INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

MATERIALS MANAGEMENT DIVISION

Powai, Mumbai 400076.

Ref. No. (PR): 1000053413

Technical Specifications : Carbon dioxide (CO_2) Cooling System (Qty : 1)

S. No.	Item Description	Detailed Technical Specification	Technical Compliance (Yes / No)	Additional Information (if any)
	Fabrication and installation of a transcritical carbon dioxide (tCO_2) cooling system (Qty : 1)			
1.	Design Basis and Expected Performance – Ambient Conditions and Local Electrical Network	Installation: Indoor; Ambient Design: 40 °C DBT max, 13 °C DBT min, precipitation as per ISHRAE; Power Supply: 415 VAC, 3 phase, 50 Hz. For the rest of the document, note that “VTC” is vendor to confirm.		
2.	Cooling Media and Philosophy	100% CO_2 operated transcritical cooling system as shown in Figure 1 (only the tCO_2 part, i.e. excluding the grey part which is shown only for the sake of completeness and better understanding).		
3.	Pressure sensors for control	LTC suction pressure ($P_{o\text{-}LT}$) : After the exit of IHX2, at stream (--2--)		

	(refer Figure 1)	LTC discharge pressure ($P_{d\text{-}LT}$) — LTC exit, at stream (--5--) MTC suction pressure ($P_{o\text{-}MT}$) — After the exit of MT evaporator, at stream (--7--) MTC discharge pressure ($P_{d\text{-}MT}$) — After the exit of MTC, at stream (--8--) HX2 exit pressure (P_{gc}) — After the HX2, at stream (--12--) Receiver pressure (P_{rec}) — At stream (--17--) PC suction pressure ($P_{o\text{-}IT}$) — After IHX1, at stream (--20--) PC discharge pressure ($P_{d\text{-}IT}$) — PC exit, at stream (--21--)		
4.	Temperature sensors for control (refer Figure 1)	LTC suction temperature ($S_{o\text{-}LT}$) — After the exit of IHX2, at stream (--2--) LTC discharge temperature ($S_{d\text{-}LT}$) — LTC exit, at stream (--5--) MTC suction temperature ($S_{o\text{-}MT}$) — Mixed stream after the MT evaporator, at stream (--7--) MTC discharge temperature ($S_{d\text{-}MT}$) — After the exit of MTC, at stream (--8--)		
5.	Additional pressure sensors (refer Figure 1)	LT evaporator exit pressure ($P_{aux\text{-}1}$) — at stream (--1--) MT evaporator exit pressure ($P_{aux\text{-}2}$) — at stream (--27--) Subcooler exit pressure ($P_{aux\text{-}3}$) — at stream (--15--) $P_{aux\text{-}4}$ — at stream (--16--)		
6.	Additional temperature sensors (refer Figure 1)	LT evaporator exit temperature ($S_{aux\text{-}1}$) — at stream (--1--) MT evaporator exit temperature ($S_{aux\text{-}2}$) — at stream (--27--) Subcooler exit temperature ($S_{aux\text{-}3}$) — at stream (--15--) IHX1 exit temperature ($S_{aux\text{-}4}$) — at stream (--16--)		
7.	Design capacity	The CO_2 system delivers simultaneous cooling at two temperature levels based on the cooling demand of the process		

fluid. Waste heat is recovered in two stages from HX1 and HX2 after the MTC. The design cooling capacity to be offered is presented in the table below. The nominal heat exchange capacity mentioned in the table shall be at design evaporation temperature

Component name	Capacity	Design evap. temp.	Range_min	Range_max
MT Evaporator	20 kW	5 °C	-5.00 °C	5.00 °C
LT Evaporator	20 kW	-15 °C	-25.00 °C	-15.00 °C

8. Coolant in and out temperatures at design condition

Component	Coolant In	Coolant Out
MT Evaporator	12 °C	7 °C
LT Evaporator	-8 °C	-13 °C
HX1 Gas Cooler	35 °C	55 °C
HX2 Gas Cooler	55 °C	90 °C
MT Subcooler	7 °C	12 °C

9. Heat rejection / Water management

All CO_2 side heat exchangers shall be brazed plate heat exchangers capable of withstanding high-pressure duty (minimum 80 bar LT and 130 bar MT).

