Tender no. IPR/TN/PUR/TPT/ET/20-21/12 Dated 18-01-2021

Compliance matrix
Of
High Temperature Vacuum Furnace with High Pressure Gas Quenching System

Sr No.	Parameter	Design Specification/Design basis	Specification offered by bidder
1.0	**Vacuum Chamber**		
1.1	Working Volume (equal to hot zone)	Diameter: 1000 ±50 mm.	Diameter: ____ ± ____mm.
		Depth: 1200 ±50 mm.	Depth: ____ ±___mm.
1.2	Internal & External pressure		
1.2.1	Base vacuum pressure	5×10^{-2} mbar.	_____ mbar.
1.2.3	Operating vacuum pressure	1 to 10 mbar	___ to ___ mbar
1.2.4	Operating Quenching Internal pressure	10 +1 bar (abs).	___ + __ bar (abs).
1.2.5	Design Internal pressure	16 bar (abs).	___ bar (abs).
1.3	Material of construction	Carbon steel SA 516 Gr70.	Material: _____
1.4	Furnace Configuration		
1.4.1	Loading & Unloading	Front loading.	
1.4.2	Configuration	Cylindrical and horizontally mounted furnace.	
1.4.3	Wall type	Double wall.	
1.4.4	Furnace water cooling	Water cooling with guiding baffles.	
1.5	Support structure		
1.5.1	Material	Mild Steel of IS 2062 GRADE E300 Quality A or BR	Material: _____
1.5.2	Duct at bottom of the support	With Cable and piping duct at bottom of the support	

<table>
<tr><th>Sr No.</th><th>Parameter</th><th>Design Specification/Design basis</th><th>Specification offered by bidder</th></tr>
<tr><td></td><td></td><td>structure.</td><td></td></tr>
<tr><td>1.5.3</td><td>Painting/Coatings</td><td>Powder coating.</td><td></td></tr>
<tr><td>1.6</td><td>Dish-ends</td><td></td><td></td></tr>
<tr><td></td><td></td><td>Front Dish-end:</td><td></td></tr>
<tr><td>1.6.1</td><td>Material of construction</td><td>carbon steel SA 516 Gr 70</td><td>Material: _____</td></tr>
<tr><td>1.6.2</td><td>Front dish end support</td><td>A hinge supported</td><td></td></tr>
<tr><td>1.6.3</td><td>Front dish end locking system</td><td>Autoclave locking ring closure.</td><td></td></tr>
<tr><td>1.6.4</td><td>Front dish end ‘O’ ring groove</td><td>Double ‘O’ ring groove.</td><td></td></tr>
<tr><td>1.6.5</td><td>Front dish end wall type</td><td>Double wall with water cooling</td><td></td></tr>
<tr><td>1.6.6</td><td>Space for loading/ unloading</td><td>Maximum open space for loading and unloading of job.</td><td></td></tr>
<tr><td></td><td></td><td>Rear dish-end:</td><td></td></tr>
<tr><td>1.6.7</td><td>Material of construction for rear dish end</td><td>carbon steel SA 516 Gr 70</td><td>Material: _____</td></tr>
<tr><td>1.6.8</td><td>Blower fan housing</td><td>Consist of housing for blower fan.</td><td></td></tr>
<tr><td>1.6.9</td><td>Rear dish end wall type</td><td>Double wall with water cooling</td><td></td></tr>
<tr><td rowspan="3">1.7</td><td rowspan="3">Ports</td><td>Material of construction: Seamless pipe carbon steel SA 516 gr 70.</td><td>Material: _____</td></tr>
<tr><td>All the port shall be water cooled.</td><td></td></tr>
<tr><td>Ports required for<table><tr><td>Purpose</td><td>Quantity</td></tr><tr><td>Vacuum pump</td><td>01 No.</td></tr><tr><td>Pirani gauge</td><td rowspan="2">01 No. each</td></tr><tr><td>Capacitance Manometer</td></tr></table></td><td>Ports:<table><tr><td>Purpose</td><td>Quantity</td></tr><tr><td>Vacuum pump</td><td>___ No.</td></tr><tr><td>Pirani gauge</td><td rowspan="2">___No. each</td></tr><tr><td>Capacitance Manometer</td></tr></table></td></tr>
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Sr No.	Parameter	Design Specification/Design basis	Specification offered by bidder
		Hydrogen gas, Nitrogen gas, Acetylene gas: 01 No. each Quenching gas inlet: 01 No. Pressure release: 01 No. Thermocouples: Bidder has to decide Electrodes for heater power: Bidder has to decide 40 KF threaded coupler welded at equal distance at bottom of the furnace.: 03 Nos.	Hydrogen gas, Nitrogen gas, Acetylene gas: ___ No. each Quenching gas inlet: ___ No. Pressure release: ___ No. Thermocouples: ___Nos. Electrodes for heater power: ___Nos. 40 KF threaded coupler welded at equal distance at bottom of the furnace.: ___ Nos.
1.8	Conductance control valve		
1.8.1	Conductance control valve	Electro pneumatically operated conduction control valve	
1.8.2	Different opening positions of conductance control valve	25%, 50%, 75% and 100% opening. Default value shall be 100% opening while evacuating the vacuum furnace.	
1.8.3	Control of opening positions	Opening shall be variable through PLC & PID controller to maintain the set total pressure.	
1.9	Cooling for entire vacuum furnace		
1.9.1	Type of cooling	Water cooling	
1.9.2	Max. outer wall temperature	35^{o}C/ room temperature.	___^{o}C
1.10	‘O’ rings		
1.10.1	Type	Moulded (without joint)	

