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Technical Specifications
SECTION 'C'

Title	UHV Compatible Motorized Manipulation System (Launcher)

Institute for Plasma Research

Bhat, Gandhinagar-382428

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1. Introduction :

This system is used for the movement of the microwave beam in vacuum system (tokamak) along two directions. There are two mirrors used in the system: reflecting (plane) and focusing mirror. As shown in fig1, the beam first incidents on focusing mirror which focuses the beam and the reflecting mirror changes the direction of beam in two axis.

This system consists of one vacuum chamber and a cover plate with the assembly of mirrors and other mechanisms. The reflecting mirror, which in in UHV, is rotatable around two perpendicular axis (shown in fig2). They are named poloidal and toroidal axis for identification purpose (similar to x and y-axis). The mirror is rotated along two axis by two individual dedicated motors. The motion can be transferred to mirrors through mechanisms. Two motors with suitable drives and a motion controller can be used in the system.

The mirrors are installed in ultra high vacuum (UHV) while the motors are in atmosphere. The UHV compatible encoders are used to measure the angular position of mirror along two different axis. Ceramic bearings can be used to reduce the friction wherever required. All the components inside the UHV are made up of non-magnetic materials.

The criticality of the system is that the poloidal movement of the mirror which is around ±10° should be completed in 100 ms time.

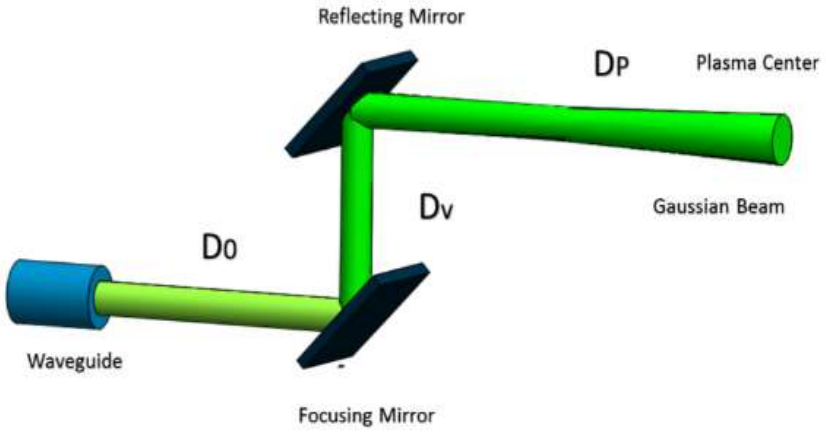

Fig 1: Schematic of launcher system

The angular positions of mirror and motors will be compared through encoders installed on mirror and motor and the backlash will be estimated. The laser beam will be incident on reflecting mirror from view port and the position of the reflected beam will be recorded on another view port which will allow to verify the accurate movement of the mirrors.

The design of the system may consider UHV compatible wet/dry lubrication. The vendor MUST ensure NOT to use any kind of grease or lubrication within the system without

appropriate approval from IPR. The vendor should ensure to maintain a clean room environment during fabrication of the system. Post Fabrication, necessary surface treatment should be provided by the vendor to ensure vacuum compatibility of the system.

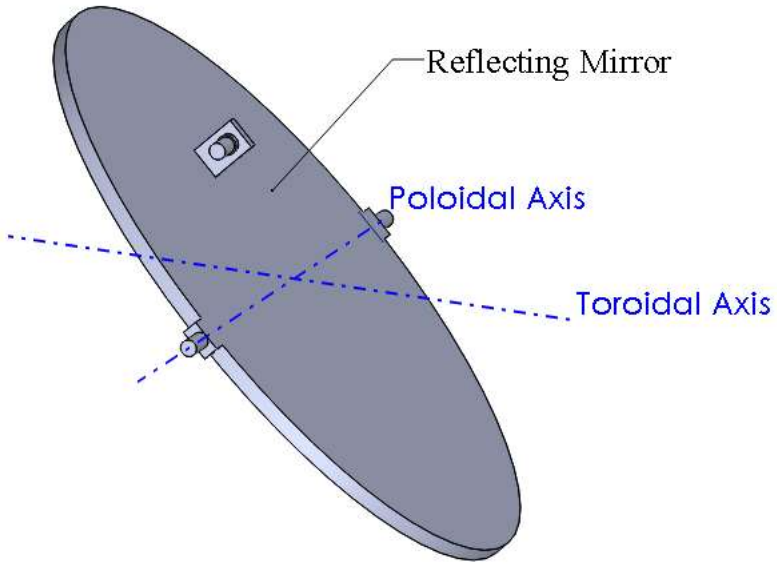

Fig 2: Reflecting Mirror with both axis

Note: Poloidal and toroidal terms are used to refer to componentS of two different drive lines. It has no relation with the functionality of the components.

