INSTITUTE FOR PLASMA RESEARCH

Technical Specifications
SECTION 'C'

Fabrication, testing, supply, assembly, integration, installation & commissioning of Cryogenic Twin Screw Extruder System at IPR site

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1. INTRODUCTION

Institute for Plasma Research is pursuing the development of a twin extruder based pellet injector system. The system comprises a small twin screw extruder operating at cryogenic temperature of < 20 K. It freezes hydrogen from gas to solid and extrudes the hydrogen filament of diameter < 4 mm. The extrusion takes place by the rotation of screw. Torque from motor is transferred to the screw. The challenge lies in precession fabrication of screw and its rest stands. As the operation of the screw is at < 20 K the precise gap is to be maintained between the barrel housing and the screw. Frictional loads can bring non uniformity in temperature distribution along the length of the barrel housing the screw which may affect the solid rod extrusion of hydrogen ice and result in slouch formation. Precession fabrication of the screw and its alignment is another challenge. Any deviation in the alignment can result in friction.

2. VENDOR QUALIFICATION ON WORK EXPERIENCE IN RELAVANT FIELDS

The twin screw cryogenic extruder system involves know how in the field of high vacuum ~ 10^{-7} mbar with perfect leak tightness of various tubes, connections and sub-sections carrying hydrogen in the gaseous, liquid and solid form with the safety measures to be taken in case of any leak detected.

It also involves knowledge in the field of cryogenic engineering with thermal contraction and expansion of materials and the stress thereby developed during the thermal cycling the system undergoes in its operation from room temperature to < 20 K.

The system requires precession fabrication experience for its twin screw part operating at cryogenic temperatures < 20 K taking care of alignment and micron level accuracies with no play and undergoing a routine warm up till room temperature.

3. SYSTEM DESCRIPTION

In a twin screw based pellet injector system room temperature hydrogen gas is initially precooled in LN2 based 80K pre-cooler. From pre-cooler the gas at 80 K is fed to 40K pre-cooler mounted on 1st stage of Cryocooler. Hydrogen gas brought to 40 K is then liquefied in the liquefier section mounted on the 2nd stage of cryo-cooler. The liquefier is coupled with solidifier made of OFHC copper comprising the extruder section. The solidifier section uses the 2nd stage of second cryo-cooler to bring down the temperature below < 20 K. The twin screw in the extruder is a pair of counter rotating screw driven by servomotor. Solid hydrogen rod is extruded by rotating the screw from a nozzle. With pneumatic fast valve based cutter synchronized with filament flow pellets are produced at predetermined frequency. The screw extruder can extrude the solid hydrogen rod continuously with pre-cooling, liquefaction, and solidification of hydrogen in its different sub systems working in complete synchronization. The diameter of the cylindrical solid hydrogen rod can be selected as 2.5mm or 3.0mm by

changing the nozzle size. The die shape may be circular or rectangular and size is based on required pellet dimensions.

