Thermo vacuum chamber: Compliance Matrix

Sl No	Parameter	General specification:	Compliance Yes /No
1.1	Thermal Vacuum chamber	Design, realization, installation, commissioning and performance demonstration of a thermo-vacuum chamber at VSSC/ ISRO.	
1.2	Scope of supply	It includes various auxiliary subsystems like liquid nitrogen & gaseous nitrogen storage tanks, air compressor, chiller etc Supplier shall obtain license from PESO for design, realization & installation of LN2 tank. Routing of all lines for Chiller, compressor, LN2, GN2 lines and vent lines are also included in the scope of work	
1.3	Chamber requirement	Thermo-vacuum chamber is for conducting thermo-vacuum tests in the temperature range of 153K to 423K at a vacuum level of $5x10^{-7}$mbar.	
2.	Vacuum Chamber	Details as Given Below	
2.1	Vacuum Chamber design		
2.1.1	Shape	The chamber shall be cylindrical with a tori-spherical end dish, placed with its axis parallel to the ground.	
2.1.2	Vacuum Level	It shall be designed for external pressure operation (internal pressure of 5.0×10^{-7} mbar absolute and external pressure of 1.01325 bar absolute at 35 ^{o}C)	
2.1.3	Material of construction	The vacuum chamber and all vacuum chamber sub-systems inside the chamber (except the thermal shroud) shall be constructed using stainless steel (AISI 304L).	
2.1.4	Material certificate	Material test certificate from NABL certified laboratory, stating mechanical and chemical properties with traceability.	
2.1.5	Flange	Utility flanges shall be of CF type with metallic gaskets for all vacuum pumps, vacuum gauges, and instrumentation feedthrough.	
2.1.6	Internal Space	The Internal dimensions of the chamber shall be arrived at considering test space dimensions and clearances required to accommodate thermal shroud fluid lines, water vapour panel, instrumentation cables, and other sub-systems.	
2.1.7	Door clamp	The chamber front dish shall be clamped using manual clamps (4Nos.) and there shall be an open/ close status indication in the control console.	
2.1.8	Welding	All joints shall be TIG welded, using certified filler rods and high-purity argon/ helium shield gas.	
2.1.9	welding joint leak rate	All welded joints shall be leak tested with a Helium Mass Spectrometer Leak Detector to an Individual leak rate of better than$1x10^{-9}$ mbar L/s of Helium.	

2.1.10	Handling Provision	Necessary provisions shall be provided for the handling of the chamber.	
2.1.11	Door Opening	The Chamber door shall be a tori-spherical dished door with flange and the opening stroke. shall allow complete access to the thermal plate and rear dish shall be welded to the chamber.	
2.1.12	O-ring type	The O-ring on the chamber door shall be moulded type and uniform compression of the O-ring shall be ensured.	
2.2		Test Space requirement.	
2.2.1	Test Space Shape and dimension	The thermal shroud shall be mouse trap shaped, with a flat thermal plate of width 600-620mm and depth 1000 to 1100mm on which the test article will be placed	
2.2.2	Thermal Plate design	The thickness of the thermal plate shall be designed to ensure temperature uniformity across the thermal plate.	
2.3		Internal Surface finish details	
2.3.1	Surface finish	3Δ (Three triangle) finish for chamber internal surfaces and all hardware exposed to vacuum.	
2.3.2	Emissivity	The infrared emissivity of the internal surfaces of the chamber shall be within 0.10.	
2.4	Painting	Surfaces of hardware exposed to outside environment shall be first coated with zinc chromate primer followed by two coats of polyurethane paint.	
2.5	Vacuum chamber orientation	The chamber shall be oriented horizontally and mounted on a stainless steel structure meeting all structural requirements.	
2.6	Vacuum chamber dimension	Details as Given Below	
2.6.1	Dimension of chamber	Diameter and depth: Chamber dimensions (1m dia x1.2m depth approx..) shall be adequately to house the mouse trap thermal shroud and test article resting on the thermal plate.	
2.6.2	Chamber Axis Height	The Chamber axis height from ground level shall be 1200 mm.	
2.7	Vacuum chamber ports	All ports shall have metallic gaskets and shall be fitted with specified feed-through. Dummy flanges shall be provided for all ports, including feed-through ports. Details of vacuum chamber ports are shown in Table No. 1&Fig No. 2	
3.0	Vacuum Pumping System	The objective of the vacuum system is to pump out vapour and gas present and given out by test articles and chamber elements and to maintain desired vacuum level in the chamber throughout the test. Schematic of vacuum pumping system shown in figure 3.	
3.1	Vacuum system design	Details as follows	

