

10.0.0 FIELD AND MEASURING INSTRUMENTS

10.1.0 General Requirements

- 10.1.1 Instruments, control devices and other equipment accessories covered under this specification shall be furnished in accordance with I&C specification sheets and drawings enclosed herewith and the requirements of all applicable clauses of this specification.
- 10.1.2 The Instrumentation and Control equipment shall conform to all applicable codes and standards. All equipment and systems shall also fully comply with the design criteria stated.
- 10.1.3 The Instrumentation & Control equipment and accessories shall be from the latest proven design for which the performance and high availability have been demonstrated by a considerable record of successful operation in power station service for similar applications. The bidder shall furnish sufficient evidence to fully satisfy the Owner in this regard.
- 10.1.4 The Bidder shall furnish all Instrumentation & Control equipment and accessories under this specification as per technical specifications, ranges, makes and model numbers approved by the Owner during detailed engineering.
- 10.1.5 All instruments, devices and accessories furnished by the Bidder as per this specification shall be designed and constructed to perform normally and meet all guarantee when subjected to the environmental and service conditions and other applicable specification documents.
- 10.1.6 The necessary root valves, impulse piping, drain cocks, gauge zeroing cocks, valve manifolds and all other accessories required for mounting/erection of all local field instruments shall be provided by Bidder as per approved hook up drawings.
- 10.1.7 In general front draw out type instruments with plug-in facility at the rear for connecting flexible cables for power supply and signal shall be provided. Separate plugs shall be provided for connecting power supply and signal wires.
- 10.1.8 The plug & sockets shall be polarized to prevent wrong connections and have facility for secure coupling in plug-in position to prevent loose connections.
- 10.1.9 Every instrument requiring power supply shall be provided with a pair of easily replaceable glass cartridge fuse of suitable rating. Every instrument shall be provided with a grounding terminal and shall be suitably connected to the panel grounding bus.
- 10.1.10 All field instruments shall be weatherproof, drip tight, dust tight and splash proof suitable for use under outdoor ambient conditions prevalent in the subject plant. All field-mounted instruments shall be mounted in suitable locations where maximum accessibility for maintenance is achieved. The enclosures of all electronic instruments shall conform to IP-65 unless otherwise specified (Explosion proof for NEC class 1, Division 1 area) and an anti-corrosive paint shall be applied to the field mounted enclosures / instruments. All the field instruments shall also be provided with SS tag nameplate and double compression type nickel-plated brass cable gland. Gaskets, fastener, counter and mating flange shall also be included wherever required with instruments.

10.2.0 Minimum Requirement of Field Instruments

- 10.2.1 Following minimum requirement of field instruments shall be fulfilled by Bidder (In addition, Redundancy criteria for instruments shall be as specified elsewhere in specification): -
 - 1) Level Transmitter, Level switches for very high / high / normal / low / very low interlocks (type as per Owner approval).
 - 2) Tapping points/test points shall be provided.

- 3) All Thermocouples & RTDs shall be Duplex.
- 4) All Field Instruments used in acid or alkaline atmosphere shall be with standard anti-corrosion coating i.e. the combination of polyurethane and epoxy resin baked coating (ANSI/ISA-71.04).
- 5) All primary instruments installed at “Minus level or Floor” shall be with protection class of IP 68.
- 6) Transmitters (all type) as on required basis for monitoring interlocks & controls as per redundancy criteria.
- 7) 6 no. duplex or 12 no. simplex embedded temperature detectors for various motor stator windings and duplex RTDs for motor/pump bearing temp.
- 8) All field mounted push button, selector switch etc. shall be as per IEC or NEMA 4X protection.
- 9) All limit switches shall be conforming to IEC-60947-5-1.
- 10) For all instruments envisaged for sea water applications, they shall be provided with wetted parts of Monel / Hastelloy C.
- 11) Primary Elements: Flow nozzles shall be made of stainless steel, with three sets of pressure taps installed in the pipe wall where required. Installation of flow nozzles and pressure taps shall be made in the pipe
- 12) Paddle type orifice plates shall be used for other flow measurements where flanged construction and higher pressure loss are acceptable. Orifice plates shall be made of stainless steel. Orifice flanges shall be of the raised face weld neck type with dual sets of taps.
- 13) Construction and installation of flow nozzles and orifices shall conform to the requirements of ASME Performance Test Code PTC-19.5, and discharge coefficients shall be predicted in accordance with data published in ASME Research Report on Fluid Meters.
- 14) Orifice plates shall be supplied with carrier rings as per process requirement.
- 15) Secondary Elements: Secondary elements for differential type flow sensors shall be strain gauge or capacitance type differential pressure transmitters. Square root extraction required for the DP transmitters shall be performed electronically in the transmitter itself.
- 16) Instrument and Service Air – Vortex/Swirl type flow meter
- 17) Any other flow element/meter required for system shall be finalized as per system requirement and as per approved drawings/documents.
- 18) At each inlet and outlet lines of gas to gas heat exchanger, the following instruments shall be provided as a minimum:
 - (a) Pressure indicator – 1 no and pressure transmitter – 2 nos
 - (b) Differential pressure transmitter across inlet and outlet lines
 - (c) Temperature transmitters – 2 nos
- 19) Redundant SO_x analyzers shall be provided at inlet (untreated flue gas) and outlet (treated flue gas) of Gas to Gas Heater (GGH). Temperature measurements for GGH shall be considered on all the sides.