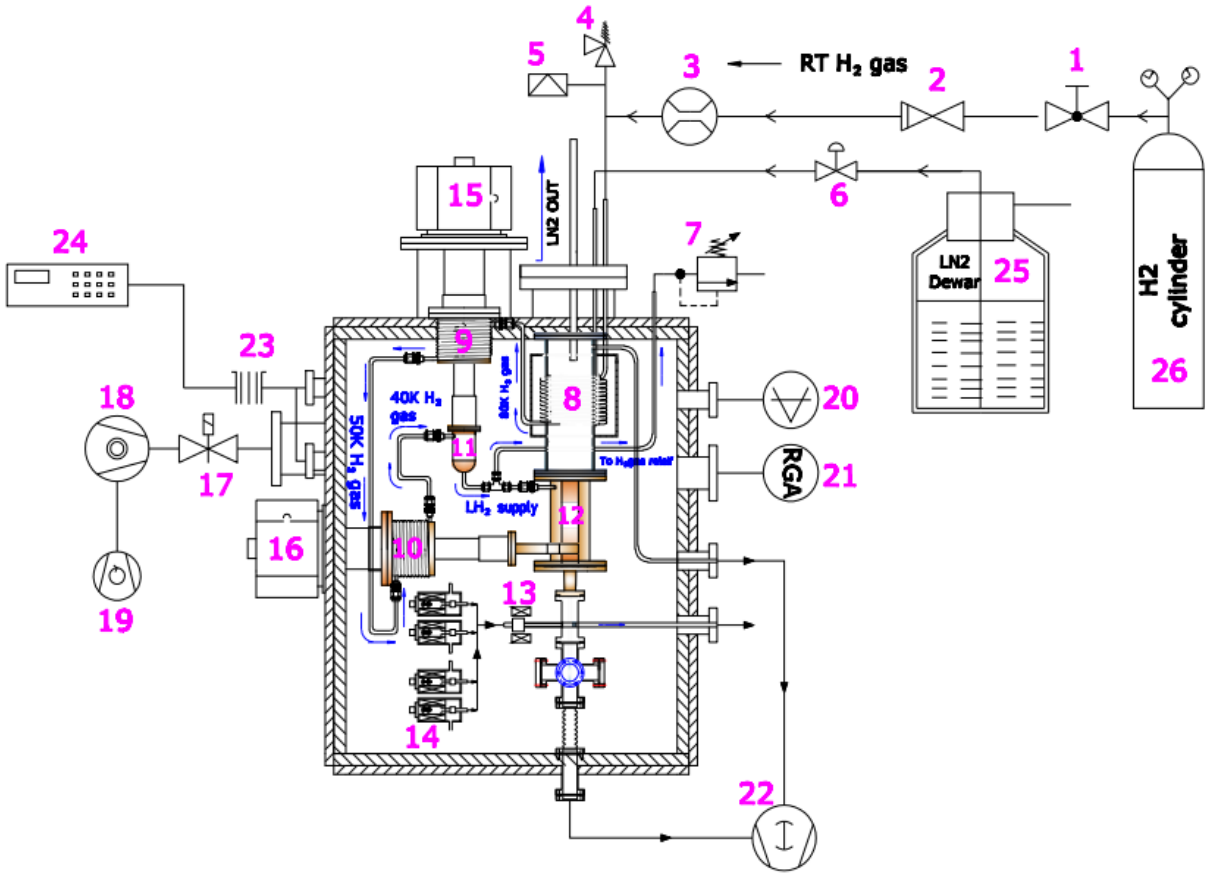

Figure 1 : Schematic of ETPIS (1.Shut-off valve, 2.Safety shut-off valve, 3.Flow control & measurement, 4.Safety pressure relief valve, 5.Bursting disk, 6.Flow control valve, 7.Press control & release valve, 8. 80K pre-cooler, 9. 40K pre-cooler, 10. 40K pre-cooler_C2, 11.LH2 receiver vessel, 12.OFHC barrel with screw pair, 13.Coaxial cutting device, 14.Fast opening valve, 15.Cryo cooler_C1, 16.Cryo cooler_C2, 17.Solenoid gate valve, 18.TMP, 19.Rotary Pump, 20.Full range gauge, 21.RGA, 22.Roots blower Pump, 23.Ele.feed through, 24.Temp.Monitor, 25.LN2 Dewar, 26.Hydrogen gas cylinder.

4. DESCRIPTION OF WORK INVOLVED

The work in the above said tender involves fabrication of precision machined twin screw components (Shown in figures below) made of OFHC copper. The assembly is required to be tested at liquid nitrogen temperature for its functionality and friction less operation taking into account thermal contraction etc as per specified parameters. The complete assembly will be housed in cuboid shaped cryostat for integrated operation under vacuum and cryogenic conditions. Precaution for hydrogen safety is required in all the welded and brazed components.