3.1.1	Vacuum level(Normal Temperature)	Vacuum pumping system shall be designed to achieve a vacuum of 1x10-6 mbar from ambient within 90 minutes for double chain and within 180 minutes for single chain respectively, without using water vapour panel.	
3.1.2	Vacuum level (Higher Temperature)	It shall also be able to achieve $1x10^{-6}$mbar within 180 minutes when the thermal shroud temperature is 380K, without using water vapour panel.	
3.1.3	Connection	Vacuum pump shall be connected to the vacuum chamber through vacuum isolation gate valves, SS piping of suitable size and flexible bellows.	
3.1.4	Pumping capacity	Pumping system shall have adequate pumping capacity and redundancy for continuous operation up to 400 hours at a stretch.	
3.1.5	Control system	The vacuum level in the chamber shall be controlled by PLC. Shall be fully automatic and provided with interlocks for safe operation, including in the manual mode.	
3.2	Rough Vacuum system configuration	Details as Given Below	
3.2.1	Roughing Skids Quantity	2 Nos	
3.2.2	Roughing Skid Capacity	Roughing skids shall be capable of achieving a vacuum level of $5x10^{-3}$ mbar.	
3.2.3	Root Pump integration	Roots pumps shall be integrated with an overflow valve to enable switch on together with the backing pump even at atmospheric pressure.	
3.2.4	Vacuum gauge	A vacuum gauge shall be provided between roots pump and rotary vane pump.	
3.3	Turbo molecular Pump (TMP) configuration	Details as follows	
3.3.1	TMP quantity	2 Nos	
3.3.2	Pumping Speed	The minimum pumping speed for TMP shall be 1200 Litre/sec.	
3.3.3	Back connection	The backing line of each TMPs shall be connected to rouging skid with isolation valves as shown in fig 3.	
3.3.4	Vacuum level	TMP shall be capable of achieving a vacuum level of less than $1x10^{-7}$ mbar.	
3.3.5	TMP body material	TMP body shall be of stainless steel.	
3.3.6	Connection	TMP connected to cylindrical chamber body through CF type flange.	
3.3.7	Cooling system	TMP shall have an appropriate cooling system.	
3.3.8	Controller	Each TMP shall have a standalone controller mounted in a rack, which shall be provided with a voltage stabilizer and spike arrestor.	

