price) of bids by shortlisted vendors	Opening of price bids in presence of participant vendor	T0 + 19 weeks
11.	Selection of vendors and award of contract	Selection and intimation to successful vendor for award of contract	T0 + 23 weeks

Table 9: Roadmap for the tender process - guidelines to vendor

13.3 Bidding, bid scrutiny and evaluation by purchaser under this tender

Vendors interested in participating in this procurement should express their interest to purchaser and participate in pre-bid meeting at IPR. Vendor shall provide details on below listed items to illustrate their resources, approach to breakdown work, project execution plan with its schedule fulfilment of specified functional requirements for procurement –

- Human Resource available and planned organization structure to undertake scope of work
- Facility and Equipment Resources to cater necessary machining, handling, testing and assembly
- Work schedule (compatible for reading in Microsoft Project) to achieve delivery schedule
- WBS and Project execution plan (PEP)

Purchaser shall use all detailed documentary information provided by vendor in his bid submission and presentation made during vendor-purchaser meeting for scrutiny and evaluation regarding eligibility, understanding of scope, capability, approach and past experience in to undertake the scope covered in this tender notice and successfully deliver the supplies within agreed schedule.

13.4 Placement of contract

Vendor shall submit price bids strictly in the format that is attached with the tender document. Prices quoted in bids shall be Ex-works basis covering scope of work described herein in this document i.e. manufacturing, testing, packing, loading and unloading of supplies at factory and delivery site.

Bid format is attached where vendors shall quote their prices for each of the chamber viz. BSC and HAM, separately as indicated in above paragraph individually for BSC

and HAM Chamber. Payment towards other charges such as freight and insurance shall be made at actual basis on submission of documentary evidence/proof of payment receipts.

The purchaser shall have right to select the lowest techno-commercial compliant bid and place separate procurement contract for one BSC chamber with one vendor and for one HAM chamber with another vendor, whose quoted Ex. Works prices (indicated in para 1 above) for these individual chambers result to be lowest. Vendor should take note of this while quoting their prices for individual chambers (one BSC & one HAM)

Purchaser's decision in selection of successful vendor will take into account –

- **Essential eligibility criteria fulfillment**
- **Clarity and content of bids, understanding of work scope**
- **Past experience of handling similar works**
- **Presentation during meeting with vendor explaining the execution of the work, project management and schedule of delivery**

ANNEXURE – 1

SPECIFICATION FOR MATERIAL:

A. Specification for Austenitic Stainless steel S304 L plates:

1. Scope

This Annexure prescribes the requirements for the manufacture, procurement, inspection, testing, packing and supply of austenitic stainless steel plates type 304L and dual marked type 304/304L.

Any other requirements indicated in ASME Sec II Part A, SA 240 and SA 480 which are not included in the text of this Annexure shall also be applicable.

2. General

All the material used in manufacture shall be firsthand. The vendor shall procure all the materials from reputed manufacturers with original Certified Material Test Reports (CMTRs) and avoid procuring from agents. Purchaser shall recommend source of procurement if there is need for use of pre-qualified material.

The dimensions mentioned in the drawings are finishing dimensions, accordingly vendor shall procure the material in sufficient quantities of appropriate size accounting for the necessary allowances required for cutting, machining during manufacture, qualification and testing.

3. Melting Process

From the point of use of material in UHV application, there is need to comply with requirements for purity as specified. The steel production should include relevant refining

processes (like Argon Oxygen Decarburization (AOD), Vacuum Oxygen Decarburization (VOD), Vacuum Arc Refining (VAR) etc.).

4. Delivery condition

The stainless steel material procured shall be of Hot Rolled, Solution Annealed and pickled (HRAP). The parameters of the heat treatment cycle shall be obtained from the source of material supply and shall be made available to the purchaser whenever they are demanded.

After final cleaning and pickling, no grinding with abrasive wheels, cloth or stones is permitted. No iron, carbon steel or other contaminants (such as grease, chloride compounds, oil hydrocarbons) to come in contact with the finished material.

5. Cleanliness

This material is intended for use in Ultra High Vacuum (UHV) application. Potential hydrocarbon contamination shall be eliminated. Entire lot of clean material shall be wrapped and covered at all times during storage and handling of the material when it is not being processed to minimize exposure to contaminants.

6. Testing Details

Clause no. 7.0 to 16.0 of this specification are to be followed as guidelines for testing of plate.

7. Chemical composition

The chemical analysis shall be performed for each lot of material from same heat. Analysis may be performed on metal discards taken from mechanical test specimens.

A lot shall be defined as plates produced from same heat, subjected to same hot working and heat treatment to arrive at the same thickness.

Chemical Analysis shall be performed in accordance to ASME Sec II Part A, SA 751.

The results shall be in confirmation with the requirements as per ASME Sec II Part A, SA 240

Chemical composition of SS304L plates as per ASTM A240

Sr. No.	**Element**	**Weight percentage**
1	Carbon	0.030 (Max)
2	Manganese	2.00 (Max)
3	Phosphorus	0.045 (Max)
4	Sulfur	0.030 (Max)
5	Silicon	0.75 (Max)

6	Chromium	18.0–20.0
7	Nickel	8.0–12.0
8	Nitrogen	0.10 (Max)

Table 10: Chemical composition of SS304L as per ASTM A240

Chemical composition of SS304 plates as per ASTM SA240

Sr. No.	**Element**	**Weight percentage**
1	Carbon	0.08 (Max)
2	Manganese	2.00 (Max)
3	Phosphorus	0.045 (Max)
4	Sulfur	0.030 (Max)
5	Silicon	0.75 (Max)
6	Chromium	18.0–20.0
7	Nickel	8.0–10.5
8	Nitrogen	0.10 (Max)

Table 11: Chemical composition of SS304 as per ASTM A240

8. Mechanical Properties Requirements

Testing procedure as per ASME Sec II Part A, SA 370

Tensile test requirements at room temperature as per ASME Sec II Part A, SA 240

Mechanical property of SS304L plates Specification as per ASTM A240M

Sr. No.	**Property**		**Value**
1.	Tensile Strength		485 MPa (Min)
2.	Yield Strength		170 MPa (Min)
3.	Elongation in 50 mm		40% (Min)
4.	Hardness	Brinell (HB) max.	201
		Rockwell B (HRB) max.	92

Table 12.Mechanical property of SS304L plates Specification as per ASTM A240M

Mechanical property of SS304 plates Specification as per ASTM SA240M

Sr. No.	**Property**	**Value**

1.	Tensile Strength		515 MPa (Min)
2.	Yield Strength		205 MPa (Min)
3.	Elongation in 50 mm		40% (Min)
4.	Hardness	Brinell (HB) max.	201
		Rockwell B (HRB) max.	92

Table 13.Mechanical property of SS304 plates Specification as per ASTM A240M

Additionally % reduction of area shall be recorded for information.

Hardness test requirements as per ASME Sec II Part A, SA 240

ASME, SA240, Dual grade SS304/304L material shall confirm the both; low carbon content of SS304L and high strength of SS304.

9. Failure of mechanical test and retests

Case-1:

If test specimen has a physical defect (which does not affect the usefulness of the product) or if unsatisfactory test results are due to incorrect mounting of the specimen or testing machine malfunction, the test shall be repeated using another specimen. If the results of the second test are satisfactory, the rolled plate shall be accepted; if not, case 2 shall apply.

Case-2:

Where unsatisfactory results cannot be attributed to causes mentioned in Case-1, two re-test may be performed for each unsatisfactory result obtained. The second set of test specimens shall be taken close to those which were defective. If the results of the each retest are satisfactory, the plate shall be accepted, if not, it shall be rejected.

10. Non-Destructive Examination

10.1 Surface Examination

The plates shall be visually examined in accordance with ASME Sec V, Article 9. The products shall show clean surfaces without any undulation. They shall be free from scratches, blowholes, scales, cracks, hairline flaws.

10.2 Ultrasonic Examination

All the plates (where applicable) shall be 100% ultrasonically examined with each pass overlapping at least 10% of the previous pass to ensure complete coverage.

Examination shall be carried out with reference to ASME Sec V, Article V and ASME Sec II Part A, SA 578.

Acceptance criteria shall be as per ASME Sec II Part A, SA 578; Acceptance Standard-Level B

11. Dimensions and Permissible Variation

Tolerance on the plate shall be governed by ASME Sec II Part A, SA 480. However No negative tolerance in plate shall be allowed.

12. Finish of plate

Finish of final products (i.e. plates) shall be as per Cl. 13.1.2 of ASME Sec II Part A, SA 480.

The Surface roughness shall not exceed 6.3 microns.

13. Repairs

Repair by welding is prohibited. Surface grinding (using permissible tools) can be carried out to eliminate surface defects provided the remaining thickness satisfies the tolerance requirements. The resulting depression shall be merged smoothly with the rest of surface.

14. Material Test Reports

Each of the following details shall be indicated in Material test report (mill test report).

- Specimen wise Material identification (batch number, heat number etc.)
- Purchase order No.
- Identification of Manufacturer
- Melting process
- Heat treatment record (Heat number)
- Chemical Analysis
- Mechanical properties
- Dimensional report
- Non-Destructive Examination report

15. Marking

Each plate shall be marked as per details given in ASME Sec II, Part A, SA240. In addition, the following shall also be marked:

- Order Number of item
- Manufacturer name or symbol
- Plate number or unique identification number for traceability of quality history

- Grade of material
- Heat number
- Direction of Final Rolling

16. Packing and Transportation

The packing of the delivered material (plates) shall be suitable for repeated handling. Suitable packing material shall be provided in between plates and each plate to prevent damage, contamination etc. All covered plates shall be packed in wooden crates. Material inside crates shall be protected from dirt and moisture during shipment and storage at site. Each carte shall bear details stenciled in bold letter with indelible paint to indicate shipping details, packing number, dimensions, gross and net weight. Handling locations of the crates shall be identified and clearly visible.

17. Access for inspector

The vendor shall allow the access for purchaser and/ or authorized representative at all reasonable facilities necessary to satisfy him that the material is being furnished in accordance with this specification.