System requirements:

1. The temperature of the hot water stream at the outlet of heat recovery heat exchanger HX1, to be controlled only if it goes above 95 °C.
2. The mass flow rate of water going to tank 2 (T2) needs to be a minimum in such a way that the temperature of the hot water stream to be around 90 °C at all operating conditions.
3. The IHX2 is integrated to achieve the degree of superheat at the inlet of the low temperature compressor (LTC). The vendor may suggest the operation mode of the IHX2 since the LT evaporator will be operating between temperatures of -15 °C (design) and -25 °C (extreme); therefore, at a higher value of LT evaporator saturation temperature, IHX2 can be bypassed.

10. Detailed component specification

LT Compressor (LTC)

	s (refer Figure 1)		Compressor Type	Semi-Hermetic Reciprocating Compressor with VFD with at least 30-50 Hz frequency range		
			No. of Compressor	1 Nos. with 4 cylinders		
			Design Pressure (LP/HP)	100 bar / 100 bar		
			FLA / MCA / MOC (each motor)	VTC		
			Construction	VTC		
			Manufacturer	Globally reputed, VTC		
			Capacity Control	VTC		
			Parallel Compressor (PC)			
			Compressor Type	Semi-Hermetic Reciprocating Compressor with VFD with at least 30-50 Hz frequency range		
			No. of Compressor	1 Nos. with 4 cylinders		
			Design Pressure (LP/HP)	80 bar / 130 bar		
			FLA / MCA / MOC (each motor)	VTC		
			Construction	VTC		
			Manufacturer	Globally reputed, VTC		
			Capacity Control	VTC		
			MT Compressor (MTC)			
			Compressor Type	Semi-Hermetic Reciprocating Compressor with VFD with at least 30-50 Hz frequency range		
			No. of Compressor	1 Nos. with 4 cylinders		
			Design Pressure (LP/HP)	80 bar / 130 bar		
			FLA / MCA / MOC (each motor)	VTC		
			Construction	VTC		
			Manufacturer	Globally reputed, VTC		
			Capacity Control	VTC		
			Gas Cooler - HX1			
			Type	Brazed Plate Heat Exchanger		
			Heat Exchange Capacity	VTC		
			Continuous Duty Pressure Rating	130 bar		
			Materials of Construction	SS316 and Copper brazed		
			Cooling Media	Water		
			Manufacturer	Globally reputed, VTC		
			Gas Cooler - HX2			
			Type	Brazed Plate Heat Exchanger		

Heat Exchange Capacity	VTC
Continuous Duty Pressure Rating	130 bar
Materials of Construction	SS316 and Copper brazed
Cooling Media	Water
Manufacturer	Globally reputed, VTC
Gas Cooler - Subcooler	
Type	Brazed Plate Heat Exchanger
Heat Exchange Capacity	VTC
Continuous Duty Pressure Rating	130 bar
Materials of Construction	SS316 and Copper brazed
Cooling Media	Water
Manufacturer	Globally reputed, VTC
MT Evaporator	
Type	Plate Heat Exchanger
Heat Exchange Capacity	VTC
Continuous Duty Pressure Rating	90 bar
Materials of Construction	SS316 and Copper brazed
Cooled media	Glycol
Manufacturer	Globally reputed, VTC
LT Evaporator	
Type	Plate Heat Exchanger
Heat Exchange Capacity	VTC
Continuous Duty Pressure Rating	90 bar
Materials of Construction	SS316 and Copper brazed
Cooled media	Glycol
Manufacturer	Globally reputed, VTC
IHX1	
Type	Plate Heat Exchanger
Heat Exchange Capacity	VTC
Continuous Duty Pressure Rating	130 bar
Materials of Construction	SS316 and Copper brazed
Cooled media flow rate	VTC