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1.10.2	Material	Viton 'O'-rings	
1.11	Design standards	Design and Fabrication of the Furnace Chamber will be as per ASME code SEC. VIII, DIV- I.	Code: _____ Sec.: _____ Div.:_____
1.12	Welding Standard	All The welding procedures will be as per ASME code SEC. IX. Hydro test of the chamber along with front dish door and water path shall be as per UG99 of ASME code.	Code for Welding standard :_____ Sec.:_____ Code for hydro test:_____
1.13	Various drawings & approval from IPR	Manufactured system as per approved design and manufacturing drawing.	
2.0	**Vacuum Pumping system**		
2.1	Ultimate vacuum pressure	Better than $5x10^{-2}$ mbar with charge of 500 kg.	_____ mbar with charge of 500 kg
2.2	Type of pump	Combination of rotary piston and booster pump.	
2.3	Variable pumping speed	Pumping speed shall be variable.	
2.4	Pump down time	Less than 20 min	_____ min
2.5	Isolation Valve-2	Electro pneumatic valve	
2.6	Pirani gauge	High pressure Pirani gauge range: from atmospheric pressure to 10^{-3} mbar.	Range: _____ to _____ mbar
2.7	Isolation valve-1	An electro pneumatic valve between pirani gauge head and vacuum furnace	
2.8	Bypass line with valve	A bypass line between the vacuum furnace and the blower fan motor hood along with an electro pneumatically operated butterfly valve	
3.0	**Process Gas feeding system (Mass Flow controllers)**		

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3.1	A capacitance mano-meter gauge	Pressure range: 1 x 10^{-2} mbar to 100 mbar.	Range: _____ to _____ mbar
3.2	Isolation valve-4	An electro pneumatic valve between capacitance mano-meter gauge head and vacuum furnace for isolation must be provided.	
3.3	Mass flow controllers for gases	1. Hydrogen 2. Nitrogen 3. Acetylene	
3.4	Total pressure to be achieved/ maintained	1 to 10 mbar.	
3.5	Flow ranges of Hydrogen & Nitrogen gas MFCs	Suitable to fill the entire vacuum furnace up to 10 mbar pressure with single gas only.	Flow range for H_2 gas: _____ Flow range of N_2 gas: ____
3.6	Flow ranges of Acetylene gas MFC	Suitable to fill the entire vacuum furnace up to 0.5 mbar pressure with single gas only.	Flow range for C_2H_2 gas: _____
3.7	Solenoid valve positions	Each MFC must contain three position of solenoid valve, I. Purge (fully opened) II. Auto (opens as per set pressure). III. Close (fully closed)	
3.8	Gas flow control through SCADA programme (refer PFC)	Through SCADA programme the flow rate of each gas shall vary to achieve set total pressure with given gas mixing ratio.	
3.9	Isolation valve-3	A suitable isolation valve shall be provided between vacuum furnace and gas flow path to isolate the MFCs during quenching process.	
4.0	**Hot zone**		