- 20) pH analyzers (redundant) to be provided for each oxidation tank and waste water tank. Density analyzers (redundant) to be provided for oxidation tank and limestone slurry preparation tank. Density measurements in hydro cyclone feed lines, slurry feed lines etc shall also be provided.
 - 21) Online Moisture analysis instruments to be provided for dewatered gypsum. Dew point analyzer to be provided for instrument air service and auto drain trap to be considered for air receiver.
 - 22) CEMS - CO, Sox, NOx, Opacity & Oxygen analyzers at the inlet and outlet duct of the FGD system. Humidity analyzer shall also be included in the outlet of FGD system
 - 23) All instruments shall be provided with durable epoxy coating for housings and all exposed surfaces of the instruments.
- 10.2.2 Above are the min. requirements, however actual quantities shall be as decided during detailed engineering based on redundancy criteria. Other pressure gauges for systems shall be decided during detailed engineering.
- 10.2.3 It is envisaged to use separate instrument / switches for initiation of interlock and trip circuits. The proposal shall include adequate number of pressure, differential pressure, level, flow and temperature switches to meet the systems functional requirements. Where blind type of pressure, differential pressure and flow switches are employed, the necessary provision shall be made for connection of test gauge. All switches shall be provided with snap action DPDT contacts and shall be equipped with plug in type connections for terminating field wiring.
- 10.2.4 Switch actuation point shall be field adjustable with a calibration scale to indicate the set point. Switches shall have capacity of 5.0 amps at 240V AC or 0.5 amps at 220V DC. Level switches for general service shall be float type. Float material shall be stainless steel SS316.
- 10.2.5 Thermowells, sight-flow indicators, level gauges etc. shall be of a reputed make and type and shall be subject to the Owner's approval. The switches should be of type designed for alarm and interlock purposes. Thermometers and pressure gauges with contacts attached to perform these functions will not be acceptable.

Field instruments shall be supplied & offered as per data sheets specified below:

10.3.0 Transmitters, Switches, Gauges and Panel Mounted Instruments

10.3.1 Pressure, Differential Pressure, Level and Flow Transmitters (PT, DPT, LT & FT)

- a. Smart Transmitters of the electronic type shall be furnished.
- b. Transmitters shall be equipped with mounting brackets suitable for a mounting in transmitter enclosures.
- c. In general, Transmitters are envisaged to be grouped at several places as to be decided during detailed engineering stage. For this purpose, suitable enclosures complete with all tubing, fittings, purge meters, loop cable trays etc. shall be provided.

Type/Construction : Sealed capacitance/ Inductance/ Silicon resonance type

Material

Body : Die cast Aluminum with epoxy coating for air & flue gas
SS316 for other services

Diaphragm	:	316 SS
Measurement element	:	Teflon seal
Valves	:	Carbon steel for non-corrosive Applications SS316 for corrosive applications.
Output signal	:	4 to 20 m Amp. DC (Two wires) HART Compatible
Local Indicator	:	LCD indicator (5 digit) with scale of Engg. Unit
Overall Accuracy	:	$\pm 0.075\%$ or better of FSR
Turn down ratio	:	10:1 for vacuum / very low pressure application 30:1 for other applications
Stability	:	$\pm 0.15\%$ for 5 years.
Response time	:	100 msec.
Power supply	:	24V DC nominal
Drive capability	:	500 Ohms minimum
Enclosure Class	:	IP-65 (Explosion proof as per NEC article 500 for hazardous area)
Span and Zero	:	Locally adjustable, non-interacting
Zero suppression / elevation:	:	At least 100% of Span

Connection

Process	:	Half (1/2) inch NPT (F)
Electrical	:	Plug and socket, unused entry with blind plug.
Accessories	:	Span and zero adjustment facility
For Absolute Pressure Transmitters	:	Two (2) valve SS316 manifold
For Gauge & Vacuum pressure transmitter	:	Three (3) valve SS316 manifold
For DP, level & flow Transmitter	:	Five (5) valve SS316 manifold
For oil and corrosive liquids	:	Separator diaphragm seals
For all transmitters	:	Mounting bracket
Mounting	:	Local (in LIE/LIR)

- d. In case it becomes necessary to use a DP transmitter for pressure measurement, then a 3-Valve manifold shall be used in place of 2-valve manifold. Manifold shall not be mounted on the transmitter; It shall be non-integral type. Pulsation dampeners shall be used where the process media is unstable for measurement such as the

discharge of a pump. Overrange protection shall be used where necessary. The coil siphons & condensate pots shall be used for steam services. Transmitters shall be provided with suitable drain & vent points.