B. Specification for Austenitic Stainless Steel 304L Forgings

1. Scope

This section of Annexure prescribes the requirements for the manufacture, inspection, testing, packing and supply of austenitic stainless steel 304L forgings.

Any other requirements indicated in ASME Sec II Part A, SA 182 or SA 961 or SA 336 or SA 965 or SA 788 which is not covered in this specification shall also be applicable.

2. General

All the material used in manufacture shall be firsthand. The vendor shall procure all the materials as per relevant applicable specification from reputed manufacturers with original Certified Material Test Reports (CMTRs) and avoid procuring from agents.

The dimensions mentioned in the drawings are final dimensions and the vendor shall procure the material in appropriate size taking into account all the necessary allowances required for cutting, machining during manufacture, qualification and testing.

3. Melting Process

The steel shall be made using an electric furnace or by any other technically equivalent process.

4. Manufacture

Sufficient discard shall be taken from the ingot to ensure that only sound metal enters the complete forging. Forging shall be as close as practicable to finished shape and size.

No grinding with abrasive wheels, cloths or stones is permitted. No iron carbon steel or other contaminants (such as grease, oil or hydrocarbons) to come in contact with the forging after the cleaning process. Machining fluids shall be water soluble and free of oil, sulfur, and chlorides

5. Delivery condition

Forged parts shall be delivered in the solution heat treated condition and machined to the as delivered dimension and profile.

Solution heat treatment shall consist of holding at a temperature between 1050ºC to 1150 ºC followed by rapid water quenching. Vendor shall propose the details of the treatment

whenever it is necessary with details of atmosphere inside oven, temperature, duration of soaking and quench method based on the dimensions of the part and submit to the purchaser for approval before performing the process.

The material shall be supplied per the requirements of ASME Sec II Part A, SA 182 or SA 961 or SA 336 or SA 965 as applicable.

6. Chemical composition

Chemical analysis shall be performed in accordance with ASME Sec II Part A, SA 751.

Chemical composition of SS304L forged material as per ASTM SA182

Sr. No.	Element	Weight percentage
1.	Carbon	0.030 (Max)
2.	Manganese	2.00 (Max)
3.	Phosphorus	0.045 (Max)
4.	Sulfur	0.030 (Max)
5.	Silicon	1.00 (Max)
6.	Chromium	18.0–20.0
7.	Nickel	8.0–13.0
8.	Nitrogen	0.10 (Max)

Table 14: Chemical composition of SS304L as per ASTM SA182

Requirement mentioned in ASME Sec II Part A, SA 182 or SA 961 or SA 336 or SA 965 or SA 788 for chemical analysis shall meet.

Additional requirement of the final content of sulfur is to be limited to 0.006% max.

7. Mechanical Properties Requirements

Specimens shall be tested at ambient temperatures for each lot of material with the same heat.

Testing procedure as per ASME Sec II Part A, SA 370

Tensile test requirements at room temperature as per ASME Sec II Part A, SA 182 or SA 961 or SA 336 or SA 965 or SA 788 as applicable.

Mechanical property of SS304L as per ASTM SA182

Sr. No.	Property	Value
1.	Tensile Strength	485 MPa (Min)
2.	Yield Strength	170 MPa (Min)
3.	Elongation in 50 mm or 4D	30% (Min)
4.	Reduction of Area	50% (Min)

Table 15.Mechanical property of SS304L as per ASTM SA182

Additionally % reduction of area shall be recorded for information.

Hardness test requirements at room temperature shall be as per ASME Sec II Part A, SA 182 or SA 336 or SA 961 or SA 965.

8. Rejection, Rework and Repeated Tests

Conditions mentioned in ASME Sec II A, SA 788 or SA 961.

9. Non-Destructive Examination

9.1 Surface Examination-Visual Examination

Each forged part shall be visually examined through entire production to machining phase to check the soundness of the metal. The part shall be sound and free from defects like strings, tears, and nicks.

Finish and appearance of the forged component shall meet the requirements of ASME Sec II Part A, SA 961. The maximum Surface roughness shall not exceed 6.3 microns.

9.2 Ultrasonic Examination

Examination shall be carried out with reference to ASME Sec V, ASME Sec II Part A, SA 388.

10. Permissible Variation in dimensions

The dimensions shall be checked in accordance with the requirements of the Approved procurement drawing.

The main dimensions shall be recorded. The values shall be within the tolerances given on the drawing.

11. Repairs

Repair by welding is prohibited. Surface grinding can be carried out to eliminate surface defects provided the remaining thickness satisfies the tolerance requirements. The resulting depression shall be merged smoothly with the rest of surface.

12. Test Reports (See part A of this Annexure)
13. Marking

    Marking on the product shall be as per the requirements mentioned in ASME Sec II Part A, SA 182 or SA 336 or SA 961 or SA 788.

14. Cleanliness

    The forgings are intended for use in a high vacuum application. Potential hydrocarbon contamination shall be eliminated.

15. Packing and Transportation
16. Access for inspector

    The vendor shall allow the inspector authorised by purchaser at all reasonable facilities necessary to satisfy him that the material is being furnished in accordance with this specification.

C. Specification for Aluminum material for Floor assembly

1. This section of annexure prescribes the requirements for the manufacture, inspection, testing, packing and supply of Aluminium 6061 extruded standard structural profiles.
2. All requirements indicated in ASME Sec II Part B, SB-308 / ASTM B308M in addition to UHV requirement mentioned in this document shall be applicable.

ANNEXURE – 2

SPECIFICATION FOR ROLLING, MACHINING AND MANUFACTURING

1. Scope

This specification covers the minimum requirements for Stainless Steel machining and rolling of shells for the LIGO vacuum components.

The specified chamber is intended for use as part of the Ultra High vacuum.

The vendor shall be responsible for coordination of their sub-contractor activities and assume surety of mechanical compatibility of material.

2. General requirements

It shall be the responsibility of the vendor to call attention to any apparent conflicts between specifications, the Purchase Order, or purchaser's drawings and request an interpretation from the purchaser. The vendor shall not assume which instruction shall prevail. In case vendor find any of purchaser's drawings or calculations are in conflict with applicable code requirements, he should seek clarification before proceeding with further processing.

The components covered in procurement specification are to be used in ultra-high vacuum service and require stringent controls overs cleanliness and contamination throughout the material handling, fabrication and shipping process.

All storage for these components shall be done in the clean and controlled area to prevent contamination from heat, smoke, dust and oily vapors from other manufacturing areas. Material contact with other carbon steel shall be avoided to prevent carbon steel contamination of the stainless steel components. Same precaution applies to handling of plates so as not to contaminate the SS plate/components with carbon steel, steel forks, hooks of lifting mechanisms.

No grinding with abrasive wheels, cloth or stones is allowed on the internal vacuum surface unless specified in this specification.

Potential hydrocarbon contamination shall be prevented. The material shall be wrapped and covered at all times when it is not being processed to minimize possible exposure to contaminants.

Material identification shall be maintained during all manufacturing operations to keep and material identity and incorporate its traceability.

Finished flange surfaces and rolled shells must be covered and protected during all fabrication steps and during shipment to the fabrication shop.

Surface defects shall be removed by grinding with carbide burr cutters only. Abrasive-type wheels and stones are not allowed on vacuum facing metal surfaces.

3. Dimensional Stability

Supplier shall ensure dimensional stability by adopting balanced welding, suitable welding technique and machining process which shall not introduce residual stresses. The purpose is to minimize distortion and provide dimensional stability to stainless steel vacuum system components with critical tolerances.

4. Machining of Parts

4.1 O-Ring Groove and Sealing Surfaces Requirements 0.8 µm

All flange O-ring and sealing surfaces shall meet the following requirements:

Basic finish required: 0.8 µm, concentric lay (finish tolerance +/- 0.2 µm)

The following processes are not allowed at any phase: grinding, honing, lapping, polishing, buffing, sanding, sand blasting, or any other process that disturbs the concentric machining lay, imbeds material into the surface, or smears the surface.

In addition to out of tolerance dimensions, the following machining problems lead to machined component rejection: ridges, chatter, waviness, scratches or marks along or across the concentric lay, tool marks, dents, gouges, burrs, sharp edges.

4.2 Machining Fluids

No iron, carbon steel or other contaminants (such as grease, oil or hydrocarbons) shall come in contact with Machined Parts during material handling and fabrication. Machining, cleaning fluids or any other materials or fluids contacting the raw material or finish component shall be water soluble, and meet the limits as mentioned in below Table

Maximum concentration limits for machining fluids:

Contaminant	**Limit**
Water Leachable Chlorides	100 ppm
Total Halogens (including Water Leachable Chlorides)	1000 ppm
Total Sulfur	1000 ppm
Hydrocarbons	None Allowed

Table 16: Maximum concentration limits for Machining fluid

5. Tolerance

Tolerances for machining and assembly shall be followed as per indication in the respective drawings sheets. Any deviation from the specification shall be prior communicated to supplier and must be approved by supplier.

6. Identification

Marking the materials with marking fluids, die stamps, crayons, paints and/or electro-etching is not permitted. Laser technique or a vibratory tool with a minimum tip radius of 0.1 mm is acceptable for marking the outside only of the rolled or finished shell. All other marking methods must be approved by the purchaser prior to use. All parts shall be marked only on outside (of vacuum) surface only.

Marking on interior of vacuum boundary surfaces is not allowed in any form.

ANNEXURE – 3

SPECIFICATION FOR WELDING AND WELDING QUALIFICATIONS FOR AUSTENITIC STAINLESS STEEL

1. Scope

Weld quality significantly govern the performance of UHV chambers. All welding shall be carried out in class 100000 (ISO 8) clean areas which is separated from other areas in machine workshop

Vendor has to control, specify and qualify following before taking up welding production -

1.1 General requirements for welding of the vacuum system components

1.2 Requirements for the preparation of Welding Procedure Specification (WPS) and qualification of welding procedure and welders by Gas Tungsten Arc Welding (GTAW), Plasma Arc welding (PAW), Shielded Metal Arc Welding (SMAW), etc. process for austenitic stainless steel material used for manufacture of BSC / HAM shall be in the scope of the vendor. The purchaser or his authorized representative shall approve the specification, procedure and qualification record to use the welders and specific welding procedures in fabrication of BSC / HAM.