Reference design is explained in annexure 1. Vendor has to suggest and implement appropriate design to meet below mentioned technical requirements.

2. Technical Requirements

This section deals with the detailed technical specifications of the UHV compatible motorized manipulation system (Launcher). Bidders are required to provide corresponding specification value and information as requested against each specification. The technical specifications are categorized based on the functions.

Sr No	Specification	IPR's Requirement
1	**Fabrication of vacuum chamber as per drawing IPR/17/A3/ECRH/8078 (sheet 6)**	
	Operating Pressure	Atm. To 1×10-8 mbar
	Material	SS304L (material test certificate required)
	Baking Compatibility	Up to 150 degree centigrade
2	**Fabrication of reflecting mirror as per drawing IPR/17/A3/ECRH/8078 (sheet 13)**	
	Material	SS 304L (material test certificate required)
	Dimensions	Ellipse with minor radius = 70mm and Major radius = 100 mm, Thickness 5 mm
	Surface finish on reflecting side (Ra)	0.5 micrometer or better
3	**Fabrication of focusing mirror as per drawing IPR/17/A3/ECRH/8078 (sheet 14)**	
	Material	SS 304L (material test certificate required)
	Dimensions	Ellipse with minor radius = 70mm and Major radius = 100 mm, Thickness 10 mm and radius of curvature = 1.8 m
	Surface finish on reflecting side (Ra)	0.5 micrometer or better

3	**Movement of the reflecting mirror in vacuum**	
	Poloidal movement speed	±10° (i.e. total 20°)in 100 ms over entire range from any poloidal location
	Total Poloidal movement	±20° (home position 0° is when mirror is at 45° to coverplate)
	Toroidal movement speed	±50° in 10 sec
	Operating vacuum range	Atm. To 1×10^{-8} mbar
	Minimum no. of cycles (for both axis) before first service/ replacement	10000
4	**Vacuum compatible Encoders for both axis (Poloidal and toroidal-mirror side)**	
	Accuracy	0.01 degree or better
	Operating pressure	Atm. To 1×10-8 mbar
	Bake out temp	120°centigrade max
	Protocol	Compatible with motor controller or readable in Labview
	Type	Absolute
5	**Electrical/Instrumentation feedthroughs for taking encoder signals**	
	Connection	25 KF (preferable) other sizes allowed if it can be accommodated in the system. But, only KF connection is required.
	Pins	According to number of pins in rotary encoder
	Operating pressure	Atm. To 1×10-8 mbar
	Bake out Temperature	Max 150 degree centigrade
	Operating Temperature	10 to 50 degree centigrade
6	**SS/AL test stand with PU/SS wheels**	
	Material	SS or Aluminum extruded channels
	height	Around 1 meter
	Wheels	PU or SS wheels

	Other requirement	Provision to mound Turbo Molecular pump(150CF) at one of the 100 CF flange
7	**View Port -1**	
	Connection	100 CF
	Lens Dia	3.5 inch or more
	Flange material	SS304L,SS316L,SS304,SS316
	Vacuum range	Atm to 1×10^{-8} torr
	Temperature Range	15 to 150 °C
	Other characteristic	Transparent to visible light
	Transmission for visible range	80% or more
	Window material	Glass or sapphire
8	**View Port -2**	
	Connection	100 CF
	Lens Diameter	2 inch or more
	Flange material	SS304L,SS316L,SS304,SS316
	Vacuum range	Atm to 1×10^{-8} torr
	Temperature Range	15 to 150 °C
	Other characteristic	Transparent to visible light
	Transmission for visible range	80% or more
	Window material	Glass or sapphire
9	**Other Requirements**	
	Electro polishing	Electro polishing is must on vacuum exposed surfaces
	Documentation	Proper documents operation manuals, troubleshooting manuals of all sub components should be provided
	Material Test Certificates	Material test certificates of all the materials should be provided before starting fabrication
	Magnetic field compatibility	The components (except vacuum compatible encoders) are exposed to **magnetic filed of Bx=600 ,By=0.6 and Bz = 60 gauss**. Hence they should be compatible to this field and proper shielding should be provided wherever required. (X axis is along poloidal axis and Y along toroidal)