- e. As for the water flow/ steam flow measurements, necessary flow elements/ transmitters are chosen in the process line and supplied such that their algebraic summation shall be mass balanced for calculating the system efficiency.
- f. Contacts less, electronic 2-wire position transmitters shall be provided for all inching type motorized valve and dampers.
- g. For acid and alkali applications, only non-contact type level transmitters like acoustic, ultrasonic, radar based shall be provided by bidders.
- h. Where the process fluids are corrosive, viscous, solid bearing or slurry type, diaphragm seals shall be provided. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application. For hazardous area, explosions proof enclosure as described in NEC article 500 shall be provided.
- i. LVDT type is not acceptable.
- j. Transmitters & other HART based instruments shall be supplied along with 3 Nos. of universal type hand held/portable pressure calibrators. Temperature transmitters shall be supplied along with 3 Nos. of hand held/portable mV source generators.

10.3.2 **Pressure Switches (PS) & Differential Pressure Switches (DPS)**

Applicable Standards	: IS3624 – 1966/ISA-RP-8.1 except as modified in spec.
Type/Construction	: Bellows /Sealed Diaphragm for low pressure / vacuum and Piston Actuated preferable for high pressure. Indicators with contacts are not acceptable.
Materials-	
Bellows	: 316 SS
Bourdon tube	: 316 SS
Movement	: 316 SS
Protective Diaphragm	: Die-cast aluminum with stoved enamel black finish. Epoxy coating shall be provided for corrosive atmosphere.
Accuracy	: $\pm$ One (1) percent or better
Repeatability	: $\pm$ 0.5(half) percent or better
Setting & Differential	: Adjustable
Over pressure range	: Fifty(50) percent of full scale.
Contact	:
Number	: DPDT /2 SPDT
Type	: Auto reset with internal Adjustable snap action micro switch
Rating	: 5 Amp, 240V AC / 0.5 Amp, 220V DC

Connection – instrument Electrical	:	Half (1/2) inch NPT male Process Suitable for Plug & socket connection. All the switches are internally connected and brought to the surface with amphenol male/female connection. Cabling need not terminated inside the switch. Cable ends are to be soldered in connector and to be inserted for easy maintenance.
Over range protection	:	Fifty (50) percent of full scale
Enclosure	:	IP 65
Accessories		
3 / 5 valve manifold	:	For all switches
Self-cleaning type Pulsation dampeners/Snubber (Material SS316)	:	Pump and compressor discharge lines
Syphon	:	For all steam lines
Protective separating diaphragm Mounting	:	For Corrosive liquid lines. Local (in LIE/LIR)

10.3.3 Pressure & Differential Pressure Gauges (PG & DPG)

Applicable standard	:	IS: 3602-1966, IS/3624, ASME B 40.1
Sensing Element and Materials	:	Bourdon for high pressure, diaphragm/bellow for low pressure of all materials in SS 316
Case	:	SS 316/ Die-cast aluminum with stoved enamel black finish. Epoxy coating shall be provided for corrosive atmosphere.
Protective Diaphragm	:	Teflon
Dial size	:	150mm with shatter proof glass
Scale Details	:	Graduations in black lines on white dial, 270 Deg pointer defection scale provided with glass cover. Smallest scale division shall be one (1) percent of full scale value or smaller. Pointer stop for all gauges.
Accuracy	:	± One (1) percent or better
Connection – Instrument Process	:	1/2 inch NPT Male Bottom
Mounting	:	Local 1/2 inch NPT Male (Back entry) mounted on local gauge board.
Accessories		
3 way needle valve/manifolds	:	For all gauges

Self-cleaning type Pulsation dampener/snubber	:	Pump and compressor discharge lines
Syphon	:	For all steam lines
Protective separating	:	For fuel oil and corrosive liquid lines
Other particulars		
Zero & span adjustment Safety device	:	For all gauges
Housing	:	IP 65
Ranges 5 to 20 Kg/cm ²	:	Rubber blow out disc with open front construction
Ranges above 20 Kg/cm ²	:	Neoprene safety diaphragm at the back with solid front construction
Over range protection	:	Fifty (50) percent of full scale Movement mechanism shall be glycerin filled for oil services & vibration prone area.
	:	For corrosive liquid lines diaphragm type sensors required. Armored capillary of 10 mtrs for Corrosive liquid service
	:	Contact type pressure gauges are not acceptable for interlock & protection.
Identification	:	Identification engraved with service legend or laminated phenolic name plate.

10.3.4 Resistance Temperature Sensors with thermowells

Applicable Standard	:	ASME PTC 19.3 / DIN 43760 for RTD -Latest Revision
Element	:	Platinum, R0=100 ohm 4 –wire Duplex
Sheath Material/ Insulation	:	316SS metal sheathed /Compacted Magnesium Oxide
Sheath OD	:	8 MM
Terminals	:	Spring loaded
Calibration	:	As per DIN Standard – 43760, Class A
Head	:	Die Cast Aluminum (Screwed) with galvanized chain
Response Time	:	< 20 Sec for measurement < 10 Sec for Control
Accuracy	:	±0.35° C or class A DIN 43760 whichever is better.