1.3 Requirements for usage and qualification of welding consumable

2. Applicable Specification

Latest active edition of the following code / specification shall be applicable for the scope of work

ASME Sec IX	: Welding and Brazing Qualification
ASME Sec V	: Non-destructive Examination (NDE)
ASME Sec II Part A, SA 370	: Test methods and definitions for mechanical testing of steel products
ASME Sec II Part C	: Specifications for Welding Rods, Electrodes and Filler metals

Table 17: Code / specification applicable for welding

3. Vendor's responsibility

3.1 Clause QW-201 and QW 301 of ASME Sec IX shall be applicable. The qualification tests shall be performed in the same workshop where the production weld is planned to be carried out.

Welding Procedure Specification (WPS), Procedure Qualification Record (PQR), Welder Performance Qualification (WPQ) and Welding Operator Performance Qualification

(WOPQ) shall include weld joint details along with Weld Data Sheet (WDS) and shall get approved by the purchaser or his authorized inspector.

The recommended format shall be:

Clause QW 482 for WPS of ASME Sec IX

Clause QW 483 for PQR of ASME Sec IX

Clause QW 484A for WPQ of ASME Sec IX

Clause QW 484B for WOPQ of ASME Sec IX

4. Welding General Requirements

Production welding shall be accomplished, strictly following the qualified and approved welding procedures using approved welding consumables and qualified welders (welding operators). A list of qualified welders identified for production work assignment shall be submitted for approval to purchaser along with copy of their supporting credentials (qualification, experience, certification etc.)

Welds should be regular, continuous, non-porous and every attempt shall be made to reduce the width of the transition region along each side of the weld. Before commencing welding of parts they shall undergo thorough cleaning procedure.

Sequencing of welds to avoid buildup of residual stress and distortion shall be proposed and submitted for approval before it is used during welding. The vendor shall prepare written procedure for distortion control for each typical joint giving the sequence of welding; heat input to weld etc. and shall submit the same to purchaser before taking up work. Approved weld procedure shall be displayed in vendor's weld shop area during work. The weld fit-up tolerance shall be as indicated in manufacturing drawing. Clearance shall be obtained from the purchaser's inspector for fit-up before welding.

The shrinkage and distortion of the welded joints shall be measured and recorded. The average heat input as per qualified PQR shall be maintained by suitably controlling voltage, current and welding speed during welding to meet the mechanical and metallurgical properties.

All vacuum boundaries shall be checked to ensure that they can be examined volumetrically during testing.

All weld consumables and weld preparation areas shall be clean areas as prescribed to UHV requirement prior to welding. Weld consumables shall be handled only with clean gloves during welding after cleaning.

All penetration in the chamber shall be welded continuously from inside and stich welded from outside in accordance with ultra-high vacuum practice. In unavoidable circumstance

full penetration welding from atmospheric side shall be used with adequate purging of argon gas inside the vacuum chamber.

Where ever it is possible single pass welds should be used. Welds to be smooth but not flush and not ground.

Use of dye penetrant is strictly prohibited on vacuum exposed surface. (prior approval is necessary for use in unavoidable circumstances)

All welds at vacuum boundaries to be vacuum leak tight with a helium leak rate less than 1×10^{-9} mbar-lit/sec.

5. Welding Procedure Qualification (WPQ)

5.1. All the procedure qualification test coupon shall be welded in presence of the purchaser/ his authorized inspector

5.2. All the welding procedure shall be developed and qualified as per latest edition of ASME Sec IX

5.3. Weld procedures are in place for both ASME and Ultra high vacuum requirements

5.4. Additional requirements

5.4.1. Non-destructive Examination -

The qualification test coupon must undergo all the non-destructive examinations applied in fabrication to the joints which it qualifies and must satisfy the highest acceptance level requirements applicable to these joints.

5.4.2. Metallographic Examination -

These are to be carried out on a complete transverse section of the weld. There shall not be any micro cracks.

The examination shall provide means of characterizing each zone of the weld in thickness, deposited metal, heat affected zone with those of the base metal.

5.4.3. Ferrite content -

Ferrite content in weld shall be limited by controlled use of welding consumables with ferrite content in the range of 5 to 8%

6. Qualification for Welders / Welding Operators

6.1 General -

6.1.1 This qualification shall be done before any fabrication work is commenced so as to ensure that the welders are certified and competent to execute satisfactory welds using the qualified welding procedure.

6.2 Technical competence of welder / welding operator -

It is strongly recommended considering the dimensional control requirement, welding shall be carried out using automatic welding as much as possible. Only when automation is not viable manual welding shall be permitted.

6.2.1 When a test assembly is made by a welder / welding operator, the inspector shall check with care which has been taken in complying with the points specified below and this shall be one of the criteria applied in reaching the assessment.

i. Ability to judge the quality of the groove preparation
ii. Ability to judge the state of cleanliness of the work piece and filler materials
iii. Ability to comply with grades and dimensions of the filler materials to be used
iv. Ability to comply with the drying of filler material where necessary
v. Ability to comply with the welding parameters such as the current, voltage, rate of gas flow, inter-pass temperature, backfilling purge gas flow etc.

6.2.2 Condition for qualification

i. The documents in which the qualification requirements are set out shall be given to the welder
ii. All the qualification test coupon shall be executed in presence of the certified welding inspector
iii. The inspector is entitled to stop the test at any time if it appears obvious that the welder lacks technical competence and operating skill necessary to achieve satisfactory results.
iv. Every test coupon shall be stamped with identifying marks of the inspector and of the welder
v. The welding equipment used shall be similar to that used in production
vi. Any welder / welding operator who has to remove an obviously excess amount of deposited metal by grinding, gouging or other method to avoid leaving defects shall be rejected
vii. The welder who has qualified the welding procedure shall be automatically qualified.

6.3 Welder / welding operator shall be properly trained and have undergone enough practice before he is considered for qualification

6.4 Welder / welding operator shall be qualified as per latest edition of ASME Sec IX with addition of other requirements of this specification

7. Welding Consumable

7.1 All the welding consumables shall be selected as per the welding method & procedure selected and Ultra high vacuum requirement.

7.2 All the welding consumable shall be manufactured, inspected, tested, packed, supplied and stored as per the requirements of ASME Sec II Part C.

7.3 Each batch of welding consumable are required to be qualified at vendor's shop as per the requirements of ASME Sec II Part C along with the additional requirements of this section before using in production.

7.4 Argon gas of ultra-high purity (99.999% min) with low moisture content [due point of (-24^0 C) or lower] shall be used for the shielding as well as purging the hot root from the rear side.

7.5 Ferrite content permissible range in weld consumable shall be 5 FN to 8 FN.

8. Welding repair procedure

8.1 For Repairs Not Requiring Welding

i. Weld defects shall be removed by grinding with Carbide burr cutters only. Abrasive-type wheels and stones are not allowed on the interior or the exterior of vacuum welds.
ii. Visually inspect the area prepared for welding to ensure that the defect has been removed or the indication reduced to an acceptable limit.
iii. The reduced material thickness shall be checked by a suitable gauge.

8.2 For Repair Requiring Welding

i. Any defect in welding on vacuum exposed side shall be removed before re welding to minimize the trapped volume and become source for outgassing
ii. Remove the defect by grinding (with Carbide burr cutters only) or by chipping and grinding to an acceptable level.
iii. Visually inspect the area prepared for repair welding.
iv. Weld as per approved welding procedure
v. The repaired area can be left in the as-welded condition or can be blended by grinding. Grinding is restricted to the use of with Carbide burr cutters only. The repaired area shall blend uniformly into the surrounding surface and shall be visually inspected after welding.

8.3 For Fillet Weld Repairs Requiring Welding

i. Remove the unacceptable weld metal by grinding with Carbide burr cutters only.

ii. If the full fillet weld is not completely removed, visually inspect the area prepared for welding.
iii. Weld as per approved welding procedure
iv. Repairs welds shall be visually inspected after welding.

ANNEXURE – 4

SPECIFICATION FOR CLEANING AND CLEANLINESS

1. Scope

This specification specifies typical cleaning procedures and processes to be used for vacuum chamber and its components compatible for operation in ultra-high vacuum.

It is intended that the vendors manufacturing such chambers shall follow the specification to achieve and demonstrate required cleanliness specifications.

The vendor is at liberty to utilize other substitute techniques not described here in this specification (in consultation with the purchaser) provided that the supplies delivered to purchaser at the end of scope of work of this procurement arrangement comply with the cleanliness requirements of contract document.

Scope includes setting up necessary cleaning facility including cleaning equipment, tools, consumable, personnel safety gear and source of supply of dry clean compressed air, steam and DM water as necessary for accomplishing the cleaning activity.

2. General requirements

The vendor shall have clean fabrication facilities (as described in this document elsewhere) required for this job. Prior experience on fabrication of large high / ultra-high vacuum components in clean room is highly desirable.

All items (including procured raw material) shall be wrapped or sealed after cleaning to maintain cleanliness throughout storage manufacturing testing, handling, transportation and. Care shall be taken to minimize exposure to corrosive environment (e.g. such as those containing chloride compounds).

No visible contaminant (viewed with naked eye under both natural and ultraviolet light) of any form shall be left within the vacuum enclosure of equipment's.

No grinding with abrasive wheels, cloth or stones is allowed on the internal vacuum surface unless specified in this specification. These supplies are intended for use in Ultra High Vacuum (UHV) application. Potential hydrocarbon contamination shall be prevented. The supplies shall be wrapped and covered at all times they are not being processed to minimize possible exposure to contaminants.

No iron, carbon steel or other contaminants (such as grease, oil or hydrocarbons) shall come in contact with the chamber interior surfaces during handling and assembly. Machining fluids shall be water soluble and free of oil and sulfur (refer table - 15).

3. Cleaning

3.1. Cleaning of components fabricated at shop –

3.1.1. Mechanical Cleaning

The components/assemblies shall be mechanically cleaned for removal of all weld tacks, sharp edges & projections, dust and particles generated during grinding.