Manufacturer	Globally reputed, VTC
IHX2	
Type	Plate Heat Exchanger
Heat Exchange Capacity	VTC
Continuous Duty Pressure Rating	90 bar
Materials of Construction	SS316 and Copper brazed
Cooled media flow rate	VTC
Manufacturer	Globally reputed, VTC
CO_2 Receiver	
Type	Receiver and phase separator
Quantity	1 No.
Volume	VTC
Continuous Duty Pressure Rating	90 bar
Materials of Construction	Carbon steel, fully welded and type tested
Accessories	Level switches, sight glasses, charging port, PRV
Type of Receiver configuration	Intermediate Pressure receiver
Manufacturer	Reputed, VTC
Oil Management	
Type	High-pressure stored oil management
Oil Separator	On high side, designed to 130 bar
Oil Reservoir	On high side, designed to 130 bar
Oil Return Philosophy	Electronic control, on-demand from compressor
Pressure equalization	Between reservoir and MT compressor suction
Oil Filtration	In-line cartridge type oil line filters
Vessels Manufacturer	Reputed, VTC
Oil Level Control Manufacturer	Reputed, VTC
Accessories and Controls (minimum requirement)	
LT Refrigerant Line Accessories	Filter-Drier with replaceable cartridges
	Sight glass
	Isolation valves (ball valves) on all equipment
	Pressure manifolds with gauge and transmitters
LT Gas and Liquid Control	1 x Electronic Expansion Valve 1 x Liquid-Gas IHX

			Filter-Drier with replaceable cartridges			
		MT Refrigerant Line Accessories	Sight glass			
			Isolation valves (ball valves) on all equipment			
			Pressure manifolds with gauge and transmitters			
		MT Gas Control	1 x High Pressure Transcritical Valve (for 130 bar) 1 x Flash Gas Bypass Valve			
		Load Control and Supervision	VFD for Compressor - Globally reputed, VTC			
			Pack Controllers - Globally reputed, VTC Supervisory PLC - Globally reputed, VTC			
		Pressure Safety Devices with changeover (mechanical)	High Pressure Safety (130 bar), pressure relief valve			
			Low Pressure Safety (40 bar), pressure relief valve			
			Receiver Safety (80 bar), pressure relief valve			
		Safeties				
		Pressure Safety Devices without changeover (mechanical)	High Pressure Vent on each Compressor Body Low Pressure Vent on each Compressor Body			
		Safety Cascade for each Group (LT and MT)	High Pressure Switch, settable High Pressure Transmitter Low Pressure Switch, settable Low Pressure Transmitter Compressor Mounted Pressure Switch, fixed Compressor Discharge Temperature Compressor Suction Temperature All pressure sensors to be with accuracy of at least ±1 bar and all temperature sensors to be with accuracy of at least ±1 °C			
		Electrical Safety Devices	Single Phasing Preventer			
			Surge and Lightning Combined Arrestor			
			Main MCCB interlocked to door opening and LOTO			
			In-built power backup for all expansion valves			
			Provision for control circuit operated on customer UPS			