Electrical connection	: Plug in connector type
Enclosure	: IP 65

Thermo well

Applicable Standard	: ASME PTC 19.3 TW – 2010
Construction	: Tapered drilled from Bar stock for SS316 material thermowell. (Straight for Air & Gas systems)
Material	: - 316 SS – water and steam services - Inconel for air & flue gas services Bidder shall provide calculation for thermo well as per ASME – PTC-19.3.
Process Connection	: i) M33 x 2 ii) Flanged for Air & Gas systems with mating flanges
Immersion Length	: Within ± 10 mm of center line of pipe
Extension neck length	: Minimum 100 mm above Insulation of pipe and Minimum 160 mm when there is no insulation on pipe.
IBR Certification	: For high pressure service, Steam Temp., Fuel oil temp. Measurement as per IBR rules and regulations

Note :

Extension/Compensating cable exposed to atmosphere in the conventional method melts away in the high temperature. Hence The terminals of temperature sensors shall not be at the high temperature zone. The temperature sensors wires are to be laid up to JB though SS tube of required diameter and the head shall be placed nearer to the JB.

10.3.5 Thermocouples with thermowells

Applicable standard	: ASME PTC 19.3- Latest Revision
Element	: Duplex
- Sheath	: 8 MM OD
- Sheath Material	: 316 SS
- Spring Loaded	: Yes
- Nipple/Union	: Yes
- Packed connector	: Compacted magnesium Oxide ungrounded
- Type	: i. Type K (Chromel – Alumel) ii. Type R (Platinum Rhodium-Platinum)
- Gauge	: 16 AWG wire of Chromel – Alumel (Type – K) or 24 AWG wire Pt-Rhodium Pt(Type R) depending on operating temperature range (Ungrounded type)
Head	: IP 65 / Die Cast Aluminum

Electrical connection : Plug in connector type.

Thermowell

Applicable Standard : ASME PTC 19.3 TW (latest)

- Construction : Tapered Drilled from Bar stock for SS316 material thermowell. (Straight for Air & Gas systems)

- Material : - 316SS for water/steam services
- Inconel for air & flue gas services

For furnace zone, impervious ceramic protecting tube of suitable material along with Inconel supporting tubes and adjustable flanges.

For Mill outlet temperature long life solid sintered tungsten carbide material of high abrasion resistance. Bidder shall provide calculation for thermowell as per ASME – PTC-19.3.

- Process Connection : (i) M 33 x 2
(ii) SS316 Flanged, for Air & Gas systems, with mating flanges.

- Extension : Threaded union 1/2" NPT (F) with two nipples of SS 316 having 1/2"NPT (M) threads at both ends

Accuracy

(For Type K T/C) : ±1.1 deg.C (for 0 to 277 deg.C)
± 0.4 percent (for 277 to 1280 deg.C)
Class-A

For Type S & R T/C : ± 0.6 deg.C or + 0.1%
For Type T T/C : ± 0.5 deg.C or + 0.4%

Accessories : Bolts, nuts and gaskets for flanged connections.

Response Time : < 20 Sec for measurement
< 10 Sec for Control

Immersion length : Within ± 10 mm of center line of pipe

Extension neck length : minimum 100 mm above insulation of Pipe and minimum 160 mm when there is no insulation on pipe.

IBR Certification : For high pressure service, Steam Temp., Fuel oil temp. measurement as per IBR rules and regulations.

Note :

Extension/Compensating cable exposed to atmosphere in the conventional method melts away in the high temperature. Hence The terminals of temperature sensors shall not be at the high temperature zone. The temperature sensors wires are to be laid up to JB though SS tube of required diameter and the head shall be placed nearer to the JB.

10.3.6 Temperature Switches (TS)
Type/Construction

- Switch : Industrial type Mercury in steel with capillary and separable thermowell and contacts directly connected to Bourdon element/vapour pressure sensing, liquid filled bellows type preferred.
- Thermowell : Bar stock

Material

- Thermowell & Bulb : 316 SS
- Capillary : Armoured Stainless Steel
- Bourdon : 316 SS
- Bourdon Movement : SS 316
- Casing : Die-cast aluminum with stoved enamel black finish Epoxy coating shall be provided for corrosive atmosphere.

Setting and Differential : Adjustable

Accuracy : $\pm$ One (1) percent of setting and differential

Repeatability : One half (1/2) percent of setting

Contacts

- Number : DPDT/2 SPDT
- Type : Auto reset with internal Adjustable snap action micro switch
- Rating : 5 Amp, 240V AC / 0.5 Amp, 220V DC

Connection

Pipe : M33 x 2

Thermowell : To suit switch

Electrical : Suitable for Plug in type.
All the switches are internally connected and brought to the surface with Amphenol male/female connection. Cabling need not terminated inside the

Enclosure protection	:	switch. Cable ends are to be soldered in connector and to be inserted for easy Maintenance.
Other Particulars	:	IP 65
- Capillary length	:	As per requirement
- Immersion Length	:	Within $\pm$ ten (10) mm of center line of pipe with adjustable nuts.
- Extension neck length	:	Minimum 50 mm above insulation of pipe / As per approved hookup drawings.
- Packing glands	:	Yes
IBR Certification	:	For high pressure service, Steam Temp, Fuel oil temp. measurement as per IBR rules and regulations
N.B	:	Switches designed for cross ambient operation shall be used in applications where the ambient temperature will approximate or exceed the switch set point.