3.1.2. Surface Cleaning

a. This shall be done after mechanical operations like cutting, bending, grinding etc. have been completed. The surfaces and ends shall be cleaned of all burrs. Only SS wire brush cleaning shall be used as necessary. Otherwise, hard nylon brushes shall be used. For internal cleaning of SS Pipes / Tubes, the brushes shall be slightly oversized than the internal diameter of the pipes. Brushing shall be alternated with compressed air in the first instance and with jet of DM water afterwards so that the loose scales are removed. Large diameter pipes shall be cleaned with hand brushes.
b. Remove gross contamination from all interior and exterior surfaces (including flange faces) by steam cleaning. Remove material markings etc. with acetone.
c. Preliminary cleaning solution wash shall follow with UHV compatible cleaning agents and rinsing in DM water.
d. Handle each piece and component with care by wearing UHV compatible clean gloves during and post cleaning.

3.1.3. Precautions in handling the materials

As a general precautionary measure, all SS items before surface treatment, shall be stored in clean racks, shelves / platforms and covered appropriately to prevent the ingress of grease, oil, dust and extraneous matter. Particularly, items meant for identified critical component (e.g. seals) shall always be handled with care so as to avoid scratch, rust stains etc. Clean gloves (replaced with new at regular interval) shall be worn while handling of materials in order to avert sweat and finger marks coming in to contact with the surface. The areas where surface treatments are carried out shall be free from dust.

Personnel shall wear as a minimum; cleanroom booties or clean boots when walking on/working in the interior surfaces of chambers, opening in assembly.

3.2. Area used during surface cleaning treatment

The vendor shall have an exclusive clean area for carrying out the surface cleaning treatment. He shall ensure to take necessary precaution for handling, exhaust of acid fumes etc. The necessary arrangements for disposal of the all the waste generated after

cleaning procedures shall be the responsibility of the vendor. This shall be clearly included in his requirements in space utilization meant for the purpose.

3.3. The cleaned chamber surface shall qualify for ultrahigh vacuum requirement after FTIR analysis report where it is specified as necessary test at the end of cleaning process. Test details and acceptable limits shall be defined and conveyed to vendors at appropriate time if they are envisaged in overall test program for assessment of cleanliness of surfaces cleaned.

4. Drying

Drying will be accomplished by blowing clean dry air over the component. (Detail specification for the dry airs will be communicated to vendor at appropriate time if necessary).

Inspect and cover the component (or the chamber) as soon after drying as possible and store in clean area. Avoid contamination from unfiltered shop air.

5. Inspection

Inspection shall be done (before removing the piece from the cleaning area) using a procedure which shall be established by vendor in consultation with purchaser and approved by purchaser.

The presence of any hydrocarbon or fingerprints on any interior surface or flange face shall be cause for rejection of supplies.

A visual inspection shall be made of exterior surfaces. Visible particulates or actual contamination shall be removed.

Immediately after inspection, cover the components with double wrap of clean, oil-free polyethylene and seal them.

ANNEXURE – 5

SPECIFICATION FOR INSPECTION AND TESTING

1. Scope

This Annexure prescribes the requirements of various inspections and tests to be conducted in the shop during the course of manufacture and before final acceptance and despatch of specified goods. These inspection and tests are primarily intended to ensure applicable execution of scope of work in conditions enacted by the governing manufacturing specification of component for ultra-high vacuum application.

2. Quality assurance, Inspection and surveillance

2.1. Quality Assurance Program (QAP) -

Quality assurance program aims to achieve quality through examination of the tasks to be performed, identification of skills required, the selection and training of appropriate personnel, the use of appropriate equipment, tool & instruments, the creation of appropriate environment in which activity can be performed and recognition of responsibility of the individual who is to perform the task. Briefly stated, then a quality assurance program shall provide a disciplined approach to all activities affecting quality, including where appropriate, verification that each task has been satisfactorily performed and that necessary corrective action have been implemented. QAP should also provide for production of documentary evidence to demonstrate that the required quality has been achieved.

2.2. Calibration of Equipment -

Vendor need to ensure following,

Measures shall be established to ensure that tools, gauges, instruments and other inspection, measuring & testing equipment & devices used in determining conformance to acceptance criterion are of proper range, type, accuracy & precision. Testing & measuring devices used in activities affecting quality shall be controlled, calibrated and adjusted at specified intervals and surrounding environment on or before use to maintain accuracy within limits. Necessary documents in support of the valid calibration shall be accompanying with each of the equipment and made available for inspection when asked by purchaser.

2.3. Qualification & Certification of NDE personnel –

Vendor need to ensure following

2.3.1. The NDE operators, inspectors and engineers shall be trained and qualified to the appropriate level to meet the requirements of ISNT / ASNT.

2.3.2. The NDE personal shall also be qualified for any special technique or procedures to be followed as per the need mentioned in examination specification or drawing

2.3.3. Responsibility of necessary Training and certification is with vendor and certification validity shall be as per applicable ISNT / ASNT standards.

2.3.4. All the air, liquids and other materials to be used at various stages of manufacture, inspection, testing, packing etc. shall be identified, checked to be free from halogen & sulfur contents as limited by the specification for stainless steel components and vendor shall get it approved at the beginning of the start of scope of work.

3. Documents to be prepared

The following are some of the important documents to be prepared by vendor and approved by the purchaser and followed to ensure appropriate execution of the work and to have records of all gathered data. The vendor can have any additional documents required by him and the purchaser can suggest for any additional documentation if felt necessary at any stage of scope work execution. All these documents shall be identified by proper numbering system for easy identification and reference.

- Manufacturing and Inspection Plan (MIP) indicating the stages of inspection and agencies to inspect and endorse reports
- Internal inspection reports for any inspection carried out (to be retained by vendor and produced when required)
- Non-destructive examination reports for radiography, Ultrasonic, vacuum leak testing etc. in the format accepted by respective specification or suggested by purchaser.
- Shop Weld Plan (SWP) with weld joint mapping identifying all the welds by proper numbering system, applicable WPS, process used, type of joint with sketch, NDT requirements & welds requiring test coupons.
- Weld data sheets, detailing all the details like joint detail, welding process, welding parameters, inspection & testing prior to, during and after welding etc.
- PMI report of all weld joints
- Weld test results for all destructive and non-destructive tests done on various test coupons, welders qualifications, procedure qualification shall be documented as prescribed in respective standards and this specification.
- List of welding qualification required for welding procedure and welders / welding operators considering all the manufacturing welds and welding positions.

- Final inspection reports for all individual parts as well as assembly.
- Report on non-conformances (to be got approved by design concession request)
- Drawings for various developments for formed parts, cutting plans for raw materials, shop drawings for various parts use in manufactures' shops, tooling drawings required at various stages of manufacture, inspection, assembly, testing, corrections, packing, transportation etc, and any other drawing required for execution on the job.
- As built drawings
- Photographs / Videography of various important operations performed through manufacture and test.

4. Inspection of Welds

4.1. Weld Data Sheet (WDS)

The vendor shall identify all the welds in a component by serial numbers indicating on a weld reference sketch. The Weld Data Sheet welding parameters shall be filled for each of these welds by vendor and shall be signed by the purchaser's as well as vendor's inspectors. The format of WDS shall be proposed by vendor and approved by purchaser.

4.2. Weld Surface –Finish

The welds shall have a regular surface. In general, all weld surfaces shall be ground smooth and merged smoothly into the adjacent base metal. However, in case the drawing calls for flush grinding for certain welds the same shall be ground flush with base metal. The weld surface finish shall be as per requirements of drawings. The weld finish shall be compared with standard surface finish plates for hand grinding.

4.3. Visual Examination

Visual Examination shall be carried out as per ASME Sec V

Weld spatter, surface cracks, surface porosity and such other defects shall not be permitted.

Lighting, natural or artificial shall be sufficient to illuminate the area being examined.

Personnel performing visual examination shall be familiar with the welding technique being used, welding procedure requirements, machining operations, and the type of discontinuities that may occur in the weld or base material being examined.

NOTE:

Unless impossible, direct visual examinations will be used for all visual examinations performed to this procedure.

In some cases, remote visual examinations may have to be substituted for direct examination.

Remote visual examinations may use visual aids such as mirrors, borescope, cameras or other suitable instruments.

4.4. Radiographic Examination

This examination shall be performed for all seal welds where they are applicable and accessible for test.

The radiographic examination shall be carried out as per ASME Sec V.

Acceptance criteria for radiographic examination shall be as per ASME Sec VIII Div 1.

4.5. Ultrasonic Examination

This examination shall be performed for all applicable seal welds where radiography cannot be performed and vice versa.

The ultrasonic examination shall be carried out as per ASME Sec V

Acceptance criteria for ultrasonic examination shall be as per ASME Sec VIII Div 1

4.6. Preferred volumetric examination

Wall Thickness (wt) (mm)	Preferred Volumetric Examination Method
wt < 8	Radiography
8 < wt < 19	Radiography or Ultrasonic
Wt > 19	Radiography or Ultrasonic
Note: For wt > 19mm ultrasonic examination of welds is preferred only in cases where radiographic examination would require excessive exposure times.	

Table 18: Range of wall thickness and preferred volumetric examination method to be applied

4.7. Liquid penetrant Examination (LPE)

This examination shall be performed on Non-seal welds and not exposed to vacuum side. This shall be reflected in the manufacturing drawings. The purchaser shall see prior permission to any weld seam to be examined by LPE.

The liquid penetrant examination shall be carried out as per ASME Sec V

Acceptance criteria for liquid penetrant examination shall be as per ASME Sec VIII Div.1

4.8. Ferrite content

Ferrite content in weld shall be limited by controlled use of welding consumables with ferrite content in the range of 5 to 8%

4.9. Repairs

Any repair welding involving grinding or grinding followed by welding shall be re-examined by all the non-destructive tests applicable to that joint. The repair shall be carried out with prior approval of purchaser or his authorized inspector and in presence of either of them.

The procedure and acceptance criteria for repaired weld remain unchanged.