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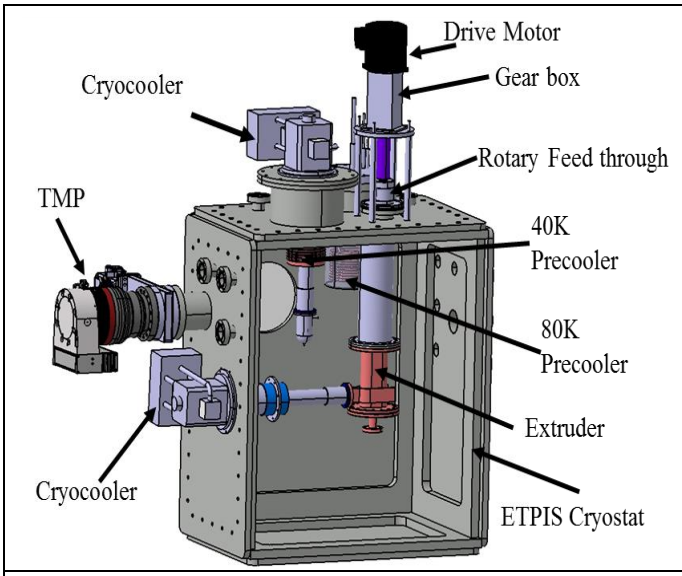
<td> 
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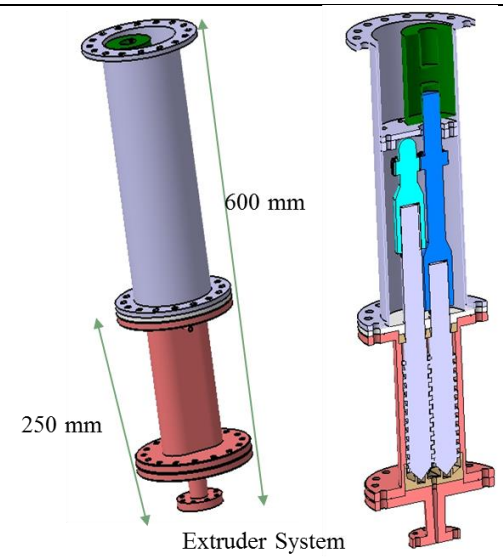
<td> 
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<td>Extruder assembly</td>
<td>Twin-Screw assembly</td>
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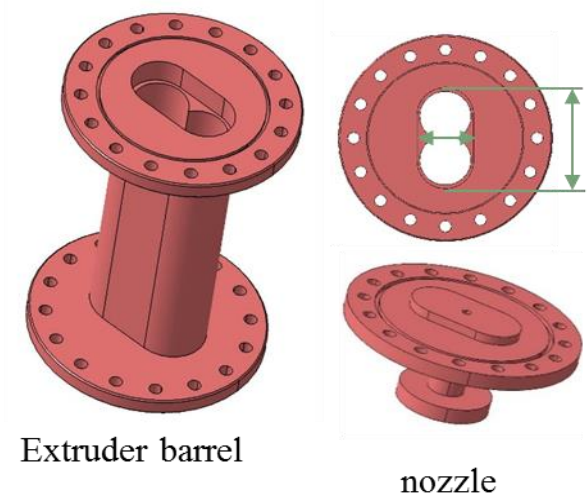
<td> 
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<td>Single piece OFHC screw barrel nozzle assembly with flange</td>
<td>Precision machined screw support made of brass</td>
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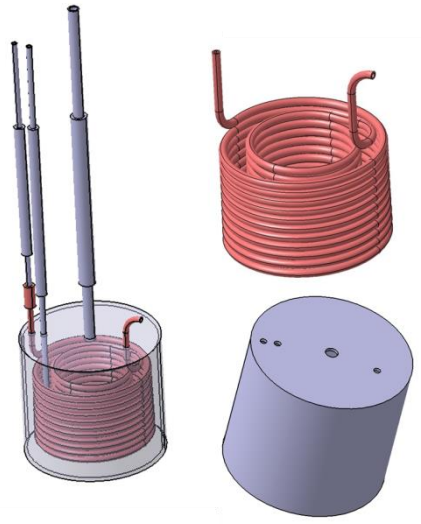
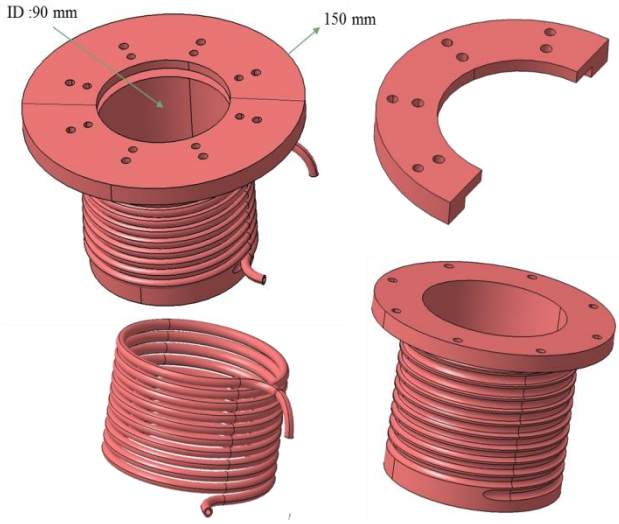
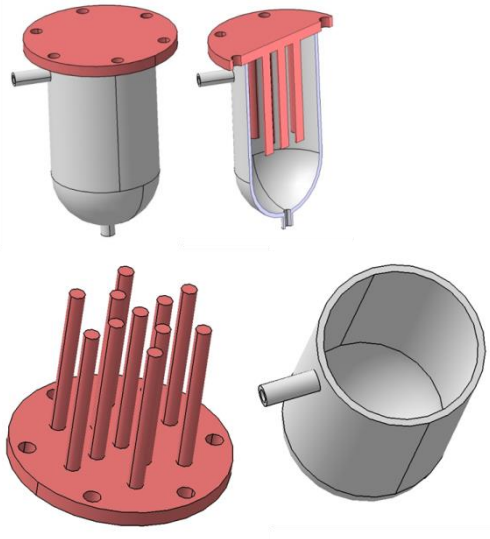
</td><td>  </td></tr>
<tr><td>Gear shaft and twin screw with splines</td><td>Precooler for hydrogen at LN2 temperature</td></tr>
<tr><td> 
</td><td>  </td></tr>
<tr><td>40K precooler components</td><td>Hydrogen Liquefier components</td></tr>
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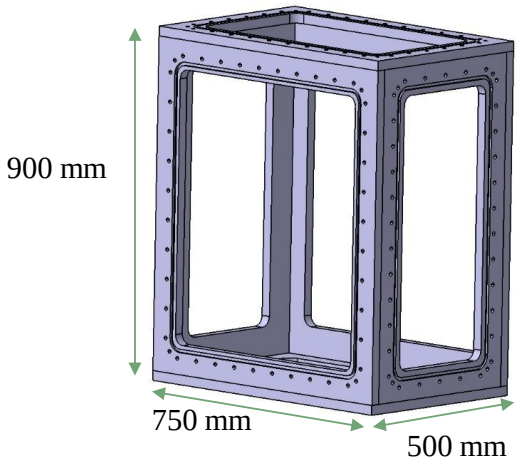
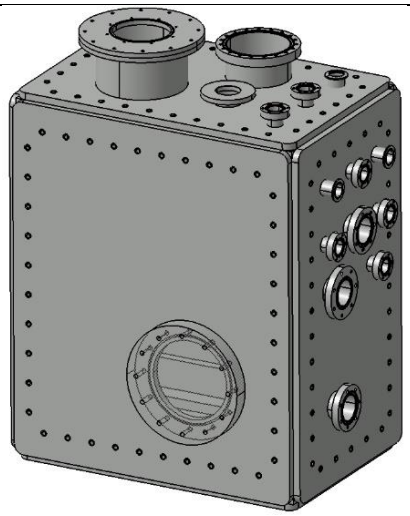
	
Cuboid shaped cryostat	**Cryostat frame**

5. SCOPE OF WORK AND QUALITY ASSURANCE PLAN

The scope of work includes manufacturing drawing, fabrication of sub components, testing of the subcomponents, assembly of subcomponents, testing of complete assembly for vacuum leak tightness and cryogenic operation at liquid nitrogen temperature with thermal cycling to room temperature, safe transportation and assembly, integration and commissioning at IPR. Vendor shall carryout all subtasks mentioned below:-