10.3.7 Temperature Gauges (TG)

Applicable standard	:	IS : 3602,BS:5235 ISA:RP:8.1 except as modified in this specification
Type/Construction		
- Thermometer	:	Industrial type, Inert gas type
- Thermowell	:	Bar stock
Material		
- Thermowell & Bulb	:	316 SS
-Movement	:	316 SS
- Capillary	:	Armoured SS (Applicable for capillary Type)
- Casing	:	SS 316/ Die-cast aluminum with stoved enamel black finish. Epoxy coating shall be provided for corrosive atmosphere
Dial Size	:	150mm with shatter proof glass
Scale Details	:	270 degree dial rotation/deflection. Graduations in black lines on white dial provided with glass cover. Smallest scale division shall be one (1) percent of full scale value or smaller. Pointer stop for all gauges
Accuracy	:	$\pm$ One (1) percent or better

Response time	:	Maximum 15 seconds without thermowell
Connection		
- Pipe	:	M33 x 2
- Thermowell	:	To suit instrument
Other Particulars		
- Capillary length	:	5Meters/10 Meters as required
- Immersion Length	:	Within $\pm$ ten (10) mm of center line of pipe with adjustable nuts.
- Extension neck length	:	Minimum 50 mm above insulation of pipe /As per approved hookup drawings.
- Stop at Maximum value	:	For all gauges of scale
- Pointer	:	Externally adjustable
	:	Contact type Temp. gauges are not acceptable for interlock & protection.
IBR Certification	:	For high pressure service, Steam Temp., Fuel oil temp. measurement as per IBR rules and regulations
Enclosure protection	:	IP 65

10.3.8 **Test Thermowells (TT)**

Applicable Standard	:	ASME PTC 19.3 TW (latest)
Type/Construction	:	Machined from Bar Stock
Material	:	316 SS
Connection		
- Pipe	:	M33 x 2
- Test Instrument	:	To suit test instruments
Accessories	:	Plug with chain
IBR Certification	:	For high pressure service, Steam Temp., Fuel oil temp. measurement as per IBR rules and regulations Bidder shall provide calculation for thermowell as per ASME – PTC-19.3 TW – 2010.

Test wells shall be provided as required to meet ASME test requirements.

10.3.9 **Ultrasonic Level Transmitter (for Water sump/Tank level measurement)**

Type	:	Non-contact Microprocessor based 2 wire type, HART protocol compatible
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Principle of Operation	:	Detection of reflected ultrasonic pulse
Measuring Ranges	:	Up to 30 meters (typical)
Signal Processing	:	Microprocessor Controlled Signal Processing
Operating Freq.	:	10 KHz to 50 KHz (typical)
Display	:	Head mounted Large alpha-numeric back lit LCD/LED
Calibration & Configuration	:	Accessible from front of panel
Diagnosis	:	On-line
Status	:	For power, Hi / Lo / V. Hi / V. Lo-level indication, fault etc.
Construction	:	Plug-on board
Power supply	:	24 V DC +/- 10% or 230 VAC 50 Hz
Signal Output	:	Galvanically isolated 4-20mA DC with HART protocol
Hysteresis	:	Fully adjustable preferred
False signal tolerance	:	Transmitter shall be capable of ignoring false echos
Output contacts	:	2SPDT Potential free changeover contacts @ 8A 230V AC.
Accuracy & Repeatability	:	±0.25% of span or better
Temperature compensation	:	To be provided with transducer
Resolution	:	±0.1% of span
Operating temp.	:	Transmitter-50 deg C and Sensor –80 deg C
MOC Sensor	:	Body- PVDF and Face – Polyurethane or Corrosion resistant material to suit Individual application requirement
Humidity	:	1% to 95% non-condensing.
Enclosure	:	IP-65 Epoxy painted die cast Aluminum or SS316L housing.
Cable Connection	:	Plug and socket.
Mounting	:	2" – 4" NPT or flanged
Accessories	:	Cable gland, prefab cable, mounting accessories like EPDM seal, SS316 flanged etc.

Additional separate local display unit with large Alphanumeric back light LCD/LED & to be provided for the applications which will be decided during detailed engineering.

All weather canopy for protection from direct sunlight and direct rain.

All mounting hardware and accessories required for erection and commissioning mounting fittings material shall be SS 316.