Sr No.	Parameter	Design Specification/Design basis	Specification offered by bidder
	configuration		
	Hot zone consist of	4.1. Hot zone 4.2. support cage 4.3. Radiation shield 4.4. Heating Elements (heaters) 4.5. Hearth Plate (charge/ Job holder)	
4.1	Hot zone		
4.1.1	Configuration of actual hot zone	Cylindrical and horizontal	
4.1.2	Hot zone diameter	1000±50 mm	_____± ____ mm
4.1.3	Depth of hot zone	1200 ±50mm	_____ ± ____mm
4.1.4	Max Design temperature	At least 200 ^{o}C above the maximum operating temperature (1100^{o}C). The system design has to be done such that it shall work 15 hours a day without fail.	____^{o}C
4.1.5	Operating temperature range	Room temperature to 1100^{o}C	_____to ____ ^{o}C
4.1.6	Range of heating rate (Time required to achieve operating temperature)	Heating rate 1 -10^{o}C/min. (Minimum 120 & Maximum 1100 minutes)	Heating rate ___-__^{o}C/min.
4.1.7	Environment of process	Partial pressure of Hydrogen (H_2), Nitrogen (N_2) and Acetylene (C_2H_2) gases.	
4.1.8	Range of Total vacuum pressure	1 - 10 mbar	__ - ___ mbar
4.1.9	Temperature Uniformity	Uniformity of temperature at 1100^{o}C and 800^{o}C shall be ± 6^{o}C as per AMS2750E pyrometry class II.	Uniformity of temperature at 1100^{o}C and 800^{o}C shall be ± __^{o}C as per AMS2750E pyrometry class II.
4.1.10	Temperature resolution	1^{o}C	__^{o}C
4.2	Support cage		
4.2.1	Material of construction	SS310	Material: _____

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4.2.2	configuration	Horizontal and cylindrical	
4.2.3	Size	Suitable for working volume	
4.2.4	Mounting of hot zone support cage	On inner wall of furnace.	
4.2.5	Extractable & insertable	It shall be easily extractable and insertable.	
4.2.6	Coaxial holes at bottom	Three coaxial holes with the 40KF threaded coupler welded at bottom of the furnace shall be made at the bottom side of cage.	
4.2.7	Load bearing capacity	The cage shall be capable to withstand the weight of I. Radiation shield, II. Heating elements with accessories of fitting. (Thermal & structural load shall be considered while load bearing capacity is being calculated)	
4.3	Radiation shields		
4.3.1	Material of construction	Graphite/Carbon board	Material: _____
4.3.2	Radiation shielding must be provided between	I. inner wall of cage and heating elements, II. between front & rear dish ends of furnace and heating elements III. Hot zone & heat exchange Other places which are not mentioned here but shielding is required.	
4.3.3	Ports in radiation shield	Radiation shielding of front & rear side of furnace must contain ports which will allow to flow hot & cooled gases for uniform quenching	
4.3.4	Open & close condition of ports provided in radiation shielding	The port shall be closed during entire process of heat treatment and shall open during quenching stage of the process.	