- Preparation and submission of Fabrication/ production drawings of "**Precision Fabrication of Cryogenic Twin Screw Extruder system** ". Base level drawings along with the dimensions will be provided by IPR. The concept of the design provided by IPR will be adhered to by the vendor.
- Vendor will provide IPR with a detail list of vacuum fittings for example flanges gaskets etc, thin pipes, pipe fitting (VCR fittings), fixers, bolts etc. The list of items will be submitted to IPR with the details of make to be procured and get approval from IPR as the fittings have to be compatible with safety for hydrogen flow.
- Vendor will provide process chart of the fabrication process and on approval by IPR will initiate the fabrication
- Vendor will provide the methodology used to test the subcomponents for vacuum compatibility and also submit a test report of vacuum leak tightness of subcomponents. On getting approval from IPR vendor will proceed for assembling the subcomponents.
- Vendor will provide the assembly and disassembly sequence of subcomponents to IPR
- Vendor will provide the test report of vacuum leak tightness after assembling the subcomponents.

- Schematic of the complete system with its subcomponents is shown in Fig 1 and the system is to be assembled with subcomponents at appropriately placed.
- Factory testing of the components and assembly as per the section 9 “Factory testing procedure and reports”.
- Cryocoolers units inserted in the cryostat through port number 15 and 16 of cryostat as shown in figure 1. At these locations vendor will provide blank flanges (for vacuum testing) and support stands (for holding 40K precoolers and liquefier for assembly and performance testing).
- Complete assembly of the twin screw extruder system with cryostat (as shown in Figure 1)
- Complete twin screw extruder assembly along with the cryostat will be placed on a support structure with extruded aluminum section of height 500 mm. The vendor will be responsible to provide the same. If IPR has to extend the support structure during Installation depending on the assembly criticality at IPR, vendors will have to do all arrangements for the same.)

- All the fabricated components will be tested for leak tightness and assembled in the cryostat chamber.
- Performance testing for twin-screw operation at room temperature and Liquid Nitrogen (LN2) temperature.
- Factory Acceptance Tests (FAT)/Pre-Dispatch Inspection (PDI) as per the mentioned qualification tests in section 10 “FAT/PDI Test conditions and reports”
- Vendor will be responsible for Packaging and forwarding the fabricated components and assemblies.
- Installation and Testing at IPR as per the test procedure mentioned in section 11 “Acceptance test condition and reports”

5.1 QUALITY ASSURANCE PLAN

- Vendor must identify the process of fabrication and technical criticalities and the same must be conveyed to IPR
- Vendor shall submit detailed time schedule along with fabrication drawings to IPR for approval.
- The time schedule should include all the activities like fabrication, testing, inspection, supply and testing at IPR.
- Final approved time schedule and fabrication drawings shall be strictly adhered.
- Any deviations, with supporting record/drawings shall be submitted to IPR before the start of fabrication.
- Vendors are requested to bring to notice of IPR about the details of works that will be outsourced.
- Vendor will submit the list of vacuum fittings and pipe fittings etc to IPR and will take approval from IPR before procurement.

- All the required documents as specified in the different sections of this document should be submitted for IPR.

6. CODES AND STANDARDS TO BE FOLLOWED

- For welding procedure qualification, welders' qualification and all other welding details ASME - Sec. - IX shall be followed
- For testing methods ASME - Sec. - V shall be followed
- Material should be according to relevant ASTM standard
- ASME Section VIII shall be used for Design, fabrication, inspection, testing and acceptance
- Ultra high vacuum and hydrogen safety precautions must be followed

7. TECHNICAL SPECIFICATION AND DRAWINGS OF COMPONENTS

This section includes the technical specification of various components and bill of material along with the drawing details.

7.1 Technical Specifications of Different Components

7.1.1 80K pre-cooler

- Purpose: Precooling hydrogen gas down to 80K from 300K
- Working temperature: 300-80K
- Material: Copper for inner coil and SS304 for housing
- **Fabrication requirement:** Compact copper coil assembly having inner coil and outer coil as per the given dimension and mentioned tolerance. **(As per the drawing reference: 80 K Precooler Assembly and parts)**
- Adapter: Flange mounted from the Top plate of the cryostat
- Helical coil dimension: Coil Dia 80mm and Dia 120mm concentric (Single pipe coil with no pinch condition)
- Pipe: Id 4mm and OD 6.35mm standard pipe with smooth inner finish
- Leak tightness: <5e-10 mbar-ltr/s in vacuum mode MSLD or <5e-6 mbar-ltr/s in sniffer mode before and after thermal cycling down to 77K
- Joint: Copper to SS standard joint (high content Silver BFM) for the above leak tightness and temperature
- End couplings: SS VCR fittings male at inlet and outlet

7.1.2 40K pre-cooler

- Purpose: Precooling hydrogen down to 40K from 80K
- Working temperature: 80K-40K
- Height: 91mm
- Material: OFHC copper

- Fabrication requirement: Helical cut on the extension body as per the given dimension and mentioned tolerance **(As per the drawing reference: 40 K Precooler Assembly & parts)**
- Coil pipe must be brazed (high content Silver BFM) on the helical groove of the extension body
- Adapter: Conducting OFHC flange
- Helical coil dimension: Pitch 7.5mm, Height 75
- Leak tightness: <5e-10 mbar-ltr/s in vacuum mode MSLD or <5e-6 mbar-ltr/s in sniffer mode before and after thermal cycling down to 77K
- Joint: Copper to SS standard joint(high content Silver BFM) for the above leak tightness and temperature
- End couplings: SS VCR fittings male at inlet and outlet