3.4	Cryo pumping system configuration	Details as Given Below	
3.4.1	Quantity	1 No.	
3.4.2	Cryo pump	Cryo pump shall be based on G-M cycle for its two stages along with the Helium compressor.	
3.4.3	Connection	The Cryo pump shall be connected to the chamber through electro pneumatic gate valve.	
3.4.4	Vacuum level	The Cryo pump shall be capable of achieving a vacuum level of less than 1 x10^{-7} mbar.	
3.4.5	Control system	The control system shall control the cryogenic pump at its cooling, heating and regeneration & vacuum pumping stages.	
3.4.6	Regeneration	The Cryogenic pump shall be regenerated using a dedicated dry vacuum pump with adequate water vapour capacity.	
3.4.7	Cryo compressor	Cryo compressor shall have an appropriate cooling mechanism (If water cooling is selected, necessary plumbing lines also shall be in the Supplier's scope).	
3.5	Vacuum Isolation valve	Based on the system design, the vendor shall provide appropriately sized vacuum valves as per fig.3.	
3.5.1	Additional requirement	The vendor has to provide additional gate valves, if necessary.	
3.5.2	Body material	Stainless steel body.	
3.5.3	Valve connection	Valves with CF interfaces to be provided for pumps having CF flanges.	
3.6	Water Vapour Panel	Details as Given Below	
3.6.1	Location	Removable water vapour panel to be located between the thermal shroud and the vacuum chamber	
3.6.2	Valves	It shall be provided with necessary electro-pneumatic valves.	
3.6.3	Temperature sensor	It shall be provided with suitable temperature sensor.	
3.6.4	Flexible tube	It shall be provided with flexible inlet & outlet tubing.	
3.6.5	Heating system	It shall be provided with heating system for removing the condensate after the operation.	
3.7	Material for vacuum pipeline	SS 304L seamless pipes and flexible bellows of 316 L, suitably sized for the highest conductance.	
3.8	Re pressurization system	Details as Given Below	
3.8.1	Air admittance valve	For re-pressurizing, the chamber after the test/ process, an air admittance valve EPV7 with 5μ inlet filters shall be provided.	
3.8.2	Design	It shall be designed such that the chamber is brought to atmospheric pressure in 10 minutes.	

3.8.3.	Redundant re-pressurization system	Provision for admitting nitrogen gas through EPV 9 to be provided as redundant re-pressurisation system.	
4.0	Thermal System	Details as follows	
4.1	Thermal system features	When the vacuum chamber is maintained in operational vacuum (5.0 x 10^{-7} mbar), the thermal shroud & thermal plate shall be heated or cooled by circulating GN2 to achieve set temperature. Thermal system features as follows:	
4.1.1	Thermal Plate and Thermal Shroud	The thermal system shall consist of a thermal plate and double-embossed thermal Shroud.	
4.1.2	Thermal conditioning system	A single common thermal conditioning system shall supply GN2 to both the thermal shroud & thermal plate.	
4.1.3	Control system	The test article will be loaded on the thermal plate. The temperature on the thermal shroud and thermal plate shall be automatically controlled to any set temperature through PLC based control system.	
4.1.4	Temperature sensor	There shall be provision to use a temperature sensor on the test article as a control sensor (selectable from consoles).	
4.1.5	Thermal system capacity	The thermal system shall be capable to follow any set linear temperature profile in the range of 153K to 423K (with multiple cycles over the entire range) without manual intervention.	
	4.1.6 Thermal system layout	The thermal system layout is shown in figure 4 and a typical test cycle profile is given figure 5&6.	
4.2	Specification of Thermal system	Details as Given Below	
4.2.1	Operating Temperature	153K to 423 K	
4.2.2	Cooling/Heating Fluid	Low pressure closed loop GN2 (153 K to 423K).	
4.2.3	Heat load expected from test article	Total heat load 1kW (Article + Plate).	
4.2.4	Temperature uniformity on thermal shroud	Details as Given Below	
4.2.4.1	End closures and on the thermal plate (at steady state)	Better than ±2 K	
4.2.4.2	End closures and on the thermal plate (at transient)	±15 K	
4.2.4.3	Control accuracy	±1 K (difference between set temperature and average of 3 temperatures measured at centre plane of the cylindrical shroud).	