<table>
<tr><td></td><td></td><td>
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<tr><th colspan="2">Skid construction</th></tr>
<tr><td>Piping</td><td>Refrigerant Piping - SS316 Sch 40/80 capable of withstanding up to 180 bar
All joints TIG Welded or tube-lock connectors</td></tr>
<tr><td>Skid Frame</td><td>Fully welded carbon steel construction with corrosion resistant epoxy-polyester powder coating</td></tr>
<tr><td>Insulation</td><td>NBR Class 0 / equivalent</td></tr>
<tr><td></td><td></td></tr>
<tr><th colspan="2">Control panel</th></tr>
<tr><td>Construction</td><td>Powder Coated CRCA Carbon Steel Panel</td></tr>
<tr><td>Ingress Protection</td><td>IP 55</td></tr>
<tr><td>Cabinet Manufacturer</td><td>Globally reputed, VTC</td></tr>
<tr><td>Switch gear Manufacturer</td><td>Globally reputed, VTC</td></tr>
<tr><td>Control gear Manufacturer</td><td>Globally reputed, VTC</td></tr>
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<tr><td>11.</td><td>Documentation</td><td>1. Individual Part OEM user manuals
2. Individual Part OEM certifications/COC
3. General Arrangement, Detail Drawings, and 3D Layouts
4. P&ID and Functional Design Specification
5. Electrical Drawings for Panel and Field termination along with BOM
6. Site IO testing protocol
7. Spare parts list
8. Operation and Maintenance Manual of the CO_2 system</td><td></td><td></td></tr>
<tr><td>12.</td><td>Quality assurance</td><td>1. Inspection and Test Plan to be agreed.
2. Dry-test (functional check) along with pressure integrity testing and leak detection before dispatch of goods.
3. The vendor should have an ISO 9001 quality management system in place and should be certified to fabricate equipment specifically designed with natural refrigerants such as CO_2. The ISO certification must be provided in the technical offer.
4. The vendor must have successfully fabricated, installed, and commissioned at least one transcritical CO_2 cooling system in an academic or industrial setting in India. Certification to this extent must be provided in the technical offer.</td><td></td><td></td></tr>
<tr><td>13.</td><td>Commercial offer</td><td>The commercial offer should include unit cost, transportation cost to IIT Bombay premises, and applicable taxes mentioned separately.</td><td></td><td></td></tr>
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14.	Scope division					

S. No.	Item	IIT Bombay	Vendor
1	**Unloading**	• The removal of material from vehicles, unloading (by means of crane/hydra or lifting devices and manpower) and safe dry storage as per the requirement	• Intimation of dispatch along with the type/size of equipment supplied
2	**Power**	• Harmonically filtered 3-phase 415 VAC, 50 Hz will be made available at incomer of vendor panel • Chemical earth pits to be provided at all motor points or suitable earth flat close by to connect to earthing grid • UPS Power Supply will be provided at the incomer of our vendor panel	• From MCC panel onwards, power & control cable, all equipment earthing, cable trays, supports, gland termination, etc. • Power cables shall be armoured copper • Control cables shall be flexible or shielded as required • Cable trays shall be prefabricated SS mesh type • Local junction boxes shall be provided for ease of termination and tracing • Requirement details for UPS Power Supply

		3	**Fluids**	• All water and glycol circuits complete with pumps, tanks, valves, instrumentation, and control system including piping and insulation	• Sizing and capacity calculation, along with make and model recommendation, for all the tanks, pumps, valves, strainers/filters, heaters, piping, fittings, and instrumentation • Internally piped and factory manufactured header and branch piping with insulation for CO_2 • Internally piped and factory manufactured take-off piping for water/glycol		
		4	**Civil Work**	• All type of civil and structural work including raised platforms required for equipment erection including light roofing	• Detailed requirement and drawings of any civil work requirement to be shared well before dispatch		
		6	**Miscellaneous**	• Shifting of existing equipment • Statutory clearances • Plant lighting and nameplates • Water lines for fire fighting • Caged enclosure with light roofing	• Details/list of items for which the nameplates should be made • List of requirements concerning suitable equipment for vacuum, leak testing, and gas boosting		

				• CO_2 gas for charging at site with suitable equipment for vacuum, leak testing, and gas boosting	• Personal protective equipment for operators who install the equipment		
15.	Warranty of the system	1 year					