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4.3.5	Material for covering of radiation shielding	Shielding shall be covered with carbon-carbon composite long fibre to reduce the erosion rate of the shielding material at high velocity of quenching gas.	Material:_____
4.4	Heating element (heaters)		
4.4.1	Material of construction of heating elements, electrodes and other connection accessories for heater	High density graphite.	Material: _____
4.4.2	Shape of elements	Rectangular bar.	
4.4.3	Element distribution	Uniform over entire length and diameter of hot zone, on front dish end and on radiation shield between hot zone and heat exchanger of vacuum furnace.	
4.4.4	No. of heating zones	Entire hot zone shall be divided in multiple heating zones.	____ nos. of heating zone
4.4.5	Electrodes for heater power	Must be passed through ports with proper electrical insulation.	
4.4.6	Electrode dimensions	Electrode diameter and length shall be capable to draw sufficient current with minimal heating effect.	
4.4.7	Water cooling of electrode	Shall be provided if required.	
4.5	**Heating Power supply**		
4.5.1	Load to heat	500 kg.	____ kg.
4.5.2	Operating temperature range	Room temperature to 1100^{o}C	_____ to ____^{o}C
4.5.3	Heating rate (to achieve operating temperature)	0 -10^{o}C/min in all heating zones (Minimum 120 min & Maximum 1100 min)	__-___^{o}C/min in all heating zones

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4.5.4	Input Voltage	415 VAC ±10%, 50Hz	
4.5.6	Output power	>160 kW	____ kW
4.5.7	Output voltage range	0 - 50V AC continuous variable	__-___V AC continuous variable
4.5.8	Voltage regulation	0.5% or better	__%
4.5.9	Voltage resolution	0.1V or better	___V
4.5.10	PLC based SCADA programme	Temperature & time duration (to achieve the temperature) will be set by user in SCADA programme and programme will automatically set the necessary parameters to achieve the set values for all the heating zones.	
4.5.11	Voltage/power control	Voltage/Power control shall be through SCADA.	
4.5.12	Protections	Over voltage & over current protection must be provided.	
4.5.13	Emergency switch	Must be provided to cut the power in the case of emergency.	
4.5.14	Temperature & Relative humidity	Supply must be efficient to work at 55°C temperature and humidity 90% RH.	
4.5.15	Cabinet coting	Close cabinet with powder coating.	
4.5.16	Material of construction of cabinet	Mild Steel	Material: _____
4.5.17	Easy access of card & devices	All the circuit cards and light weight devices shall be mounted in such a way so that electrical input & output faces towards user for easy access.	
4.5.18	Input/output cables accessibility	Main input & output shall be rear side of the power supply (but not at the bottom).	
4.5.19	Nomenclature & tagging	All the cable shall be tagged on both ends.	
4.5.20	Lifting	Lifting hooks must be provided at the top.	
4.5.21	Movement on floor	Sufficient space must be	

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		provided to insert hydraulic pallet trolley at bottom of the power supply for movement on floor.	
4.6	Hearth Plate (charge/ Job holder)		
4.6.1	Size	Hearth plate must be provided. The size of the hearth plate shall be defined in such a way so that nearest edge of the hearth plate shall be apart about 70 mm from all sides from the heater.	Length:_____ mm Width:_____ mm Thickness:_____ mm
4.6.2	Material of construction	High Density Graphite (Shall be fabricated such that it can withstand at 1100^{o}C with a charge/ job of 500 kg.)	Material: _____
4.6.3	Support for hearth plate	Shall be welded longitudinally with inner wall of vacuum furnace.	
4.6.4	Isolation of hearth plate	Hearth plate must be electrically isolated from all the side.	
4.6.7	Sliding mechanism	The bidder shall provide a suitable mechanism for loading and unloading charge/ job on the hearth plate in the system.	
4.6.8	Material of insulator	Ceramic	Material:_____
4.6.9	Life of hearth plate	The hearth plate shall have a life of minimum one year.	
5.0	**Heat Exchanger & High pressure gas quenching System**		
5.1	Heat Exchanger		
5.1.1	Type	Finned and tube type	Type:_____
5.1.2	Material of finns	Aluminum	Material: _____
5.1.3	Material of Tubes	Copper	Material: _____
5.1.4	Inlet water temperature	~35^{o}C/room temperature.	——^{o}C
5.1.5	Temperature and time for cooling the	A Suitably designed Heat Exchanger shall be provided	