4.2.4.4	Measurement sensor	3 wire film type RTD as per IEC 60751 class B.	
4.2.5	Ramp rate (hot & cold)	3 K / minute (maximum). Also, provision for set between 1 K/ min to 3 K / minute (1 K / minute resolution)	
4.2.6	Mounting of the thermal shroud and thermal plate	Thermal plate and thermal shroud shall be with demountable circulating fluid inlet/outlet feed lines to enable easy removal from the chamber for maintenance & cleaning purposes. Joints to be easily accessible for the operator.	
4.2.7	General Requirements	Details as Given Below	
4.2.7.1	Safety Interlock	There shall be a safety interlock for preventing the operation of thermal system above vacuum level of $1x10^{-3}$ mbar.	
4.2.7.2	Super-insulated Vacuum jacket line	Super-insulated vacuum jacketed lines (SIV) to be used in the thermal conditioning unit to maximum possible extent to prevent heat-in-leak. For certain cases where super-insulated vacuum jacketed lines are not feasible inside the unit, such lines shall be properly insulated with Aerogel insulation along with necessary water vapour barrier.	
4.2.7.3	Feed through Design	Thermal shroud and thermal plate with parts such as liquid feedthrough. shall be designed for thermal cycling in the range of 77 K to 423 K.	
4.2.7.4	Bellows/flexible joints	Necessary bellows / flexible joints shall be provided for preventing thermal stresses during long duration thermal cycling operations.	
4.3	Specification for Thermal shroud		
4.3.1	General requirements	Details as Given Below	
4.3.1.1	welding details	Shroud shall be inflated to form annular gap and to be laser welded/ resistance spot welded. TIG welding at the edges of the shroud.	
4.3.1.2	Design temperature and pressure	Shroud panels shall be designed for thermal cycling from 77 K to 423 K and internal pressure of at least 2 times the circulating GN2 pressure.	
4.3.1.3	Thermal Plate configuration	The thermal plate shall have an internal channel for circulating GN2 for cooling /heating the test article.	
4.3.1.4	Thermal Plate load capacity	It should withstand at least 15 kg test article mass.	
4.3.1.5	Sample mounting details	The thermal plate to have an array of threaded holes pitch 50mm x 50mm to mount the test article. Thread size: M6 x1x 10 deep. No. of rows & columns: 4Nos (each).	

4.3.2	Thermal Shroud Shape and construction	Mouse trap shape, Double embossed type, laser welded & inflated/resistance spot welded & moulded. Each sheet shall be at least 1.5 mm thick.	
4.3.3	Size	The shroud shall be able to house a test article with a maximum envelope of 600-620 mm (width) x 1000-1100 mm (depth) x 450 mm (height) on the thermal plate. Tentative schematic of Thermal Shroud with Thermal plate as mentioned in fig.7	
4.3.4	End Shrouds	Two separate active shroud panels to be attached the front and rear dish of chamber.	
4.3.5	Material of construction	SS316L	
4.3.6	Leak tightness	Leak tightness of the welded joints in the shroud, thermal plate, and feedthrough shall be better than $5x10^{-9}$ mbar L/s of Helium. It will be demonstrated again after thermal cycling at the VSSC site.	
4.3.7	Painting	Painting details as follows	
4.3.7.1	Internal Painting details	Test space environment including the inner surface of shroud, both active end shrouds, and top surface of thermal plate shall be painted with thermo vacuum compatible paint with an emissivity of 0.9 meeting the out-gassing requirements for space environment (TML:< 1%).	
4.3.7.2	External Painting details	Outside the main shroud, active end shrouds and thermal plate shall be electro-polished.	
5.0	Auxiliary system details	Details as Given Below	
5.1	Auxiliary system	The auxiliary system consists of Liquid Nitrogen Storage tank, a gaseous Nitrogen Storage tank (as per the design of TCU), an air compressor, and water chiller. Details as follows.	
5.1.1	Scope	The scope includes obtaining the necessary license from PESO according to prevailing SMPV (U) rules. SIV lines of adequate size shall be used for transferring Liquid Nitrogen from the storage tank to TCU.A tentative layout of the LN2 storage yard is shown in Fig.8 for obtaining PESO License.	
5.1.2	Pressure Sensor	Adequate pressure sensors shall be provided in the LN2 transfer lines.	
5.1.3	Safety Relief valves	Safety relief valves shall be provided on the LN2 transfer lines where there is chance for trapping LN2 by the closing of upstream and downstream valves.	
5.1.4	Additional Space	Space for installing one more LN2 tank of 6kL capacity shall be provided inside the yard (additional LN2 tank not in the present scope of work).	
5.1.5	Foundation and civil work	The foundation and civil works required for the tank and fencing is in the scope of VSSC.	