	Material Properties	All the materials (except the shielding material used for motor etc.) should be non-magnetic and all the materials in vacuum should be UHV compatible
	Surface finish	Surface finish of vacuum exposed surfaces should be better than 3 micron
	Outgassing rate	Total outgassing(of entire system with all components) rate after baking at 150 ° centigrade should be less than 3×10^{-8} mbar lit/s
	Reports to be submitted	FAT (in presence of IPR personal), SAT, operational sequence, manufacturing procedure for entire system
	Encoders	Absolute encoders on load(mirror) as well as prime mover side (i.e. motor) with minimum accuracy of 0.01° for both axis.
	Control Requirements	Whole system should work remotely with independent software (application)
		All measurements data of motor or mirror movement with given accuracy should be displayed in GUI
		System should be capable of being operated through PC/Laptop sitting at 50 meter away
	Guarantee	12 months from the date of final acceptance for poor workmanship, faulty material, malfunctioning of any electronic, electrical or mechanical component etc. If fault occurs during this period, contractor will rectify without any extra cost.
10	**Spare Items**	
	Wire Seal	5
	Ball screw and nut	1*
	Bush and bearings	3 per each used *
	Motor	1 per each used *
	Coupling	2 per each used *
	Bellow	1 per each used *

*Spares for only those components which are used in the system have to be provided

3. Scope of work:

The scope of work includes the below mentioned activities to be carried out by vendor.

- Design of the entire system as per technical requirements mentioned above.
- Generation of 2D fabrication drawings, bill of materials (BOM), 3D CAD model, write ups and approval of the same from IPR.
- Procurements of all necessary materials, items and equipments with test certificates, whenever applicable.
- Fabrication and assembly of all the components.
- Testing & Inspection of the materials, parts, components & sub-assembly at appropriate stages before the final assembly. Supply of appropriate test report to IPR
- Demonstration of mentioned tests before dispatch. (FAT, mentioned in sec 4) and submission of test report to IPR.
- Packaging and delivery of components to IPR with appropriate unloading instructions at IPR site.
- Re-assembly of all the components at IPR in case of transportation of the system in assembled condition is not possible.
- Demonstration of SAT (mentioned in sec 4.2) and submission of test report to IPR.
- Measurement of final backless error for both the axis at factory and site.
- Source code and software (preferably in labview) has to be provided by vendor with system to run it remotely through desktop or laptop.

Note:

- List of works mentioned above to be carried out by vendor as per technical specification/drawings under purchaser's supervision and guidance. For any required deviation from this procedure, prior permission of IPR is must.
- Vendor will discuss the fabrication methodology with IPR authority and will give complete breakup of activities, facilities to be used and time schedule. Periodical review of work progress/status with IPR is mandatory.
- Procurement of bought out items (bearings, bushes, vacuum feedthroughs, motors, controllers, drives etc.) should be from original manufacturer or their authorized agents.

4. Acceptance Criteria

4.1 Factory Acceptance Test (FAT)

- Proper working of all components and dimensional check
- Leak tightness of whole assembly. Leak must be less than 1×10^{-8} mbar l/s
- UHV testing. Vacuum level upto 1×10^{-8} mbar has to be demonstrated before dispatch

- Full span movement of reflecting mirror along both axis in above mentioned time scales. This will be repeated for at least 1000 cycles. The accuracy should be better than 0.5° (mirror side) for both the directions and backlash not more than 0.2°.
- Full span working and control of system with remote software as well as manually.