7.1.3 H2 Liquefier

- Purpose: Liquefying hydrogen at ~20K
- Working temperature: 40-15K
- Material: OFHC copper
- Fabrication requirement: Compact assembly with condensing fins **(As per the drawing reference: H2 Liquifier Assembly & parts)**
- Adapter: Flange mounted from the Cold head of cryocooler
- Leak tightness: <5e-10 mbar-ltr/s in vacuum mode MSLD or <5e-6 mbar-ltr/s in sniffer mode before and after thermal cycling down to 77K
- Joint: Copper to SS standard joint(high content Silver BFM) for the above leak tightness and temperature
- End couplings: SS VCR fittings male at inlet and outlet

7.1.4 Extruder:

A. Extruder Screw:

- Type: Clockwise and anti-clockwise
- Operating: Counter-rotating
- Screw root diameter : 28mm
- Width: 4.8mm
- Cavity width: 4.8mm
- Depth: 4mm
- Pitch: 10mm
- Material: SS304
- Number of splines: 12
- Fabrication requirement: Given dimension and mentioned tolerance must be followed **(As per the drawing reference: Extruder screw clockwise and anti-clockwise)**

B. Extruder Gear Shaft

- Type: Driving shaft and driven shaft
- Purpose: Gear with internal spline for screw rotation
- Material: SS304
- Gear Module: 2
- Spline slots: 12
- Fabrication requirement: **(As per the drawing reference: extruder driving and driven gear shaft)**

C. Barrel

- Purpose: Housing twin screw assembly
- Material: OFHC copper
- Fabrication requirement: Single piece fabrication with internal screw cavity with required tolerance and surface finish (Ra value below <1µm). Given dimension and mentioned tolerance must be followed **(As per the drawing reference: extruder barrel)**
- Height: 185mm
- Flange Diameter: 152mm
- Flange connection: Indium sealing with set pin arrangement for alignment
- Leak tightness: <5e-10 mbar-ltr/s in vacuum mode MSLD or <5e-6 mbar-ltr/s in sniffer mode before and after thermal cycling down to 77K
- Joint: Copper to SS standard joint (high content Silver BFM) for the above leak tightness and temperature
- Fluid inlet connection: : SS VCR fittings male connector

D. Screw Top & Bottom Support:

- Purpose: Supporting twin screw assembly
- Material: Brass
- Fabrication requirement: Single piece fabrication with required tolerance and surface finish (Ra value below <1µm) with axial deviation and center distance for proper functionality of screw. **(As per the drawing reference: Twin screw top support and bottom support)**

E. Thermal Link

- Purpose: High efficiency thermal linking of barrel to cryocooler
- Material: OFHC copper
- Fabrication requirement: Single piece fabrication with required dimensions. **(As per the drawing reference: Extruder thermal link)**
- Length: 147mm
- Connecting flange diameter: 68mm

F. Nozzle

- Purpose: Extruding solid hydrogen with increasing pressure
- Material: OFHC copper
- Fabrication requirement: Single piece fabrication with required dimensions. Tapered hole through the nozzle. **(As per the drawing reference: Extruder nozzle)**
- Length: 50mm
- Flange Diameter: 152mm (top) and 34mm (bottom)
- Flange connection: Indium sealing

G. Vespel Insulator

- Purpose: Sealing cum insulator for barrel to stand off
- Material: Vespel SP21
- Fabrication requirement: Single piece fabrication with required dimensions and tolerances with smooth finish **(As per the drawing reference: Vespel insulator)**
- OD: 152 mm
- Flange connection: Indium sealing

H. Thermal Break

- Purpose: Torque transmission with thermal insulation through motor shaft
- Material: ABS
- Fabrication requirement: Single piece fabrication with required dimensions and tolerances with smooth finish. **(As per the drawing reference: Extruder Thermal break)**
- OD: 50 mm
- Length: 100mm
- Connection: Key way connection

7.1.5 Extruder Stand off

- Purpose: Housing of gear and thermal break, vacuum insulation, support to driven shaft
- Material: SS304
- Fabrication requirement: As per required dimensions and tolerances with smooth finish. **(As per the drawing reference: Extruder Stand Off Assembly & parts)**
- Connections: Top side rotatable CF fittings and indium sealing at bottom with set pin arrangement for alignment
- Length: 330mm
- Flange OD: 152mm
- Leak tightness: <5e-10 mbar-ltr/s in vacuum mode MSLD or <5e-6 mbar-ltr/s in sniffer mode before and after thermal cycling down to 77K

7.1.6 Cryostat

- Purpose: Vacuum enclosure for extruder assembly and components
- Material: SS304
- Dimension: 900mmx750mmx500mm
- Fabrication requirement: Cuboid shaped vacuum chamber with internal rib structure. Single piece rectangular cover plates with necessary ports having surface finish (Ra value below <1µm). **(As per the drawing reference: Cuboid Vaccum Chamber & parts)**
- Operating Vacuum level: ≤ 5E-6mbar
- Leak tightness: <5e-10 mbar-ltr/s in vacuum mode MSLD or <5e-6 mbar-ltr/s in sniffer mode
- Support structure: Fabrication of a 500mm high support structure with extruded aluminum section
- Flanges and ports: All flanges should be as per drawing with suitable blank flanges for vacuum and leak tightness.
- Handling Options: Set pin arrangement for each plate mounting to rib structure, Provision for pick and placement hook