5.1.6	Design and Drawings	The Required design drawings/inputs shall be given by the vendor well in advance for civil works.	
5.1.7	Fencing	Fencing of licensed premises is also in the scope of VSSC.	
5.2	Specification for Liquid Nitrogen Tank		
5.2.1	General requirements	Details as Given Below	
5.2.1.1	Evaporation loss rate value	The liquid nitrogen storage tank shall be vacuum insulated and designed for an evaporation loss rate better than 0.25% of gross volume/day.	
5.2.1.2	MOC	All valves, devices, valve handles, tags, etc. shall be SS316L/ bronze.	
5.2.1.3	Drain points	Suitable drain points with blow-down valves shall be provided on LN2 / circuits at suitable locations for initial purging to drive out any resident moisture due to the stoppage of the system for a long duration.	
5.2.1.4	External surface painting	Outside surfaces of hardware exposed to ambient environment shall be first coated with zinc chromate primer followed by two coats of polyurethane paint.	
5.2.2	LN2 tank specification		
5.2.2.1	Quantity	1 No	
5.2.2.2	Orientation	Vertical	
5.2.2.3	Storage Capacity	6,000 litre (Water capacity)	
5.2.2.4	Design Standard tank and piping	ASME SEC. VIII Division I, ASME B31.3 or equivalent	
5.2.2.5	The outer diameter of Dewar	1.8 meter (max.)	
5.2.2.6	Insulation	Multilayer super insulation with vacuum .	
5.2.2.7	Net evaporation rate	Less than 0.25 % of gross volume per day.	
5.2.2.8	Maximum working pressure	As required for TCU operation (with adequate margin to take care pressure drop etc.).	
5.2.2.9	Design Pressure	With standard margin over maximum working pressure as per applicable codes.	
5.2.2.10	Automated operation	Provision for automated operation of LN2 tank from GUI/ SCADA console (Pressurization, Filling, Draining & venting) shall be included. Additional manual isolation valves shall be provided for all these operations.	
5.2.2.11	Safety provision	Two Safety relief valves and two burst discs shall be provided for the inner vessel, and one Safety Device for outer vessel. Safety relief valves shall be provided for the lines in LN2 tank circuit where there is a chance for trapping LN2 during operation (by closing upstream and downstream valves).	

5.2.2.12	Filling and drawing lines	Permanently connected to thermal conditioning unit with SIV lines. Additional drain points shall be provided with necessary isolation valve for drawing LN2 for purposes other than the Thermal conditioning system.	
5.2.2.13	Pressure, level, and flow indications	Digital readout of level, flow, and pressure gauges with necessary redundancy and facility for automatic logging of data with respect to time shall be provided. This is in addition to mechanical differential pressure gauges and pressure gauges fitted on the tank.	
5.2.2.14	Ingress Protection rating	Instruments/ control valves positioned outdoors shall have an adequate ingress protection rating.	
5.3	Air Compressor	Details as Given Below	
5.3.1	Quantity	1 No	
5.3.2	Capacity	A rotary screw air compressor of adequate capacity shall be provided	
5.3.3	Reservoir	A compressed air reservoir of adequate capacity and a refrigerated air dryer compatible for the selected air compressor shall be provided.	
5.3.4	Refrigerated air dryer	A refrigerated air dryer compatible for the selected air compressor shall be provided.	
5.3.5	Fine filter	A fine air filter shall be provided at the outlet of the dryer.	
5.3.6	Drain valve	An automated drain valve with a timer shall be provided for the reservoir and dryer.	
5.3.7	Compressed air lines	Compressed air lines shall be of Stainless steel. Hydrolysis resistant Flexible PU tubes shall only be used for short lengths near to actuators & valves.	
5.4	Chiller(for Cryo pump Compressor)	Details as Given Below	
5.4.1	Capacity	A closed-circuit water chiller unit of adequate capacity shall be provided.	
5.4.2	Breakup Cooling requirement	Chiller capacity shall be worked out based on all service requirements in extreme test conditions. Detailed breakup of the cooling requirement shall be submitted	
5.4.3	Margin	There shall be a margin of 50% over the required cooling capacity.	
5.4.4	working environment	The chiller shall operate efficiently in the extreme environment at the VSSC site (40°C& 90% RH).	
5.4.5	Additives	Necessary additives shall be used for preventing corrosion in pump cooling paths/channels.	
6.0	Control and instrumentation system	Details as Given Below	
6.1	PLC modules with its execution software	PLC (Programmable Logic Controller) modules with associated software shall be used for real time monitoring and control of all equipment in the system.	