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	charge	in front of the blower to cool the hot gas coming from the Hot Zone when sucked by the blower to achieve the desire cooling rate to decrease the temperature from 1100°C to 100°C in 25 min.	
5.1.6	Rate of quenching	10 – 40°C/min. Gas quenching system shall be capable of cooling the hot charge from 1100°C to 100° C within 25 min.	___-___°C/min.
5.2	Blower fan		
5.2.1	Blower fan motor	Blower fan motor shall be provided with suitable power capacity.	
5.2.2	Variable speed (VFD)	Speed of blower fan motor shall be variable.	
5.3	Nitrogen chamber (quenching gas storage tank)		
5.3.1	Material of construction	Carbon steel SA516 Gr 70	Material:_____
5.3.2	painting	Epoxy painting on internal surface and outer surface powder coating.	
5.3.3	Volume	The gas storage system of suitable volume and pressure to transfer 16 bar (abs) into the chamber for nitrogen gas quenching.	Volume: _____ m^3 Pressure: _____ bar
5.3.4	Safety devices	Gas storage system must have necessary safety devices suitable valves and necessary pressure gauges to control and store the gas.	
5.3.5	Gas refilling provision	Gas refilling provision in nitrogen chamber shall be provided.	
5.3.6	Flow control valve	Electro-pneumatically operated valve to control the flow shall be provided.	
6.0	**Data acquisitions**		

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	system		
6.1	Industrial PC	Industrial PC with I. 19”TFT touch screen. II. SCADA software for complete automation with operation of the system. III. i7 processor, IV. Windows 10 or above, V. 8GB RAM, VI. 2TB HDD, Data analysis software for retrieving particular parameter for definite time duration and date.	Industrial PC with I. ___”TFT touch screen. II. _____software for complete automation with operation of the system. III. ____ processor, IV. Windows ____ V. __GB RAM, VI. ___TB HDD, Data analysis software: _____
6.2	Data logging & Plots	1. SCADA Software must have data logging in convenient format like ASCII or excel table with real time value for a) Voltage (each heating zone), b) Current (each heating zone), c) rate of heating (each heating zone), d) power of heater (each heating zone) e) temperature (each heating zone), f) total pressure (chamber), g) gas flow rates (three gases) h) Proportionate ratio of all the three gases, i) Inlet and outlet water temperature of furnace j) Inlet and outlet water temperature of Heat exchanger. k) Quenching pressure l) Quenching rate 2) Sampling rate shall be 1	

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		sec. 3) Plots for all the above parameters (a to l) with respect to real time shall be display during entire process and entire plot shall be stored at the end of the process. ASCII or excel file shall be saved with a unique title format like yyyy-mm-dd-hh-mm.	
6.3	Remote control access	Remote control access from other network shall be enabled through licenced software like, team viewer. Entire recipe shall be controllable through remote control access (within LAN and also outside the LAN network)	
6.4	Ethernet/LAN	Ethernet card shall be provided for LAN connection for internet.	
6.5	Mimic diagram and flow chart	A mimic diagram with flow chart shall be provided on the control console front panel for entire vacuum system, heating system and gas inlet system with indicators along with audio alarm for utility failure with integrated alarm management system which show alarm conditions, logging of alarm & action and register root cause of alarm. All the variable and set parameter given in flow chart shall be display in mimic diagram.	

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6.6	Vacuum & high pressure gauge communication with SCADA	All the gauges shall be communicated to PLC and SCADA.	
7.0	**Utilities**		
7.1	Water cooling system	Cooling tower	
7.2	Water temperature at cooling tower outlet	~ 35^{o}C/ room temperature	——^{o}C
7.3	Water pump	Water pump for cooled water circulation must be provided.	
7.4	Accessories	Following accessories shall be supplied with water cooling system. I. Pressure gauges, II. Switches, III. Manifolds for input and output, IV. Valves, V. Pressure relief valve if required, VI. Bypass line if required VII. Hose connection, VIII. Water flow controller.	
7.5		Supplier will inform IPR well in advance before dispatching the system to keep ready necessary quantity of water, air compressor with pressure details and other necessary arrangement.	
7.6	UPS	UPS with sufficient power back up capacity shall be supplied for entire water cooling system devices like, electric motors for water circulation, cooling tower data acquitions system, vacuum pumps, all the valves etc.	