Note:

1. **All the components should be as per the drawings and all the standard components like flanges should be fabricated as per applicable standards.**
2. **Compatibility and Interchangeability of the components:** Interchangeability of Fabricated components should be matched with standards mentioned or as per IPR drawings.
3. All detailed technical specifications are included in drawings. All the other fabrication related details have to be worked out by vendor and approval should be taken from IPR.
4. Any damage to the free issue material will be at vendor's account.
5. Strict tolerances and dimensional accuracy is mandatory.
6. Internal connections, VCR fittings, indium sealing, blank flanges and necessary equipment must be supplied by the vendors for factory and site acceptance tests.\

7.2 LIST OF DRAWINGS & BILL OF MATERIAL

Following conceptual drawings are being supplied by IPR along with this tender document.

SR No.	TITLE	DWG No.	MATERIAL	QTY
1	**80 K Precooler Assembly**	**80KPRECOOLER-010**	**Multiple**	**1**
a	CU-SS Pipe Joint	80KPR00ECOOLER-001	OFHC Copper	1
b	H2 Inlet Jacket	80KPRECOOLER-002	SS-304	1
c	LN2 Inlet Jacket	80KPRECOOLER-003	SS-304	1
d	LN2 Outlet Jacket	80KPRECOOLER-004	SS-304	1
e	Precooler LN2 Dewar	80KPRECOOLER-005	SS-304	1
f	LN2 Inlet Pipe	80KPRECOOLER-006	SS-304	1
g	LN2 Outlet Jacket	80KPRECOOLER-007	SS-304	1
h	H2 Precooler Coil First Stage	80KPRECOOLER-008	Copper	1
i	H2 Inlet Pipe	80KPRECOOLER-009	SS-304	1
2	**40 K Precooler Assembly**	**40KPRECOOLER-004**	**Multiple**	**2**
a	Cryocooler First Stage Extension	40KPRECOOLER-001	OFHC Copper	2
b	Secound Stage H2 Precooler	40KPRECOOLER-002	OFHC Copper	2
c	Conductive Flange Secound Stage H2-1	40KPRECOOLER-003	OFHC Copper	2
d	Conductive Flange Secound Stage H2-2	40KPRECOOLER-004	OFHC Copper	2
3	**H2 Liquifier Assembly**	**HLIQUIFIER-003**	**Multiple**	**1**
a	Condensor Vessel	HLIQUIFIER-001	OFHC Copper	1
b	Condensor Vessel	HLIQUIFIER-002	OFHC Copper	1
4	**Extruder Type Pellet Injection System**	**ETPIS-001**	**Multiple**	**1**
a	Extruder Assembly	ETPIS-EXTRUDER-001	Multiple	1
b	Thermal Break	ETPIS-EXTRUDER-002	ABS	2
c	Driving Gear Shaft	ETPIS-EXTRUDER-003	SS-304	1
d	Driven Gear Shaft	ETPIS-EXTRUDER-004	SS-304	1
e	Vespel Insulator	ETPIS-EXTRUDER-005	Vespel SP21	2
f	Twin Screw Top Support	ETPIS-EXTRUDER-006	Brass	3
g	Screw (Anticlockwise)	ETPIS-EXTRUDER-007	SS-304	1
h	Screw (clockwise)	ETPIS-EXTRUDER-008	SS-304	1
h	Extruder Barrel	ETPIS-EXTRUDER-009	OFHC Copper	1
i	Screw Bottom Support	ETPIS-EXTRUDER-010	Bronze	3
j	Extruder Nozzle	ETPIS-EXTRUDER-011	OFHC Copper	1

k	Extruder Thermal Link	ETPIS-EXTRUDER-012	OFHC Copper	1
5	**Extruder Stand Off Assembly**	**ESO-006**	**Multiple**	**1**
a	16 CF Flange	ESO-001	SS-304	1
b	16 CF Neck Pipe	ESO-002	SS-304	1
c	Driven Gear Shaft Top Support	ESO-003	SS-304	1
d	Extruder Vessel Weld	ESO-004	SS-304	1
e	Extruder Vessel Support	ESO-005	SS-304	1
6	**Cuboid Vaccum Chamber**	**ETPIS-CRYOSTAT-001**	**SS-304**	**1**
a	Cube Frame	ETPIS-CRYOSTAT-002	SS-304	1
b	Front Frame	ETPIS-CRYOSTAT-003	SS-304	2
c	Right Side Frame	ETPIS-CRYOSTAT-004	SS-304	2
d	Top Frame	ETPIS-CRYOSTAT-005	SS-304	2
e	Front Plate	ETPIS-CRYOSTAT-006	SS-304	1
f	Bottom Plate	ETPIS-CRYOSTAT-007	SS-304	1
g	Back Plate	ETPIS-CRYOSTAT-008	SS-304	1
h	Left Plate	ETPIS-CRYOSTAT-009	SS-304	1
i	Left Plate Assembly	ETPIS-CRYOSTAT-010	SS-304	1
j	Right Side Plate	ETPIS-CRYOSTAT-011	SS-304	1
k	Right Side Plate Assembly	ETPIS-CRYOSTAT-012	SS-304	1
l	Top Plate	ETPIS-CRYOSTAT-013	SS-304	1
m	Top Plate Assembly	ETPIS-CRYOSTAT-014	SS-304	1
n	View Port	ETPIS-CRYOSTAT-015	SS-304	2
o	Gear Box Mount Plaate	ETPIS-CRYOSTAT-016	SS-304	1
p	Gear Box Stud	ETPIS-CRYOSTAT-017	SS-304	1

8. MATERIAL AND FABRICATION PROCESS TO BE FOLLOWED

8.1 MATERIAL

- The cryostat chamber, flanges and other components should be made up of the material as indicated under technical specification section 7.
- Any other material which needs to be used from vendor side should be UHV compatible and is subjected to IPR approval.
- Inside surfaces of the cryostat chamber and other components shall have mirror finish and suitable good finish on the outside surfaces.
- The material shall be tested by the vendor in procured condition for its chemical, physical and mechanical properties as well as for any internal defect.