6.2	Electrical Power distribution and switching panel	Electrical Power distribution and switching panel is in the scope of the supplier. Hence supplier shall install it to facilitate power distribution for all the electrical equipment through appropriately sized starters/relays, switches etc. to ensure proper switching of all equipment and safety of personnel and equipment.	
6.2.1	Special Earthing	Special earthing & routing shall be in the scope of the supplier. Earthing pit alone will be in the scope of VSSC.	
6.3	Control and instrumentation panel	Details as Given Below	
6.3.1	control and instrumentation panel	All the systems like vacuum and temperature shall be controlled from the control and instrumentation panel located close (3 to 5m) to the chamber facilitating the operators to control and monitor the operation of the chamber.	
6.3.2	Electrical cabling	The electrical cabling to and from the panels shall be done professionally as per industry standards and shall be ensured that the routing and clamping doesn't interfere with routine operations and facilitate periodic maintenance and repair works.	
6.3.3	Identification and Document	Every input and output cable shall be properly identified and tagged. Detailed documentation of the electrical wiring and interconnections shall be provided.	
6.3.4	PLC	PLC (Programmable Logic Controller) for real time monitoring and control of all equipment in the system.	
6.3.5	Rack	All instrumentation related to vacuum gauges, temperature sensors, gate valve position indicator, LN2 consumption status monitoring etc shall be positioned in a rack.	
6.3.6	Ethernet/USB	All instruments shall have provision for automation through an instrument interface like Ethernet/USB etc. The output from all these instruments shall be acquired in a PC through Ethernet/USB interface for monitoring and storage.	
6.3.7	Test Profile	There shall be provision for generating different temperature test profiles (Time vs Temperature) using graphical user interface (GUI) in the control PC.	
6.3.8	Storage Test cycles	There shall be provision for storing a minimum of 20 Nos of such test profiles	
6.3.9	PC with software	The PC/computer system in the console shall be provided with suitable PLC/ GUI software along with license in the name of ISRO to fulfil the following tasks:	
6.3.9.1	Mimic diagram	Mimic Diagrams displaying functional status of all system components and safety interlocks.	

6.3.9.2	Display	Display the state of main process regulation loops such as shroud and thermal plate temperature control.	
6.3.9.3	Display and Storage	Display and storage of all test facility functional data, alarm condition, messages etc.	
6.3.9.4	Temperature Profile	Display of temperature profiles on shroud and test article with proper scaling of temperature profiles.	
6.3.9.5	Customize Program	Customizable program for vacuum and temperature profiles for its generation, storage and execution.	
6.4	PC based Data Acquisition System	PC based Data Acquisition System (DAS) shall monitor and display the temperature data from all the thermocouples/RTDs fixed on the test article and the thermal shroud & thermal plate inside the chamber and also the vacuum parameters of the system. The control and data acquisition PC can be the same one. Details as follows.	
6.4.1	Fail safe mechanism	The data logging system shall have a fail-safe mechanism not to lose any test data during electrical power failure/system failure condition.	
6.4.2	PC based system	A PC based system to be provided with the following configuration is in the scope of supplier.	
6.4.2.1	Processer type	Intel core i5, 12th gen. processer or latest.	
6.4.2.2	RAM	Minimum 8GB	
6.4.2.3	Hard disk	2TB (SSD)	
6.4.2.4	Monitor	LED 26”	
6.4.2.5	Operating System	Windows 11	
6.4.3	On Screen Display	On screen displays shall include real time plot of vacuum system, thermal system and auxiliary systems data.	
6.5	Salient features of the control software	Details as Given Below	
6.5.1	Mode of Operation	There shall be provision for 3 modes of operations such as Auto mode, Semi auto mode and manual mode.	
6.5.2	Auto mode	The temperature and vacuum shall be controlled based on a predefined test profile without any manual intervention.	
6.5.3	Semi auto mode	It shall allow the generation of a new test profile, edit (change parameters and set points) an existing one and save in its memory.	
6.5.4	Manual mode (Expert mode)	Each sub system shall be operated in manual mode (expert mode) and shall be protected with necessary passwords.	
6.5.5	Switching Provision	There shall be provision for switching over to manual mode from the current mode (Auto /Semi auto mode) without any interference in the process of the test.	