4.2 Site Acceptance Test (SAT)

- Visual inspection , dimensional check and proper working of all components as per specification
- Leak tightness of whole assembly. Leak must be less than 1×10^{-8} mbar l/s
- Full span movement of reflecting mirror along both axis in above mentioned time scales. The accuracy should be better than 0.5° (mirror side) for both the directions and backlash not more than 0.2°.
- UHV testing. Vacuum level upto 1×10^{-8} mbar has to be demonstrated.
- Full span working and control of system with remote software as well as manually.

Note: Consumables like gaskets, wire seals etc. for FAT and SAT have to be provided by vendor.

5. Schedule:

- Vendor should submit the design details along with drawings within 45 days from the reception of PO.
- IPR will give the comments/acceptance of the drawing within in 15 days after receiving it from the vendor.
- After the acceptance of drawings from IPR, vendor can start the fabrication.
- Vendor should inform IPR for the Factory acceptance test/PDI at the vendor/factory site well in advance preferably 20 days before.
- The delivery of the system should be within 4 months from the date of acceptance of drawings.
- Reassembly of the system should be done within three weeks from dispatch.
- Final acceptance will be given after carrying out all the acceptance tests at IPR.

6. Intellectual Property Rights:

- All the Intellectual Property Rights for design and fabrication methodology of the system will be owned by IPR and it cannot be replicated without IPR's consent.

7. Annexure 1 (Design for Reference)

1. Description of the system:

The mirror is rotated along two axis by two individual dedicated motors. The motion is transferred to mirrors through mechanisms. Two motors with suitable drives and a motion controller will be used in the system.

The drivelines are as follows

1) Motor (Poloidal) → Ball screw →Bellow → linkages → Reflecting (Plane) Mirror
2) Motor (Toroidal) → Rotary feedthrough → Spur Gear → Reflecting (Plane) Mirror

The mirrors are installed in ultra high vacuum (UHV) while the motors are in atmosphere. The UHV compatible encoders are used to measure the angular position of mirror along two different axis. Ceramic bearings are used to reduce the friction wherever required. All the components inside the UHV are made up of non-magnetic materials.

2. List of the Components:

The following list explains the components used in the system

Sr. No.	Name of the Component	Quantity
1	Vacuum chamber	1
2	Cover plate with motor mountings	1
3	UHV Bellow	1
4	Rotary feedthrough	1
5	Motors (Poloidal and Toroidal)	2
6	Programmable motion controller	1
7	Servo Drives suitable with motors	2
8	UHV compatible gears	2
9	Ball screw	1
10	Vacuum Compatible encoders	2
11	Electrical feedthrough	As per requirement
12	UHV bearings	4
13	Reflecting Mirror	1
14	View Port-1	1
15	View Port-2	1
16	Focusing Mirror	1
17	SS/Al test stand with PU/SS wheels	1
18	Flanges	As per given details
19	Other small miscellaneous components	As per the drawings