- Vendor shall submit these test certificates to IPR for approval before starting any fabrication work. Materials should be according to relevant ASTM standard.

The procurement of all the tools, fixtures, jigs, equipment's, motor couplings, material, test gases, cryogens (LN2) etc.; required for the fabrication, inspection, testing, supply and erection at IPR shall be in the scope of vendor.

8.2 MATERIAL UNDER PROCURMENT

- All the fittings including VCR fittings, SS pipes must be of Swagelok make
- Vacuum feed through should be compatible to UHV application
- 4-wire Pt-100 temperature sensor for 77K temperature measurement

8.3 Free Issue Material

- Servomotor with servo drive and gearbox for factory and acceptance tests.
- Rotary feed-through.
  Servomotor, gearbox and rotary feed through Specification are given in annexure-1
- ***Transport of Material under FIM with insurance is under/on vendor's scope (Total cost of the FIM will be Rs. 4,00,000/-)***

8.4 FABRICATION PROCEDURE

All welding involved in the fabrication of the vacuum vessel shall be carried out in accordance with applicable code or approved equivalent codes as mentioned in the **section 6** of this document.
The following practice shall be followed for all welding/fabrication:-

- Before welding all parts should be cleaned with detergent and finally cleaned with acetone or 1:1:1 trichloroethane
- As specified in the drawings all welds to be done on Material SS 304 should be according to ASME - Sec. IX.
- Trapped volume should be avoided during welding. Full penetration weld should be employed wherever it is possible.
- Single pass weld up to a maximum extent is preferred. Interruption during welding should be reduced to a minimum possible extent.
- If leak develops; weld should be ground off with the base metal and re-welded.
- Filler material, if used, should be compatible with the parent material.
- All welds should be ground smooth and flush with adjoining surfaces with convex curvature with adjoining wall everywhere prior to leak test.
- The welding shall be carried out only by qualified welders
- Pickling and passivation, of all the components shall be done with nitric acid or HF. And they shall be followed by detergent cleaning.
- All inner surfaces exposed to high vacuum shall be grounded to 0.5 micrometer surface finish.

9. FACTORY TESTING PROCEDURE AND REPORTS

- All the fabrication drawings completed with dimensions and tolerances shall be checked and should be submitted to IPR for necessary approval.
- All the raw materials as mentioned in Section 4 to be used for the fabrication shall be tested for their chemical composition, physical properties and mechanical properties. All the test certificates shall be submitted to IPR for approval.
- After fabrication of all the components, they shall be inspected for dimensional accuracy as per approved drawings and specifications.
- Radiography Test (RT) shall be carried out on all the possible welds as per ASME Sec. V. and the reports needs to be submitted to IPR for approval.
- Dye penetration test (DPT) shall be carried out on all weld joints on the root pass only. Inspection reports shall be submitted to IPR for approval.
- The components shall be Helium leak tested for any leak with He spray technique and the reports should be submitted to IPR.
- Vacuum leak testing with an acceptable leak rate ≤ 5e-9 mbar-ltr/s as a global for the cryostat with twin screw assembly
- Local leak rate of ≤5e-10 mbar-ltr/s for all the welded and brazed areas and assembly sections
- Thermal cycling of the screw-barrel assembly with flow of liquid nitrogen through the channels
- Temperature measurement upto ~ 77K at four different location of the twin screw assembly (Will be informed to vendor before PDI)
- Friction–free smooth operation of twin-screw assembly with maximum 15 RPM for half an hour continuous operation at 300K and ~77K
- IPR authority / representative shall have access to all manufacturing facilities, inspection and testing facilities, tools, drawings etc.; during all stages of manufacturing.

10. FAT/PDI TEST CONDITIONS AND REPORTS

- All the assembly components will checked for the physical verification of items to be supplied
- Vacuum leak testing with an acceptable leak rate ≤ 5e-9 mbar-ltr/s as a global for the cryostat with twin screw assembly
- Local leak rate of ≤5e-10 mbar-ltr/s for all the welded and brazed areas and assembly sections
- Thermal cycling of the screw-barrel assembly with flow of liquid nitrogen through the channels
- Temperature measurement upto 77K at four different location of the twin screw assembly (Will be informed to vendor before PDI)
- Friction–free smooth operation of twin-screw assembly with maximum 15 RPM for half an hour continuous operation at 300K and at 77K
- Any modification and re-fabrication must be under vendor’s scope
- All the components shall be delivered only after issue of ‘Release of Shipment’.

- This document shall be issued by IPR authority / representative after verification of dimensions, testing, etc.; to one's satisfaction of compliance with drawings, specifications and functional requirements.