10.3.10 Guided Wave Radar/Radar Level Transmitter

Type	:	Guided wave Radar (Contact type)/Radar (Non-contact type).
Application	:	For Low pressure Vacuum vessels.
Environment Class	:	Highly abrasive with Gases and Fumes
Orientation	:	Vertical
Probe Type	:	Flexible Single lead with chuck
Probe Material	:	SS 316L
Connection Size & Type	:	2" Flanged ANSI 300 lb SS316L material
Connection material	:	SS 316L
Accuracy	:	±5 mm
Resolution	:	±1 mm
Type (Transmitter)	:	SMART, 2 Wire
Operating Principle	:	Time Domain Reflectometry
Signal Output	:	4-20mA DC with HART protocol and
Electrical Connection	:	1/2" NPT
Enclosure Class	:	IP 65
Electrical Power	:	11-42 V DC
Housing material	:	Die Cast Aluminum
Vent & Drain Plug material	:	SS
Side Flange Material	:	SS
Local Display	:	Provided (LCD Digital)
Units of Measurement	:	Length M

10.3.11 3 D Type Acoustic Wave Level Transmitter

Type	:	Acoustic Wave Level Transmitter (3D type)
Temperature compensation	:	Required for high temp applications
Operating Principle	:	Non – Intrusive acoustic wave transmission & Reflection
Frequency Range	:	3 – 10 KHz
Accuracy	:	±0.25 % for even surface & ± 0.5 % for uneven surface.
Resolution	:	1 MM
Output	:	4-20mA DC with HART

Local Display Unit:

Type	:	Head mounted LCD Display with Engg. Units
Location	:	Suitable location at bunker / Silo operating floor area
Protection Class	:	IP 65

Material of construction:

Housing	:	Polypropylene
Flange	:	Polypropylene

Sizes:

Flange Size	:	2" ANSI 300 # RF SS
Electrical connection size	:	1/2" NPT (F)
Accessories	:	i. Double compression type Nickel Plated Cable glands ii. Suitable Mating Flange, necessary gaskets iii. Local display unit & Suitable mounting brackets, necessary mounting hardware for Local display unit iv. Complete software as required to have 3 D view on monitors

10.3.12 Level Switches (LS)

Type/Construction	:	a) External float cage type with magnetic switch actuator for tanks and vessels. b) Displacer –Top mounted for all clean water sumps.
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- c) Conductivity type for high Pressure and high temperature enclosed vessel like drain pot, HP heaters etc.

Materials

- Body : Cast Carbon Steel suitable for specified pressure and temperature ratings
- : For corrosive liquids suitable anti-corrosive coat/lining shall be provided.
- Float/Displacer : 316 SS
- Wire rope : 316 SS

Differential & Setting : ± 12 mm minimum (Adjustable) Contacts

-Number : DPDT/2 SPDT

- Type : Snap action micro switch Auto reset with internal Adjustable

- Rating : 5 Amp 240V AC, 0.5 Amp 220V DC

Connection – Process : One (1) inch Scrd NPT Female
One (1) inch ANSI Flanged
Four(4) inch ANSI Flange for sump services.

Electrical : Suitable for Plug in type. All the switches are internally connected and brought to the surface with Amphenol male/female connection. Cabling need not terminated inside the switch. Cable ends are to be soldered in connector and to be inserted for easy maintenance.

Enclosure protection : IP 65
Temperature/pressure rating: As per service conditions

Accessories : Counter flanges, still pipe of requisite length with anticorrosive coating for sump services.

10.3.13 Capacitance Type Level Switch

Type : Capacitance type

Probe : a) Rod or suspended electrode
b) Rope type probes may be used only where required probe length is greater than 3 meters.

Probe Mounting : Stainless steel 1-1/2 ANSI RF Flange / 3/4" NPT (M)

Material of construction : 316 SS

Insulation : PTFE Part/Full as per service.

Enclosure : Powder/Epoxy coated Die cast Aluminum. With neoprene gasket conforming to IP-65. (Explosion proof for NEC Class-1, Division 1 area)

Repeatability : $\pm 0.5\%$ of full range.

Ambient temperature	:	0-60 °C.
Mounting	:	On top
Supply voltage	:	240V AC, 50Hz / 24V DC
Relay output	:	2SPDT
Contact rating	:	5A min. at 240V AC on resistive load
Response time	:	100 msec or better
Cable connection	:	3/4" ET
Accessories	:	Counter flange, Cable gland, prefab cable and stainless steel name plate engraved with alpha-numeric.

10.3.14 RF Type Level Switch

Electronic Controller

1. Input Supply	:	240 V AC (+/-10%), 50 Hz (+/- 5%)
2. Construction	:	Cast Aluminum Housing
3. Relay Output	:	2 Nos. Relay Changeover Potential Free Contacts (2SPDT)
4. Contact Rating	:	5A at 240 V AC & 0.5 at 220 V DC
5. Class of Protection	:	IP-65
6. Ambient Temperature	:	55 Deg. C(Max)
7. Local Indication	:	Local LED Indications
Green	:	Normal Level
Red	:	Alarm Level
Yellow	:	Probe Healthy
8. Cable connection	:	3/4" ET(2 Nos.) for Supply and Output 5/8" ET(1 No.) for Probe Connection
9. Repeatability	:	100%

B. Sensing Probe

1. Type of Probe	:	Rigid
2. Material	:	Stainless steel SS 316
3. Probe Head Housing	:	Cast Aluminum
4. Insulation (B/W Active & Shield And Shield & Ground)	:	PTFE
5. Probe Head Protection	:	IP-66
6. Mounting	:	Side Mounted

- 7. Cable Connection : 5/8" ET (1No.)
- 8. Process Connection : 40 NB BSP THREADED
- C. Signal Cable : Coaxial cable for Connection Between Sensing probe and electronic Controller (@ 10 Mtrs. Per Level Probe)
- D. Application : Silos