5. Factory Acceptance Test

5.1. Visual and Dimensional inspection

Vendor shall be required to demonstrate the dimensional and distortion control of the component during welding. If necessary vendor should undertake welding trials using mock up pieces or scaled down model how this could be achieved. Alternately, vendor can simulate the distortion using a combination of experiments and modelling and then come up with a procedure that would not only meet the qualification requirement as per properties or weld quality but also with respect to distortion control.

5.2 Visual and Dimensional inspection

The vendor shall respect the tolerances mentioned on the drawing. He shall establish the procedure for dimensional and geometrical shape verification by identifying and defining the measuring instruments, inspection methods and accuracies of the measurement, no. of readings to be taken etc. Such procedures whenever established shall be submitted for approval of the purchaser.

The dimensional verification of parts before assembly, eventual heat treatment, or machining shall be done by the vendor. The purchaser's representative may participate in this verification. The final dimensional check shall be conducted by the vendor, in the presence of purchaser or his authorized inspector at vendor's premises and at purchaser's site.

The purchaser will take decision regarding the acceptance of parts, which are outside the tolerance limits.

All dimensions indicated on the drawings are in millimetre and at 25^0 C. The vendor shall submit to the purchaser a report on dimensional check performed. This can be in form of "as-built drawing" describing all the dimensions in its actual value. Measurement made at different temperatures of all components to be matched at site should be corrected to 25^0 C.

5.3 Helium Leak test of all seals and welds (Purchaser shall provide all the pumps and gauges on demand by vendor; Vendor shall make available MSLD for vacuum leak testing) (As per Annexure 6 of this specification)

5.4 Cleaning inspection *(As per Annexure 4 of this specification)*

5.5 Ultimate vacuum test *(As per Annexure 7 of this specification)*

ANNEXURE – 6

SPECIFICATION FOR VACUUM LEAK TESTING AND ACCEPTANCE

1. Scope

This Annexure defines the criteria for the leak testing of BSC / HAM supplied to IPR. It gives test procedure, acceptance criteria and general instruction and guidelines to vendor and inspector.

The procedure includes methods for leak checking of welded joints and the double O-ring /pumped annulus flange joints.

2. General

The leak testing methods shall use a dry (oil free) Helium Mass Spectrometer Leak Detector.

All roughing vacuum pumps and turbo pump shall be OIL-FREE Scroll type.

Gases used to back-fill evacuated parts shall be ultra-clean (5N purity N_2).

3. Reference Documents

- Leak testing standard- ASTM E498-Standard Test Methods for Leaks Using the Mass Spectrometer leak Detector
- ASME Sec. V Article 10 – Non Destructive Examination - Leak Testing

4. Certification of Personnel

The Examination shall be performed by qualified and certified personnel (ASNT Level III in leak testing).

5. Choice of Units

The measured leak rates shall be reported in mbar l/s.

6. Equipment Calibration

All equipment used in testing shall have valid calibration certificates and shall be submitted before their use.

7. General Requirements

- Chamber shall be cleaned according to Annexure 4 of this specification prior to Leak testing.
- 100% welds shall be tested for Leak testing.
- Tests shall be performed both at ambient temperature of the chamber, with the pressure differential in the same direction as for operation of the chamber.

- All required examination like Non Destructive Examination (if required) shall be done prior to Final Vacuum Leak Testing.
- In no circumstance any vacuum components of BSC / HAM chamber shall be accepted without an accepted Leak testing.

8. Vendor's responsibilities for accessories of leak testing

- The vendor is responsible for providing all tools, probes, gas, seals, blank off flanges and vacuum equipment's to perform the leak detection test and subsequent leak measurements across all vacuum boundaries (weld joint, sealed flanged joints "O" ring joints annulus space)
- The Vendor is responsible for the supply of tooling and methodologies for the subsequent removal of tools, seals, and temporary closure plates etc. fitted to chamber to facilitate the leak testing.

9. Documentation Requirements

- Vendor shall submit the Leak testing procedure which describes how the leak test will be performed and include configuration diagrams and technical specification of equipment to be used etc. to purchaser for approval.
- Vendor shall prepare leak test report and submit it for approval to the purchaser.

10. Leak Testing Methods

This Annexure describes recommended procedures for carrying out the most widely used methods of helium leak testing. Other methods may be used, but only with the prior approval of the purchaser.

10.1 Overpressure Methods

Over pressure methods enable thin walled vacuum chambers to be leak tested which might otherwise collapse under vacuum.

10.1.1 Mass spectrometer sniffing probe

Chamber subjected to leak testing is pressurized by Helium and a sampling probe "sniffs" used for detecting leaks.

Helium passing through the leak is sampled from the surrounding atmosphere through a long narrow flexible tube which is connected to a mechanical pump to give a drop in pressure from atmosphere to about 10^{-4} mbar at the ion source of a mass spectrometer detector. Traces of helium in the environment can also be detected, which may lead to errors in the measured leak rate.

The Sampling tube should be as short as possible to reduce the response time of the gas flow of the air-helium mixture from the entrance of the tube to the detector.

10.1.2 Probe leak testing

This method can be used for leak testing of welds or parts having incomplete enclosures.

A Partial enclosure which can be evacuated by a leak detector is tightly pressed against the wall of the component being tested. The enclosure is evacuated and helium tracer gas applied to the opposite surface of the wall by a spray gun or other means. Helium leaking through the wall can pass to the detector via the vacuum box. The sensitivity is usually limited by diffusion of helium through the seal between the evacuated enclosure and compound wall.

10.2 Vacuum Leak Detection Method

10.2.1 Helium Leak Detector

These are based on a mass spectrometer, usually a small magnetic sector device. Leak detection can begin only when high vacuum conditions are obtained in the mass spectrometer. The inlet pressure at the entrance to the leak detector depends on the design of the unit, but can range from atmosphere down to at least 10^{-6} mbar.

Helium is used as a tracer gas in this technique. To increase the helium detection sensitivity and improve detector stability, the mass analyzer in helium leak detection system is often de tuned to give lower mass resolution.

For large component leak testing at high sensitivity, it may be necessary to reduce the partial pressure of hydrogen at the analyzer by selectively pumping it with a getter in series with the leak detector input. It may also be necessary to selectively pump condensable gasses at the leak detector inlet. This can be achieved by the addition of a cold (i.e. liquid nitrogen) trap in series with the inlet.

11.Leak Testing Procedure

It is recommended that vendor follow the procedure as specified in “ASTM E498-Standard Test Methods for Leaks Using the Mass Spectrometer leak Detector”. However vendor may propose any other procedure which shall be subjected to approval of purchaser.

Leak checking procedure for various type of joints

Joint Categories:

Category I

Welded joint located away from the double O-ring flange assembly.

Category II

Welded joint located near the double O-ring flange assembly.

Category III

CF flange joint.

Category IV

Atmospheric O-ring (O-ring between atmosphere and annulus channel)

Category V

UHV O-ring. (O-ring between annulus channel and UHV chamber)

(a) Leak Checking of Welded Joints

All weld Joints shall be tested and shall have leak rates less than 1.0×10^{-9} mbar-l/s.

Category I

Welded joint located away from the double O-ring flange assembly.

These leaks can be detected using standard MSLD leak detection procedures with He as the tracer gas. The leak detector is sensing the vacuum chamber and He is sprayed external to the chamber.

Category II

Weld joint located near a double O-ring flange assembly.

Helium leak detection procedures are still preferred. The proposed method is to bag the O-ring flanged joint and introduce a pure nitrogen purge into the bag. This will keep the concentration of helium in the bag low in order to minimize permeation or leakage of Helium through the atmospheric O-ring seal. Maintaining a vacuum in the O-ring annulus is required to prevent helium from permeating thru the UHV O-ring and entering the vacuum chamber.

(b) Leak Checking of Conflate flange joints

All Conflates shall be tested and shall have leak rates less than 1.0×10^{-9} mbar-l/s.

Category III

Conflate flanges.

The conflate flanges can be leak checked using standard Helium MSLD procedures. As in Category II leak detection, nearby O-ring flange assemblies may need covering (enclosing) and nitrogen purging.

(c) Leak Checking O-ring sealed joints

All Annulus passages shall be capable of being pumped to less than or equal to 1×10^{-5} mbar.

Category IV

Atmospheric O-ring (O-ring between atmosphere and annulus channel)

Leak checking method

An Ion vacuum gauge will be used to sense the vacuum pressure in the pumped annulus volume between the atmospheric O-ring seal (Cat. IV) and the UHV O-ring (Cat. V). Air that leaks across or diffuses through the O-ring seals will be pumped by the test annulus pumping system. If the annulus vacuum pressure, as measured by the Ion gauge is less than or equal to 1×10^{-5} mbar, the annulus seals pass the test.

Category V

UHV O-ring (O-ring between UHV space and annulus channel)

Leak checking method

Same as Category IV O-ring leak checking method described above.

12. Acceptance Criteria

Acceptance of leak testing of component is subject to successfully completion of all stages and following conditions have been met.

- The leak detector has been correctly calibrated and its calibration value is within ±5% of the standard leak rate value as corrected for the ambient temperature.
- The test shall be carried out by qualified personnel (ASNT Level III) as stated in Clause 4 of this Annexure
- The leak rate value as measured by the leak detector has not increased in value above the measured background to a value greater than the specified leak rate during the entire duration of the global leak test.
- The location and magnitude of all identified leaks shall be recorded. All practicable efforts shall be made, after agreement with purchaser to bring down any leak quantified during the manufacturing phase to a level lower than the limit of detection of the leak testing methods used.

12.1 Acceptable Leak Rate

All Weld Joints and Conflate flanged joint shall be tested and shall have leakage rates less than 1.0×10^{-9} mbar-l/s.

13. Test Report

The Leak test report shall contain the following minimum information.

- Identification of the Manufacturer, the purchase order and equipment
- Identification of the part ,weld or the area subjected to examination
- Time/duration of Examination
- Test Equipment
- Reference to approved procedures
- Surface condition and cleanliness

- Examination condition and in particular ,calibration conditions
- Interpretation of test results
- Name and qualification/certification details of the inspector
- Identification of the subcontractor conducting the examination (if applicable)
- Date of examination and inspector's signature.