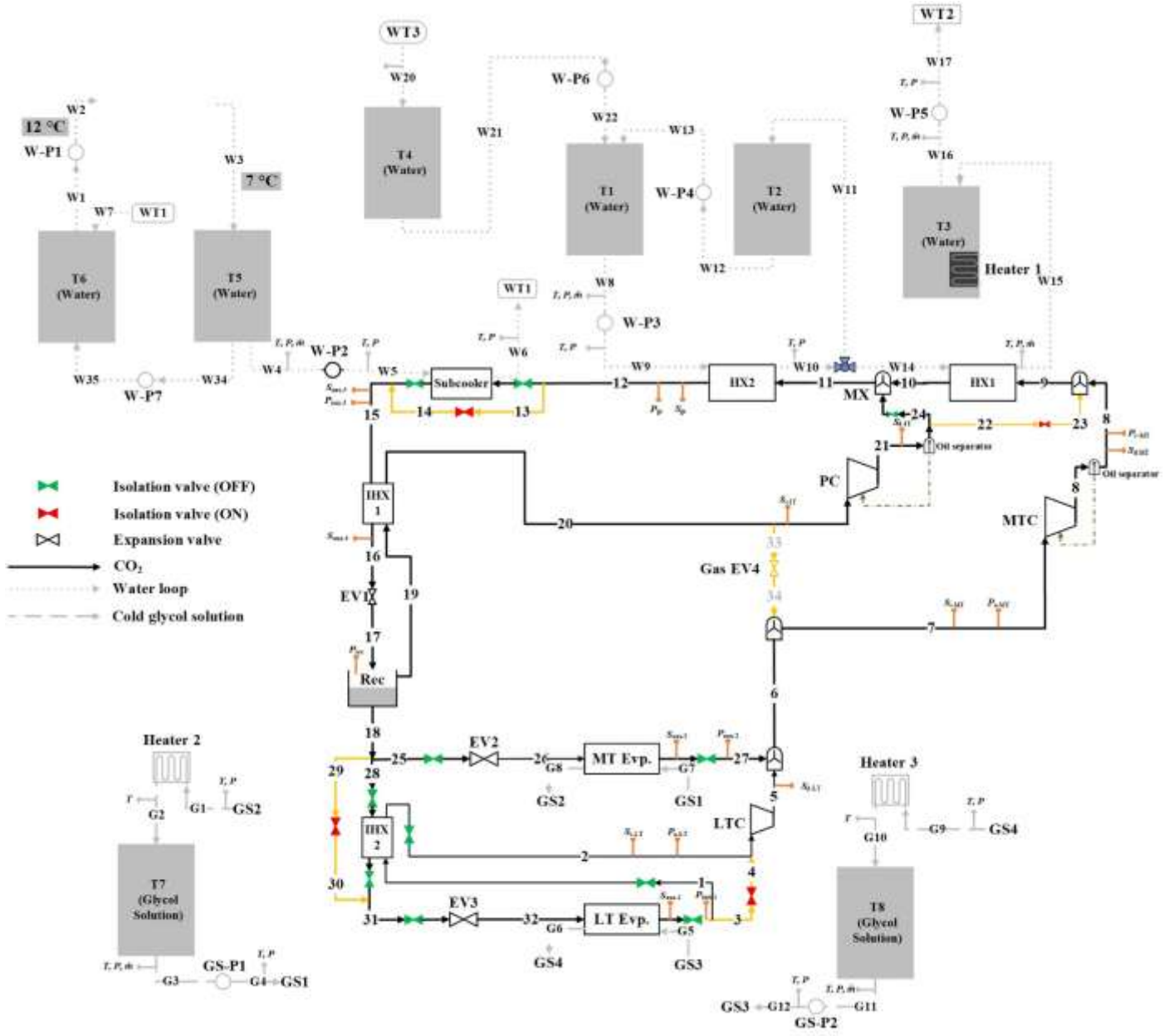

Figure 1: Schematic of the modified transcritical CO_2 booster refrigeration system. LTC is low temperature compressor, MTC is medium temperature compressor, PC is parallel compressor, HX is heat exchanger, Rec is receiver, MX is mixer, and EV is expansion valve.