3. CAD model of the system

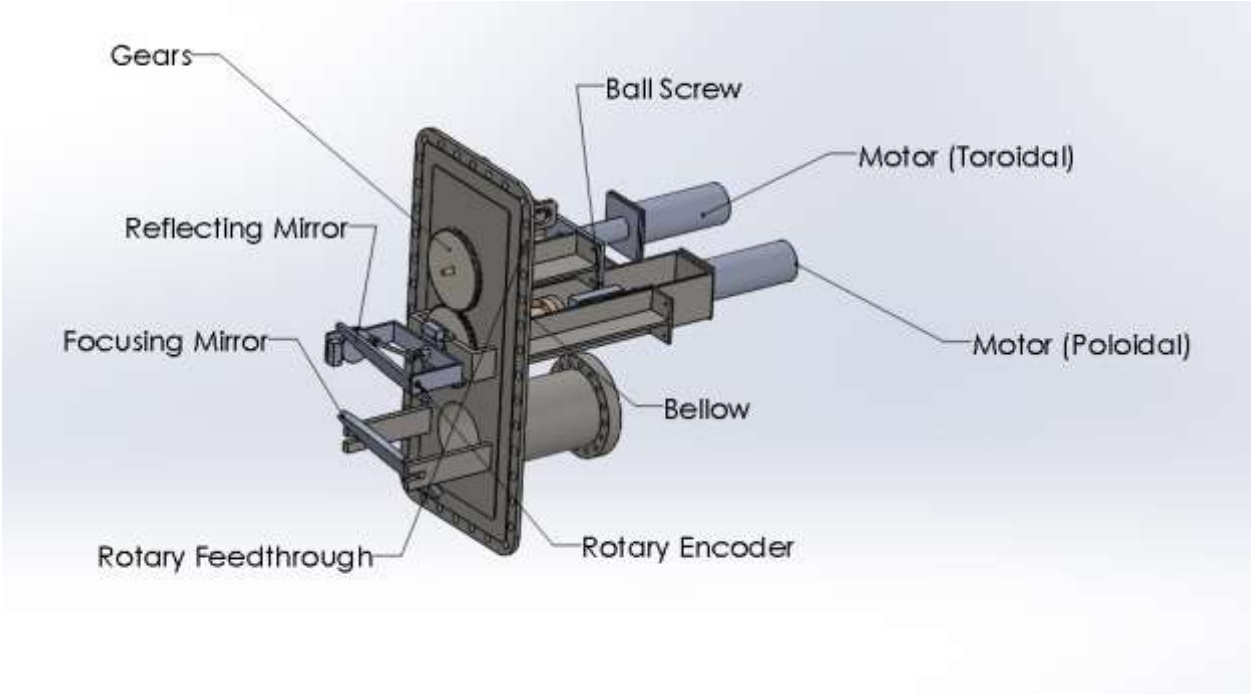

Image of the assembly without Vacuum chamber

Refer drawing IPR/17/A3/ECRH/8078 (total 14 sheets) for more details

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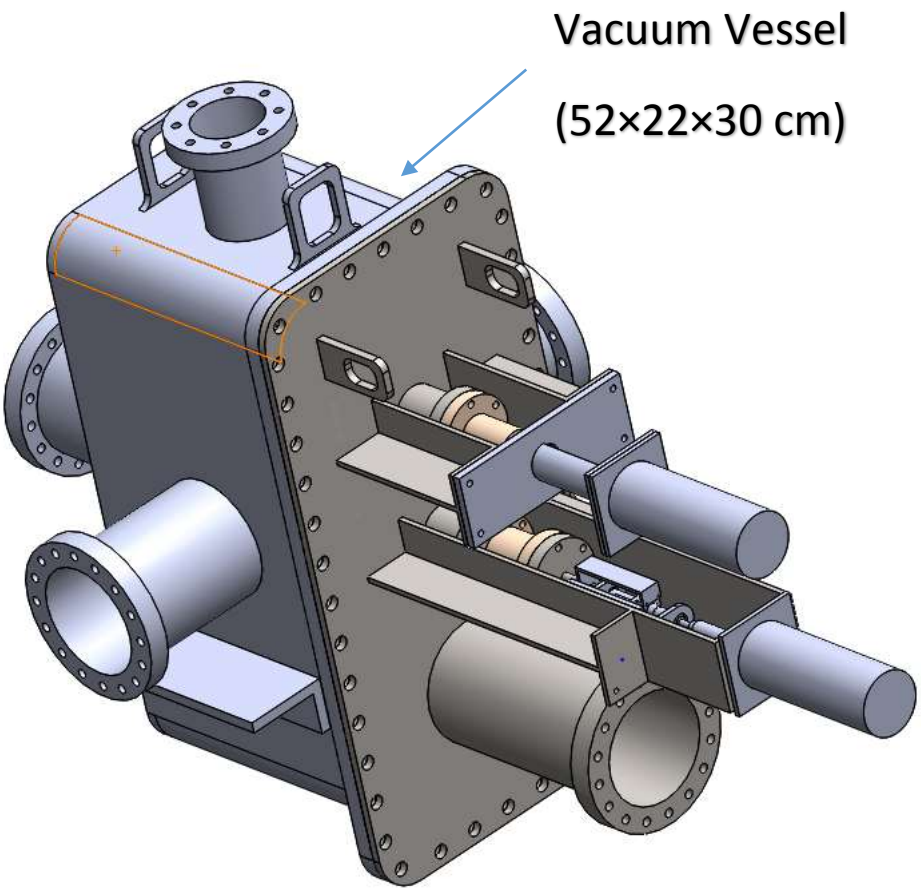

Mirror assembly along with components and vacuum chamber

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4. Technical specifications of the components for the designed system:

1) Vacuum chamber (Quantity – 1)

Sr. No	Specification	Requirement
1	Size	Approx. 52 ×22.4× 29.1 cm (as per drawing-sheet 6)
2	Thickness	As per drawing (Sheet 6)
3	Operating Pressure	Atm. To 1×10^{-8} mbar
4	Material	SS304L

The ports and flanges are to be fabricated as per the drawing (sheet 6).