10.3.15 Level Indicators (Gauge Glass) (LI)

- Type/Construction : a) Reflex
b) Tubular (For tanks open to atmosphere only)
- Material:
 - a) Glass : Tempered toughened borosilicate resistant to thermal shock
 - b) Body material : Forged Carbon steel / SS 304
 - c) Integral cocks and : i) Forged carbon steel with drain valves stainless steel internals
ii) Rubber lined corrosion resistant stainless steel 316 (for demineralized and Osmosis water service)
 - d) Fittings : i) Forged carbon steel
ii) Rubber lined 316 steel/PVC for corrosive liquids Demineralized and Osmosis water service)
iii) 304 Stainless Steel for non-corrosive liquids
 - e) Packing : Teflon
- Dial size/scale : 150 mm /1.4 Meters maximum length with shatter Proof glass
- Scale details : Aluminum/SS316 scale Graduated in mmwc
- Connection : 25 Nb/40 Nb ANSI Flanged
- Enclosure protection : IP 65
- Accessories : a) Integral cocks
b) Drain/vent valves 15 NB
c) Bolts, nuts and gaskets for all KEL-F shield for transparent type
d) Illuminating lamps as required
e) Periscope as required
- Tests : Tested at two hundred (200) percent of the maximum process pressure
- Other details : For larger lengths, additional gauge glasses shall be provided with minimum of 50 mm overlap.

10.3.16 Vortex Flow Meter

Sensor

- Type : Vortex

Output Signal	: Pulse.
Material of Construction	: AISI 316
Sensor Seal	: PTFE / higher based on temperature.
Flow range	: As required.
Linearity	: $\pm 0.25\%$ or better.
Repeatability	: $\pm 0.02\%$ or better.
Ambient temperature	: 50 deg C
Mounting	: On-Line mounting with flanges of stainless steel.
Enclosure	: IP 65.
Accessories	: Nuts, bolts, gaskets etc.
Transmitter	
Electronics	: Solid State.
Power Supply	: 240V AC, 50Hz.
Input	: Input from Sensor.
Display	: 4 1/2 digit LCD.
Output	: Isolated 4-20mA DC HART.
Measuring Accuracy	: $\pm 0.5\%$ of full scale range.
Totalized Value	: Required.
Housing	: IP-65 (Explosion proof for NEC Class-1, Division 1 area)
Nameplate	: Tag number, service engraved in stainless steel tag plate.
Accessories	: Clamping strip, bracket, prefab cable etc. Special tool kit for calibration / configuration.

10.3.17 Flow Transmitter (Ultrasonic)

Type	: ULTRA SONIC, 2-wired.
Sensing element	: Non-contact.
Output	: 4-20mA with HART Protocol.
Accuracy	: $\pm 0.1\%$ FS.
Supply	: 24 V DC.
Enclosure class	: IP-65.

Transmitter

Mounting	: On Nozzle.
Mounting position	: Top mounted.
Housing	: Plastic.
Display	: Head mounted LCD Display & remote display.
Accessories	: As per process requirement.
Process connection	: 1/2" NPT.
Electrical connection	: 1/4" NPT.
Turn Down ratio	: 1:100.
Measuring range	: Adjustable (as per process requirement).
Totaliser	: Required.
Enclosure class	: IP-65.

10.3.18 Positive Displacement Flow Transmitter

Positive displacement flow transmitters shall be offered. An electronic totalizer shall be provided for each flowmeter with IP 65 protection and the location of the totalizers shall be acceptable to the Owner. Air eliminators shall also be provided to ensure maximum accuracy.

10.3.19 Electromagnetic Flow Meter

Electromagnetic flow meters shall have separate transmitter having accuracy $\pm 0.2\%$ with zero stability feature, electrode material SS-316, liner material Teflon and enclosure IP65, local digital display, 4-20 mA output HART signal with zero and span field adjustable. Application – DM Water and for other application as decided by owner.

10.3.20 Flow Gauges (FG)

Type/Construction	: a) On-line type rotameter for 50 Nb & below lines. b) Bypass type rotameter for above 50 Nb lines.
Material	
- For On-line type	
Metering tube	: Borosilicate glass
Float	: 316 SS
Packing	: Teflon
End fittings	: 304 SS
- For bypass type	

Metering Tube	:	Borosilicate glass
Float	:	316 SS
Packing	:	Teflon
End fittings	:	304 SS
Orifice Plate	:	316 SS
Carrier ring	:	304 SS
Flanges & Mating flanges	:	Same as pipe material, 200 lbs ANSI – RF.
Impulse pipe	:	Same as pipe material.
Fittings	:	2000 ANSI, SW ends to match with pipe material.
Dial size / Scale length	:	250mm.
Scale Details	:	Direct reading type engraved on detachable aluminium scale.
Accuracy	:	± Two (2) percent.
Reproducibility	:	Half (1/2) percent.
Connection	:	SCRD NPT
Enclosure class	:	IP-65.
Accessories	:	a) Isolating valves (for Bypass type only). b) Bolts, Nuts and Gaskets as required.
Tests	:	Shall be tested at two hundred (200) percent of the maximum process pressure.