ANNEXURE – 7

SPECIFICATION FOR VACUUM REQUIREMENT

1. Vacuum pressure requirement -
   1.1 Pressure requirement during normal operation in BSC / HAM is better than or equal to 10^{-9} mbar.
   1.2 Surface treatment / preservation
   - 304/304L type stainless steel shall be handled without direct contact with carbon steel or other contaminants at all time
   - Storage, Welding. Fitting and Assembly shall be performed in clean space (class 100,000 – ISO 8 equivalent)
   - Welding exhaust fumes shall be collected and extracted outside
   - Welding wire and joints shall be cleaned with CO_2 spray before welding
   - No grinding with abrasive tools unless specified in the document, grinding allowed at weld prep area using rotary carbide tools
   - Potential contact with hydrocarbon material (like human hair, oil, grease etc.) to be prevented at all stages.
   - Fabricated component to be covered at all times when not in use
   - Machining fluids to be water soluble and free of oil and sulphur.
   - Personnel to wear clean boots when walking in the interior surface of the chamber as well as inside the clean work areas
   - Smoking not allowed at the manufacturing or fabrication area
   - Clean components shall be handled by wearing clean vacuum compatible gloves
2. Acceptance of vacuum -
   BSC chamber shall achieve a vacuum of $1x10^{-9}$ mbar

   HAM chamber shall achieve a vacuum of $1x10^{-9}$ mbar

   (The worst case scenario in ultimate vacuum achievement will be continuous permeation from the O-rings used in connecting flanges with double "O" ring as vacuum seal)

3. Leak rate requirement -
   Location wise leak rate measured for vacuum inside of BSC / HAM chambers shall be less than the indicated values below -

   - Weld joint : $< 1x10^{-9}$ mbar l/s
   - ConFlat seal joint : $< 1x10^{-9}$ mbar l/s
   - "O" ring seal joint : $< 1x10^{-9}$ mbar l/s
4. Pumping system & associated gauges (scope of supply) -
   The vacuum pumps, vacuum monitoring gauges, leak detectors, residual gas analyzer (wherever needed) will be made available by vendor during leak testing and vacuum pumping.

5. Monitoring and control system -
   Monitoring and control of the evacuation process of BSC / HAM will be manual in nature. In case of emergency shut down due to power failure, the gate valve shall isolate the chamber with vacuum pump to prevent backflow or contamination of the chamber from the vacuum pump side.

6. Vacuum baking & insulation -
   Baking of chamber at 150^0 C ($+10^0$ C) at factory site to reduce hydrogen and water vapor content from vacuum facing surface during vacuum pumping is carried out using heating elements covered with insulation. For demonstration of ultimate vacuum performance (1 X 10^{-9} mbar) of BSC / HAM chamber, equipment and instruments necessary to bake the chambers, shall be arranged by the vendor.

7. O-ring requirement -
   - Clean O-ring using standard degreasing (Liquinox or equivalent) solution for 10 minutes in an ultrasonic cleaner before their use for sealing flanges.
   - Bake for 12 hours at170^0 C in air bake oven.

8. Annulus pumping requirement -
   Annulus space between two "O" rings is to be pumped down to less than $1x10^{-5}$ mbar pressure using ion pump.

9. Surface (vacuum facing) treatment of vacuum component –

   For any of the components of UHV chambers (BSC/HAM) no further surface treatment shall be done other than that mentioned in this annexure. Surface finish of as received HRAP material shall be retained. Vendor shall obtain prior approval for any changes envisaged to the finish to the vacuum facing surface.

ANNEXURE – 8

A. VARIOUS PARTS DETAILS & LOAD SPECIFICATION FOR BSC CHAMBER

1. Scope:

The aim of this section is to put together all information for constituent part details and the loads applicable to Basic Symmetric Chamber (BSC) assembly.

2. System Description:

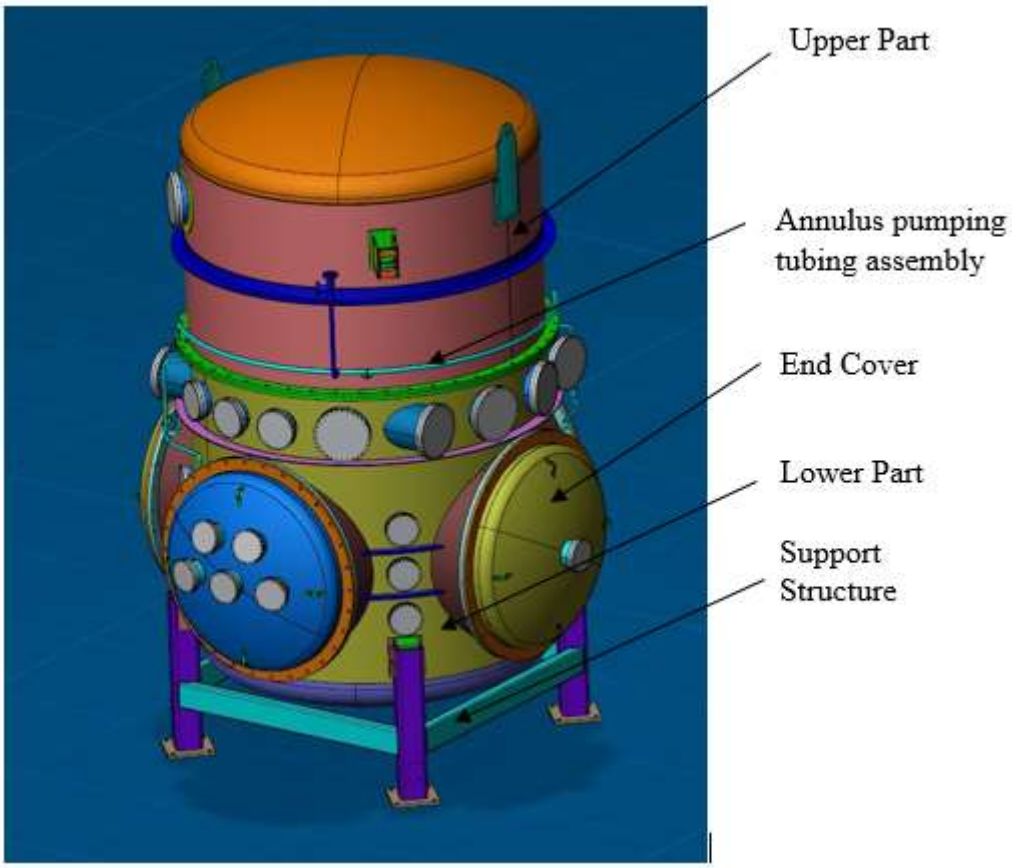

Figure 1: BSC chamber description

3. Type of Loads:

The following types of loads are applied on chamber:

- Self-weight
- Pressure load: due to difference of pressure between atmosphere pressure and inner chambers pressure
- Seismic Load

- Thermal load (baking to 150^0 C temperature before vacuum pumping)

4. Weight:

Sr. no.	Component	Value (kg)	Quantity	Application Point	Figure No.
1.	Upper part	2000	1	Top flange of lower part	2
2.	Lower part	4000	2	Ground (through Leg support)	3
3.	End covers	1800	2 + 2	Side flange of lower part	4

Table 19: Weight of Major Parts of BSC

FIGURE OF PARTS of BSC Chamber:

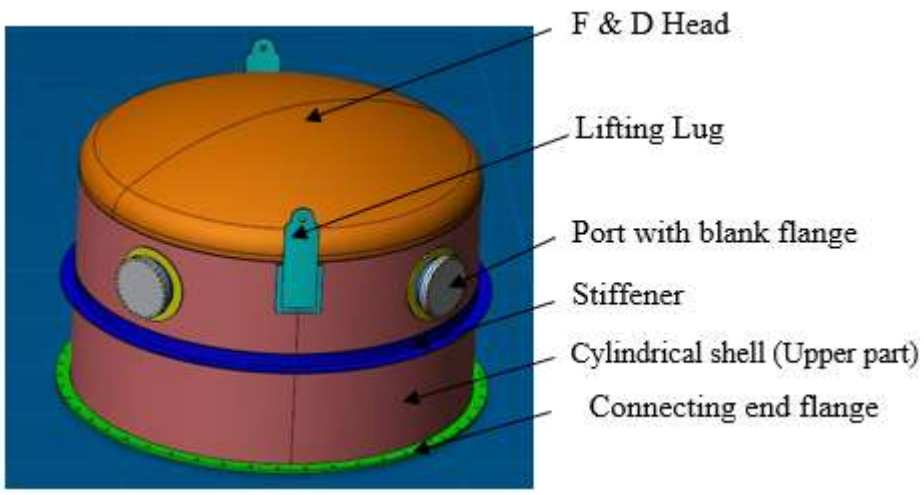

Figure 2: Upper part supported on top flange of lower part

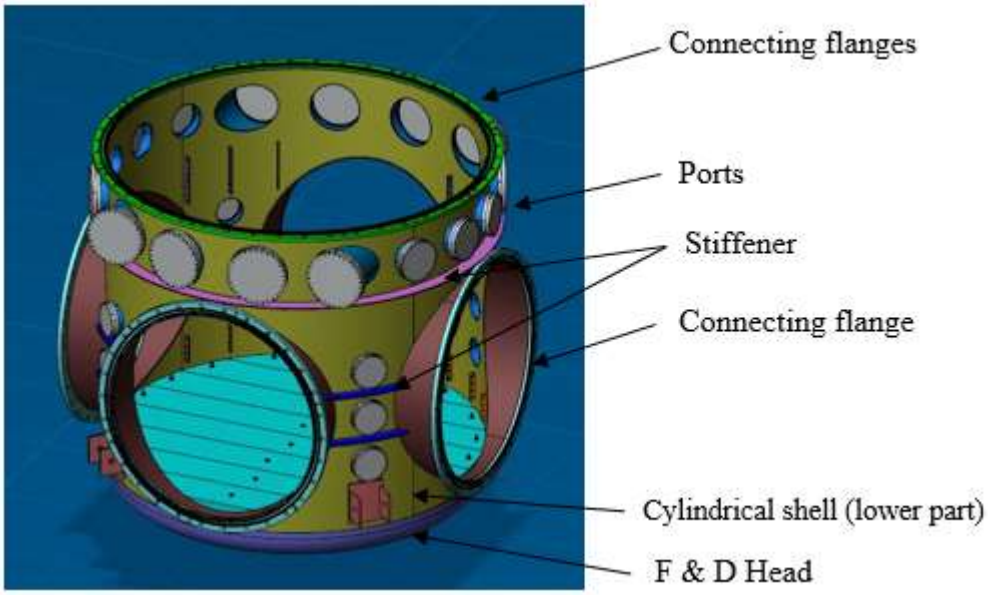

Figure 3: Lower part supported on leg support

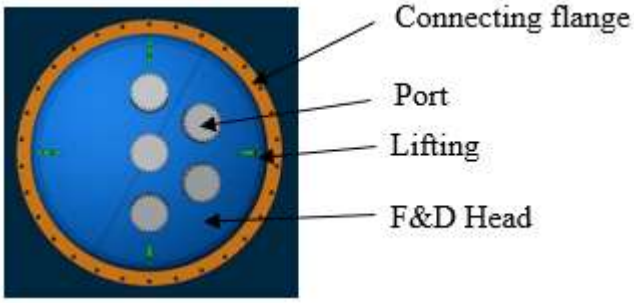

Figure 4: End cover supported on side flange of lower part

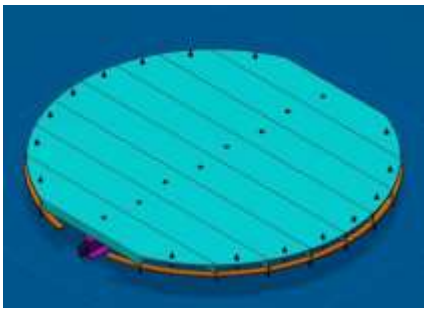

Figure 5: Floor Assembly

5. Pressure load:

5.1. Design Pressure -

Case I

Internal Pressure: 0.12 MPa (1.2 bar)

Case II

Internal pressure Ultra High Vacuum (UHV – 1.0 X 10^{-9} mbar)

External Pressure: Atmosphere

5.2. Operation Pressure -

Internal Pressure: Vacuum

External Pressure: Atmosphere

B. VARIOUS PARTS DETAILS & LOAD SPECIFICATION FOR HAM CHAMBER

1. Scope:

The aim of this section is to put together all information for constituent part details and the loads applicable to Horizontal Access Module (HAM) chamber assembly.

2. System Description:

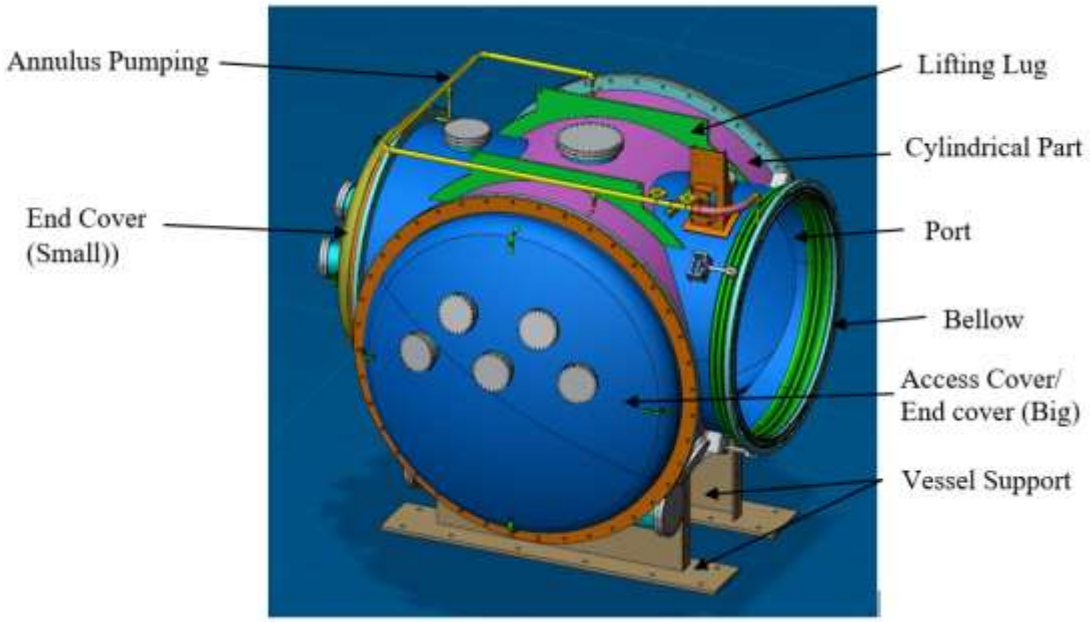

Figure 6: HAM chamber description

3. Type of Loads:

The following types of loads are applied on chamber:

- Self-weight
- Pressure load: due to difference of pressure between atmosphere pressure and inner chambers pressure
- Seismic Load
- Thermal load (baking to 150^0 C temperature before vacuum pumping)

4. Weight:

Sr. no.	Component	Value (kg)	Quantity	Application Point	Figure No.
1.	Cylindrical part	1650	01	Saddle of vessel support	7

2.	Port	800	01	Cylindrical part	8
3.	End covers (big)	600	02	Side flange of cylindrical part	9
4.	End covers (small)	350	02	End flange of cylindrical part	10

Table 20: Weight of Major Parts of HAM

FIGURE OF PARTS HAM Chamber:

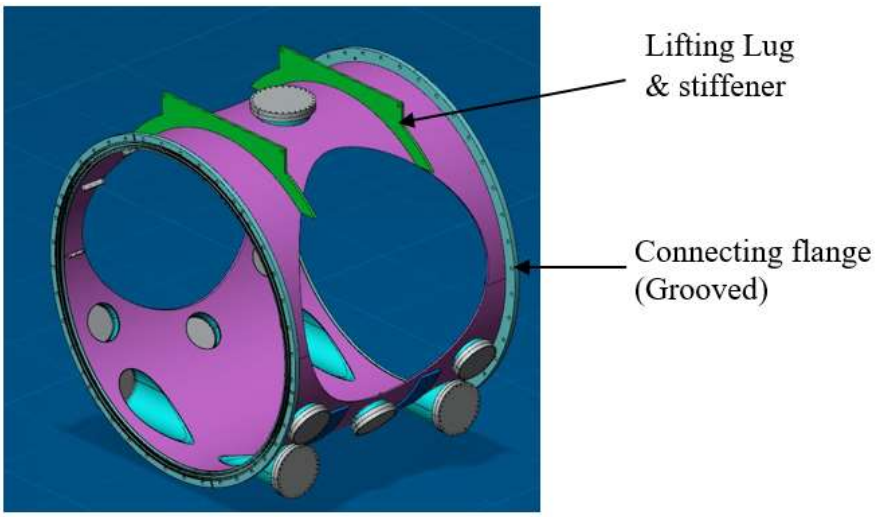

Figure 7: Cylindrical part supported on support structure

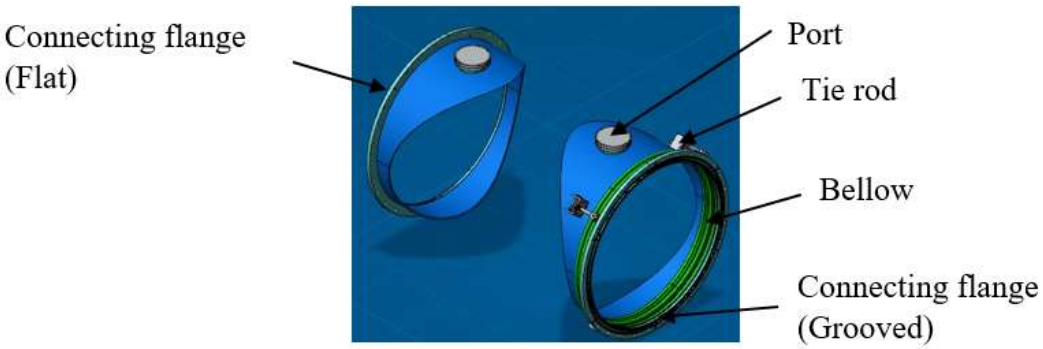

Figure 8: Port of ID 1654mm

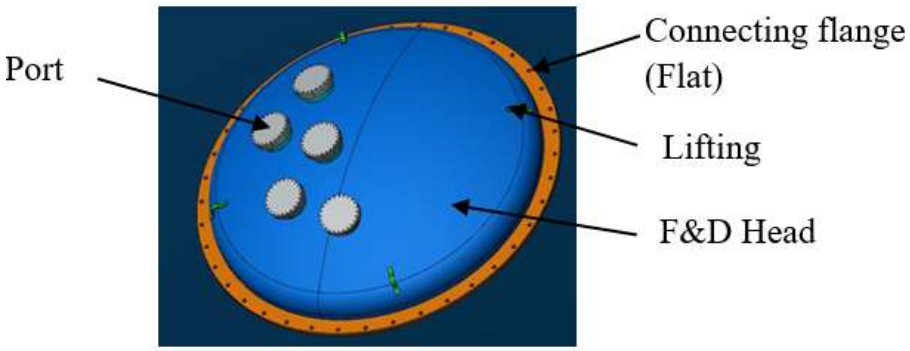

Figure 9: End covers (big)

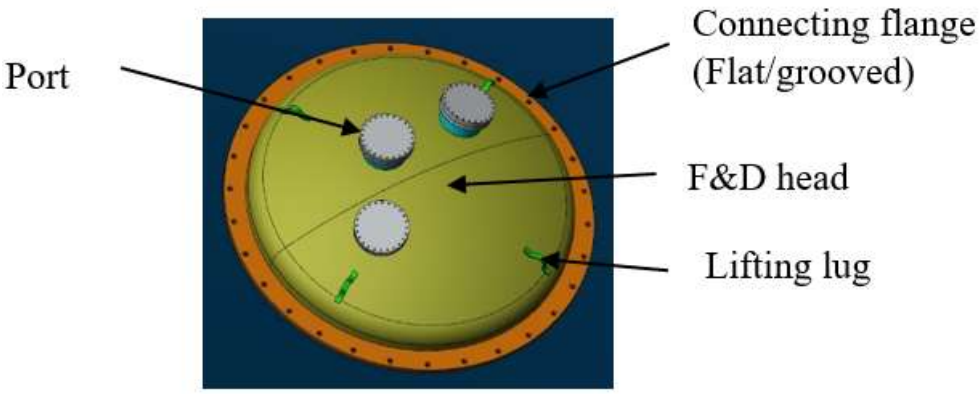

Figure 10: End covers (small)

5. Pressure load:

5.1. Design Pressure -

Case I

Internal Pressure: 0.12 MPa (1.2 bar)

Case II

Internal pressure Ultra High Vacuum (UHV – 1.0 X 10^{-9} mbar)

External Pressure: Atmosphere

5.2. Operation Pressure -

Internal Pressure: Vacuum

External Pressure: Atmosphere

ANNEXURE – 9

LIST OF DELEVERABLES

Section 3 of this document covers the scope of work for successful vendor of this procurement tender and defines the deliverable. These annexure sum-ups the list of deliverables under scope of work specified in section 3 of this document. The deliverables shall be transmitted to purchaser, in the form of soft copy and one hard copy in case of items in digital form (Table-21), in the form of physical item in case of manufactured / standard bought out items (Table-22) as listed below in details.