2) Cover plate with motor mountings (Quantity – 1)

Sr. No	Specification	Requirement
1	Material	SS304L
2	Dimensions	As per the drawing (Sheet 2)

Note : Wire seal (aluminum) of 2 mm diameter and around 55 × 25 cm (rectangular shape) has to be used between cover plate and the main chamber. Exact dimensions are given in drawings.

3) UHV Bellow (Quantity – 1)

Sr. No	Specification	Requirement
1	Flange size	CF 40 or smaller
2	Max axial force	100 N
3	Max stroke length	20 mm or more
4	Operating Pressure	Atm. To 1×10^{-8} mbar
5	Leak Rate	$<1\times10^{-9}$ mbar-liter/s
6	Baking compatibility	upto 150 degree centigrade
7	Total length	Around 10 cm or less
8	Effective Spring rate	10 N/cm or less
9	Max outer diameter	Around 5 cm
10	Type	Edge Welded
9	Material	Nonmagnetic austenitic steel
10	Free length	Around 6 cm
11	Compressed length	Around 4 cm
12	No. of Cycles	10000 or more

4) Rotary feedthrough (Quantity – 1)

Sr. No	Specification	Requirement
1	Flange size	CF 40 or smaller
2	Max Torque	1 Nm
3	Max Rotational Speed	50 RPM
4	Operating Pressure	Atm. to 10^{-8} mbar
5	Leak Rate	$<10^{-9}$ mbar-liter/s
6	Baking Temperature	upto 150 degree centigrade
7	Material requirements	Non magnetic

5) Motors (Poloidal and Toroidal) (Quantity – 2)

Sr. No	Specification	Requirement
1	Rated Speed	3000 rpm or more
2	Rated torque	2.5 Nm or more
3	Rotor Inertia	1×10^{-4} kg-m^2 or less
4	Mass	less than 3.0 kg
5	Brake	Required for rated speed and torque
6	Brake Inertia	Less than 5×10^{-5} kg-m^2
7	Motor diameter	Less than 80 mm excluding connectors
8	Encoder	Absolute > 12 bits
9	Standard compliance	CE standards
10	RoHS compliance	Required
11	Type	Servo motor

6) Programmable motion controller

Sr. No	Specification	Requirement
1	Processor speed	400 MHz or more
2	Internal memory	Required
3	External Memory	SD card or USB
4	Input Power	230 V AC or DC (for DC with adapter)
5	Bus interface	Ethercat or any other
6	Plug and play compatibility with broad range of motion control solution.	Required
7	Support for modbus, Ethernet, profinet,ethercat	Required
8	Control	Local and Remote

9	On board digital I/O as well as expansion support with Ethercat	Required
10	Support for controller programming and HMI programming as per user application	Required
11	Programming support for Lab view	Required
12	Encoder support	Absolute

7) Servo drive compatible with motor (quantity -2)

Sr. No	Specification	Requirement
1	Supply voltage	230 V AC /50Hz
2	Input/output current	As per motor requirement
3	On board Analog and Digital I/O	remote expansion and for user
4	Encoder	Absolute
5	Bus interface	Ethercat or compatible with controller
6	Service support	Ethernet TCP/IP
7	Safety function	According to IEC standard

Note: Combined Drive cum controller can also be used in place of separate drive and controller

8) UHV compatible gears (Quantity – 2)

Sr. No	Specification	Requirement
1	Type	Spur Gear
2	Material	SS 316L with TiN or equivalent coating (around 5µm) on teeth
3	Module	1.00
4	Number of teeth	120
5	Face width	10 mm
6	Operating pressure	Atm. To 1×10^{-8} mbar
7	Max Coefficient of Friction	Less than 0.2
8	No. of cycles	10000 or more
9	Outgassing rate	1×10^{-11} mbar lit/s cm^2 less at room temperature after baking
10	Bake out temperature	150° centigrade