6.6	Salient features of the Data acquisition software	Details as Given Below	
6.6.1	Data acquisition	Real time Data acquisition of temperature, Pressure with respect to Time shall be done.	
6.6.2	Menu and Icons	All functions to be made selectable by menus and icons.	
6.6.3	Data Presentation	Real time graphics and numerical data presentation of selected channels.	
6.6.4	Data Storage	Data shall be stored in hard disk periodically for later retrieval.	
6.6.5	Data management	Data file generation, management and storage.	
6.6.6	Report Generation(word format)	VSSC shall be provide standard report template, all the data to be updated based on this template.	
6.6.7	Extra Software copy	An extra copy of the software(s) developed for this system shall be provided in installable form to take care of any exigency arising due to software corruption/ / malfunction that may occur.	
6.7	Vacuum Sensor and Instrumentation	The pressure / vacuum at various locations including inside the chamber is measured using.	
6.7.1	Vacuum Gauge	Vacuum gauge (Bayard-Alpert Pirani Capacitance Diaphragm Gauge) for monitoring the chamber pressure.	
6.7.2	Monitor/Display unit with interface	Suitable monitoring/display units having standard PC interfaces shall be provided along with the vacuum gauges.	
6.7.3	Numbers of vacuum gauge	Supplier shall provide adequate number of vacuum gauges integrated to the vacuum system for controlling the entire vacuum pumping chain.	
6.8	Temperature sensors and Instrumentation	Details as Given Below	
6.8.1	Type of thermocouple	T-type thermocouples (24AWG)	
6.8.2	Quantity	6 Numbers each to be placed on the shroud and Thermal plate for temperature monitoring.	
6.8.3	Mounting Location	T" type thermocouples for shroud temperature monitoring to be located on the shroud surface inside the chamber and connections taken through thermocouple Feed through with miniature T/C connectors at both ends of the feed through harness.	
6.8.4	Make	Thermocouple and suitable accessories for installing the thermocouples and other sensor shall be sourced from reputed internationals brand meeting international standard.	
6.8.5	Thermocouple Feed Through	T-Type Thermocouple Feed through-3Nos and K-Type Thermocouple feed through 2 numbers, with connectors on both sides are to be provided for test article temperature monitoring.	

6.8.6	Feed through leak rate	The connectors and feed through shall be compact and sealed (maximum admissible leak rate per feed through: $1x10^{-9}$ mbar l/s) and shall be thermal vacuum compatible.	
6.8.7	Installation	All the temperature sensors located on the shroud surface shall be installed in such a way that they can be removed for calibration and can be replaced after calibration without affecting the performance.	
6.8.8	PLC controller	The thermal plate/specimen temperature shall be controlled by precise heating or cooling using PLC controller.	
7.0	Online UPS system	The system shall have with minimum 30min. back up time. Within this time all systems like PLCs, control system equipments etc shall be switched to safe mode, in case of power failure.	
8.0	Electrical Feed Through	Details as Given Below	
8.1	Rating	10 A rating (for each Pin)	
8.2	Channels	120 channels electric feed through for device testing with mating connectors on both sides shall be provided.	
8.3	Identification	Each feed through shall be identified by a unique number and tag. Each wire in the harness shall also be tagged.	
8.4	Connectors	At both the ends the harness of each feed through shall be terminated on to 32 pin ITT D type gold plated connectors.	

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