Vendor shall give undertaking while bidding for the tender that he agree to this list and shall comply with supply of deliverables included herein at the end of completion of scope of work under the contract.

A. Items in the digital form –

Below table list all the items which shall be transmitted to purchaser in soft copy and one hard copy of each listed item

Sr. No	Item (Applicable to both BSC and HAM)	Form of submission Unit / Quantity	Confirm Status
1.	Design appraisal report with identified proposed changes and their approval status	Report (Set)	
2.	Manufacturing drawings – Approved for manufacturing	A. Soft copy (Set) B. Hard copy (Set)	
3.	As Built Drawings (Part of end of manufacturing report)	Complete set of drawings A. Soft copy B. One set in hard copy	
4.	Material Testing – Certificates (for procured raw material and standard bought out items)	Original certified Material test reports	
5.	Material Testing – Report (for procured raw material and standard bought out items)	Complete set A. Chemical composition B. Mechanical Properties	

Sr. No	Item (Applicable to both BSC and HAM)	Form of submission Unit / Quantity	Confirm Status
6.	List of activity for which the special tool / fixture designed and manufactured for - - Machining - Fabrication - Welding - Handling / Lifting - Cleaning - Testing - Transportation - Temporary support structure to store parts of BSC in stable configuration - Temporary support structure to store parts of HAM in stable configuration	Set of tool / fixture specifically designed and manufactured to use activity covered in the scope of procurement of BSC / HAM - A. Design report (Set) B. Tool Specification including standard bought out items used in tool assembly if any C. Manufacturing Drawings D. Dimension check report E. Tool use procedure	
7.	Procedure / Qualification established – - Material traceability procedure - Manufacturing process - Weld Procedure qualification - Welding parameter used - Welding consumable details - Cleaning procedure - Cleaning consumable details - NDE procedure details - Assembly procedure for BSC - Assembly procedure for HAM - Dimensional stability control procedure - Packing procedure	One soft copy and one hard copy of approved procedures and qualifications performed during the scope of work execution	
8.	Testing and Inspection report – - Dimension check report for individual part of BSC / HAM - Dimension check report for assembly of BSC / HAM - Visual inspection report	Report containing each of following covering total scope of procurement of BSC/HAM A. Visual inspection for part/assembly B. Dimension check for parts (Set)	

Sr. No	Item (Applicable to both BSC and HAM)	Form of submission Unit / Quantity	Confirm Status
	- NDE test report	C. Dimension check for assembly (Set) D. NDE testing for raw material E. NDE test reports for welding	
9.	Vacuum Leak Testing – - List and specifications of equipment and instruments used - Vacuum leak test report with details of magnitude of leak detected and its location	Report containing vacuum leak testing records for parts, weld joint and assembly of BSC/HAM chambers A. Substantiated leak test results with identified location, magnitude with acceptance status B. In case of non-accepted vacuum leak recorded details of repairs and outcome of further leak test record status	
10.	Ultimate Vacuum Demonstration – - List and specifications of equipment and instruments used - Pump down curve covering duration to achieve 1 X 10^{-9} mbar pressure inside chamber	Report consisting of 1. List of used equipment 2. Technical specification of equipment 3. Pump down procedure adopted 4. Pump down curve covering vacuum pumping duration until realisation of 1X10^{-9} mbar ultimate vacuum	
11.	End of manufacturing report – - Digital photograph of critical operations and stages	Report consisting of 1. Nonconformity report 2. Deviation/Change request with their resolution status	

Sr. No	Item (Applicable to both BSC and HAM)	Form of submission Unit / Quantity	Confirm Status
	- Video covering material procurement stage till the demonstration of ultimate vacuum in BSC / HAM - Nonconformity report covering duration of entire scope of work	3. As Built Drawing set 4. Specified set of digital photographs in soft copies on storage media 5. Specified video in soft copy on storage media	

Table 21: List of Deliverables

B. Items in the physical form –

Items included in below tables are the physical items. These items along with temporary support structure to store dismantled parts of BSC & HAM in stable configuration when these chambers are opened (listed at serial no 6 in Table 21: List of Deliverable) shall be transported and delivered to RRCAT, Indore after FAT and dispatch clearance in the form of complete assembly of one number of BSC and one number of HAM:

1. Assembly of Basic Symmetric Chamber (BSC) Chamber:

Sr. No.	Parts name	Total no required
1	Upper part	01
2	Lower part	01
3	End cover Type A11	02
4	End cover Type 1	02
5	Annulus Tubing Assembly	01 set
6	Floor Assembly	01
7	Nut, Bolt, Washer (set)	As specified in BoM in approved Manufacturing drawing and additional quantity of 15% (set) as spare packed separately
8	ConFlat (CF) blank flange of different size with set of fasteners	As specified in BoM in approved Manufacturing drawing and one additional flange of each type as spare packed separately

Sr. No.	Parts name	Total no required
9	Vacuum Seals – "O" Ring and ConFlat (CF) copper gaskets	As specified in BoM in approved Manufacturing drawing and additional 1 set of "O" rings and CF gasket per joint as spare

Table 22: List of Deliverables – BSC Assembly

2. Assembly of Horizontal Access Module (HAM) Chamber:

Sr. No.	Parts name	Total Quantity (no. off / Set)
1	HAM shell (cylindrical part with big port)	01
2	Support	01 set
3	End cover (Small)	02
4	End cover (BIG)	02
5	Annulus Tubing Assembly	01 set
6	Set of Nut, Bolt and Washer per flange	As specified in BoM in approved Manufacturing drawing and additional quantity of 15% (set) as spare packed separately
7	ConFlat (CF) blank flange of different size	As specified in BoM in approved Manufacturing drawing and one additional flange of each type as spare packed separately
8	Vacuum Seals – "O" Ring and ConFlat (CF) copper gaskets	As specified in BoM in approved Manufacturing drawing and additional 1 set of "O" rings and CF gasket per joint as spare

Table 23: List of Deliverables – HAM Assembly

Vendor shall provide guarantee of performance of Assembly of BSC and HAM for period of one year at least from the date of site acceptance after delivery.

All the listed items included in table 22 & 23 above shall be delivered in assembled form (except spares).

(Complete assembly each of the chamber i.e. BSC and HAM, with all openings / ports covered and sealed with blank off flanges and "O" ring / metals gasket seals. Internal volume of the

chamber shall be filled with the dry nitrogen (5N purity) gas up to 1.2 bar pressure and suitably connected with pressure gauge to monitor internal pressure and observe leakage if any).
Tools which are used as attachments between parts of chamber and handling during lifting **(e.g. shackles, lifting ropes or chains etc.)** shall be part of deliverables to enable handling of deliverable at delivery site which is RRCAT, Indore, Madhya Pradesh.

All the custom built tools and fixtures used during execution of scope of work shall be part of deliverable and will be delivered at IPR, Gandhinagar, Gujarat.

List of ABBREVIATION's used in document

AC: After Completing (of activity)
ASME: American Society of Mechanical Engineers
ASNT: American Society for Nondestructive Testing
ASTM: American Society for Testing and Materials
AOD: Argon Oxygen Decarburization
BSC: Basic Symmetric Chamber
BS: Before Start (of Manufacturing)
BOM: Bill of Material
CAD: Computer Aided Design
CF: ConFlat (CF) Flange
CS: Carbon Steel
DM: Demineralization
DR: Deviation Requests
EF: End of the Factory acceptance
F&D: Flanged and Dished
GTAW: Gas Tungsten Arc Welding
H: Hold Point
HAM: Horizontal Access Module
IPR: Institute for Plasma Research
ISNT: Indian Society for Non-Destructive Testing
ISO: International Standards Organization
KOM: Kick of Meeting
LIGO: Laser Interferometer Gravitational Wave Observatory
LOI: letter of Intent
LPT: Liquid Penetration Test
MSLD: Mass Spectrometer Leak Detector
N: Notification point
NDE: Nondestructive Examination
NDT: Non Destructive Testing
MIP: Manufacturing and Inspection Plan
OD: Outer Diameter

OFHC: Oxygen Free High Conductivity (Copper)

PAW: Plasma Arc Welding

PQR: Procedure Qualification Record

PMI: Positive Metal Identification

PPM: Part Per Million

PWHT: Post Weld Heat Treatment

QAP: Quality Assurance Plan

QP: Quality Plan

RGA: Residual Gas Analyzer

RMS: Root Mean Square

SS: Stainless Steel

SWP: Shop Weld Plan

UHV: Ultra High Vacuum

VOD: Vacuum Oxygen Decarburization

WDS: Weld Data Sheet

WOPQ: Welding Operator Performance Qualification

WPQ: Welder Performance Qualification

WPS: Welding Procedure Specification