9) Ball screw (Quantity – 1)

Sr. No	Specification	Requirement
1	Type	Backless free Ball screw
2	lead	8 mm
3	Length	Around 4 cm
4	Nominal diameter	12 mm or less
5	Axial Load	300 N or more
6	Material	Non magnetic

10) Vacuum compatible Rotary encoders (Quantity 2)

Sr. No	Specification	Requirement
1	Type	UHV compatible Absolute rotary encoders
2	Accuracy	0.01 degree or better
3	Outer diameter	as per design
4	Inner diameter	as per design
5	thickness	as per design
6	Operating pressure	Atm. To 1×10^{-8} mbar
7	Bake out temp	120°centigrade max
8	Protocol	Compatible with motor controller or readable in Labview

11) Electrical/Instrumentation feedthroughs (Quantity 2) (quantity may vary as per requirement)

Sr. No	Specification	Requirement
1	Type	UHV compatible electrical feedthrough
2	Connection	25 KF
3	Pins	According to number of pins in rotary encoder
4	Operating pressure	Atm. To 1×10^{-8} mbar
5	Bake out Temperature	Max 150 degree centigrade
6	Operating Temperature	10 to 50 degree centigrade
7	Leak rate	less than 1×10^{-9} mbar-lit/s

12) UHV bearings (Quantity – 4)

Sr. No	Specification	Requirement
1	Type	UHV Compatible bearing
2	Operating pressure	Atm to 1×10^{-8} torr
3	Operating temperature	10 to 50 degree centigrade
4	Bake out temperature	Max 150 degree centigrade

5	Maximum radial load	15 N
6	Outer Diameter	10 mm
7	Inside Diameter	5 mm
8	Thickness	4 mm
9	Material	UHV Compatible and non-magnetic
10	Outgassing Rate	1×10^{-9} mbar lit/s or less

13) Reflecting Mirror (Quantity – 1)

Sr. No	Specification	Requirement
1	Material	SS 316l
2	Dimensions	As per drawing (Sheet 13)
3	Surface finish on reflecting side (Ra)	0.5 micrometer or better

14) View Port-1 (Quantity – 1)

Sr. No	Specification	Requirement
1	Connection	100 CF
2	Lens Dia	3.5 inch or more
3	Flange material	SS304L,SS316L,SS304,SS316
4	Vacuum range	Atm to 1×10^{-8} torr
5	Temperature Range	15 to 150 °C
6	Other characteristic	Transparent to visible light
7	Transmission for visible range	80% or more
8	Window material	Glass or sapphire

15) View Port-2 (Quantity – 1)

Sr. No	Specification	Requirement
1	Connection	100 CF
2	Lens Dia	2 inch or more
3	Flange material	SS304L,SS316L, SS304, SS316
4	Vacuum range	Atm to 1×10^{-8} torr
5	Temperature Range	15 to 150 °C
6	Other characteristic	Transparent to visible light
7	Transmission for visible range	80% or more
8	Window material	Glass or sapphire

16) Focusing Mirror

Sr. No	Specification	Requirement
1	Material	SS 316l
2	Dimensions	As per drawing (Sheet 14)
3	Surface finish on reflecting side (Ra)	0.5 micrometer or better

17) SS/AL test stand with PU/SS wheels* (Quantity – 1)

Sr. No	Specification	Requirement
1	Material	SS or Aluminum extruded channels
2	height	Around 1 meter
3	Wheels	PU or SS wheels
4	Other requirement	Provision to mound Turbo Molecular pump(150CF) at one of the 100 CF flange

*Simple test stand to mount the assembly with one TMP

18) Flanges s

Common specifications for all flanges

Sr. No	Specification	Requirement
1	Material	SS 304 l, SS316l
2	Leak rate	1×10^{-9} mbar-lit/s or less
3	Electro polishing	required

Types of flanges and their quantities to be used

Sr. No	Type	Quantity	Purpose
1	100 CF to 25 KF	2	For mounting of gauge and electrical feed through. (connections can be changed as per requirement)
2	63 CF to 25 KF	1	For evacuation of the chamber

19) Other small miscellaneous components

Sr. No	Specification	Requirement
1	Material	As mentioned in drawings
2	Quantity	As per BOM in drawings