11. SITE ACCEPTANCE TEST CONDITION AND REPORTS

- Vacuum leak testing with an acceptable leak rate ≤ 5e-9 mbar-ltr/s as a global for the cryostat with twin screw assembly
- Local leak rate of ≤5e-10 mbar-ltr/s for all the welded and brazed areas and assembly sections
- Thermal cycling of the screw-barrel assembly with flow of liquid nitrogen through the channels
- Installation of GM cryocoolers and necessary assembly and modification at IPR site.
- Friction–free smooth operation of twin-screw assembly with 2-15 RPM for half an hour continuous operation with IPR servo motors at 300K and at 77K.
- Any modification and re-fabrication must be under vendor's scope

12. INSSURANCE, PACKING AND SUPPLY

- Contractor will pack all the components with the proper material to avoid damages during transportation.
- All components will be cleaned thoroughly with detergent and dried before packing.
- Contractor will obtain 'Release of Shipment' from IPR authority before supply of the material to IPR.
- The transfer Insurance will be in the scope of vendor.

13. GUARANTEE

- Contractor shall give guarantee for the manufacturing defects and leak rate performance of the fabricated components for minimum twelve months from the date of final acceptance.
- During this period any deviation in performance due to manufacturing defects occurs vendor shall rectify it at no extra cost.

14. DELIVERY SCHEDULE

- Fabrication drawings to be submitted within 2 months from the date of LOI/Purchase order.
- The complete system should be delivered within10 months from the date of approval of drawings by IPR.
- Assembly, integration, installation and commissioning of the system should be made within 2 months after delivery of material at IPR.

15. ANNEXURE-1 : SPECIFICATION OF SERVO-MOTOR AND GEAR BOX (Free Issue Material)

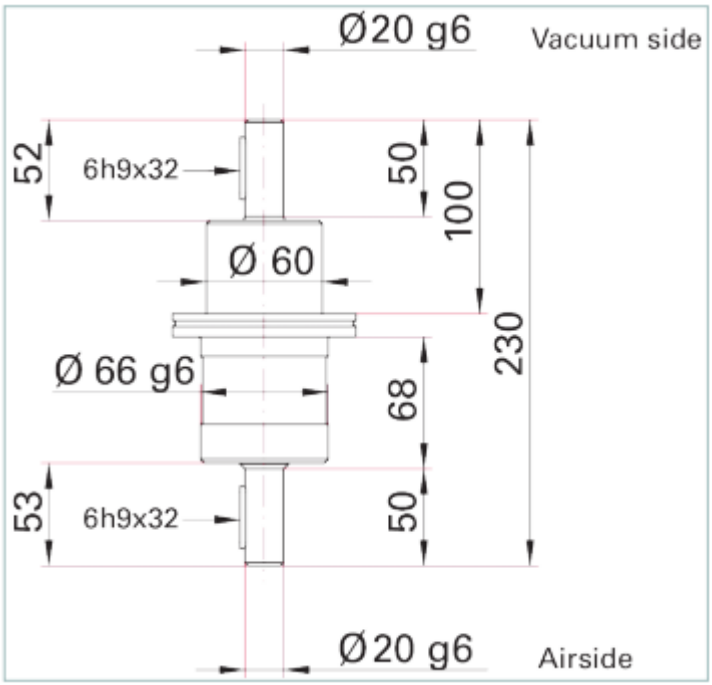
Specification for Servo Motor

Sr. No.	Parameter	Requirement
1	Motor Type	AC Servo
2	Stall Torque (Continuous)	11.4 N-m
3	Stall Current (Continuous)	19.1 A
4	Rated RPM	5000
5	Peak Stall Torque	29.8 N-m
6	Peak Stall Current	57.4 A
7	Rated Motor Power	3.08 kW
8	Max. Rated Voltage	480 VAC
9	Standard IP rating	IP40
10	Shaft Dimension(Dia. & Length)	24 mm & 50 mm
11	Motor Dimension (Dia. & Length)	108 mm x 234.5 mm
12	Holding Brake	Yes
13	Brake Torque (N-m)	14.5 N-m
14	Motor Weight	7.4 kg
15	Feedback Device	SFD
16	Compatibility with Drive	AKD Series
17	Accessories (motor connector compatible)	Power Cable with brake : 6 m SFD Cable: 6 m

Specification for Gearbox

Sr. No.	Parameter	IPR requirement
1	Gear Ratio	16:1
2	Backlash	5 arc-min
3	Efficiency	90 %
4	Flange/ Frame square	115 mm
5	Input shaft diameter	24 mm
6	Output shaft diameter	32 mm
7	Output shaft length	72 mm
8	Key way (L x H)	50 mm x 35 mm
9	Key square	10 mm
10	Pilot diameter	110 mm
11	Pilot length	12 mm
12	Weight	8.0 kg

SPECIFICATION OF ROTARY FEEDTHROUGH (Free Issue Material)



Technical Data	DD 063 A, Rotary feedthrough, DN 63 ISO-K
Bakeout temperature	110 °C
Feedthrough	FPM
Material	Housing: aluminum; shaft: stainless steel
Mounting orientation	any
Nominal diameter	DN 63 ISO-K
Operating temperature	50 °C
Pressure range	$1 \cdot 10^{-8}$ hPa to ambient pressure
Rotation speed	500 min^{-1}
Seal	FKM
Shaft connection	ø 20 x 50 mm
Shaft load, axial	100 N
Shaft load, radial	500 N
Transferable torque	100 Nm
Weight	2 kg | 4.41 lb