10.3.21 **Sight Flow Glass Indicators**

Type/Construction	:	Rotary type/ Flapper type as per process requirement.
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Materials

Body	:	Carbon steel.
Glass	:	Toughened Borosilicate
Gaskets	:	Neoprene.
Bolts & Nuts	:	SS
Flappers / Rotating Wheel	:	316 SS
Flappers / Rotating Wheel holder	:	304 SS
Process Connection	:	SW

Enclosure class	:	IP-65.
Accessories	:	Bolts, Nuts, Cover plates and Gaskets as required.
Tests	:	Tested at two hundred (200) percent of the maximum process pressure.

10.3.22 Solid Flow Meter

Type	:	Online Impact type Microprocessor Based.
Measuring Principle	:	The system measurement is basically pertains to the measurement of horizontal deflection using LVDT, created by the impact of solid flow upon online sensing plate. The horizontal deflection being proportional to the impact forces, LVDT convert this horizontal movement into electrical signal. The inbuilt integrator convert this signal into time based flow rate indication & provide totalized flow also.
Sensing plate	:	316 SS
Sensing head	:	Sensing mechanism shall be mounted outside the process flow line.
Enclosure	:	316 SS
Enclosure protection	:	IP 65
Class		
Accuracy	:	+/-1%
Repeatability	:	+/- 0.2%
Drift	:	Both zero & span $\pm$ 2% / month.
Output	:	4-20mA DC isolated, load 600 ohm (min)
Digital communication	:	yes, (HART) facility.
Power Supply	:	240 V AC, 50Hz.
Ambient condition	:	Temperature -60°C, RH-95%. Environment – Highly Dusty.
Accessories	:	Shall be complete with all the accessories including digital display for flow rate, integral vents, baffles for air separation, etc., whichever required for satisfactory operation.

Note:-

1. The above on line flow meter shall not create any obstruction on flow.
2. User's list shall be submitted to support on proven satisfactory performance for similar Process application.

10.3.23 Dew Point Meter

Type	:	2 Wire Loop Powered Dew point transmitter
Overall Range	:	-60°C to +20°C Dew point
Accuracy	:	± 2°C Dew point
Material	:	SS316 (wetted parts)
Features	:	i) Automatic calibration ii) Can be Configured for Linear 4-20mA signal in °C & °F Dew point, ppm(v), ppb(v), g/m3 iii) Temperature Compensation iv) Failure Diagnostics v) Long Term Stability vi) Fast Response vii) IP 65 / NEMA4X Protection viii) Supplied with Calibration Certificate Traceable to National & International Humidity Standards ix) Sensor protection with sintered filter x) Local LCD Display for Dew Point

10.3.24 Analyser Instruments:
Common requirements:

Output signals Analog	4-20 mA DC galvanically isolated. If analyser provides superimposed HART signal on 4-20 mA DC output, It shall have provision also to be connected to PC based station.
Binary	2 NO + 2 NC for high alarm
Zero & span Adjustment	To be provided with range selection facility.
Ambient temp.	50°C
Indication	Digital Alphanumeric Display. Display of reading in engineering units shall be provided.
Enclosure	Type/Material Weather & Dust proof (IP 65) Die cast Aluminium/SS.
Type of Electronics	Microprocessor based with self-diagnostic.
Digital Signal transmission	HART / RS 485 Port Modbus Protocol / Ethernet TCP/IP protocol for communication with plant control system.
Calibration	Auto & Manual (from Remote)
Power Supply	To be arranged by Bidder subject to Owner's approval

Enclosure class	IP 65
Others	All interconnection tubing and cabling between probe and analyzer / analyzer panel and cabling from analyzer/ analyzer panel to local junction box are to be provided All the calibration gases required for one year continuous operation shall be provided. The calibration gas container material shall not contaminate the calibration gas.

10.3.25 SO₂,NO₂,CO₂,CO Analyzer:

Principle	UV Fluorescence
Measurement	SO₂,NO₂,CO₂,CO
Display	LCD
Ranges	SO₂: 0-500, 1000, 2000, 3000 ppm. NO_x: 0-300 ppm CO₂: 0-1000 ppm CO:0-200,0-1000 ppm
Minimum Detectable Limit	1 PPB
Noise Level	0.5 PPB or less
Zero Drift at Lowest Range	2% per month with automatic zero Compensation.
Span Drift at Lowest Range	2% per month of full scale
Response Time at Lowest Range	2 minutes or less
Linearity	+ 1% of full scale
Calibration	Built-in Calibration Facility
Consumables and spares	Recommended requirements of 3 years Continuous operation
Digital Signal Transmission	RS 232 link. Analyzer shall be capable to transfer all the data through RS 232 link to a PC based data logger.

10.3.26 pH Analyser

Type :	Cell - flow through
Accuracy :	< ± 1% of reading
Range :	0 - 14 pH freely programmable (For others)
No. of steams :	Single
Temp. compensation :	Automatic

10.3.27 Oxygen Analyzer

O₂ analyzers shall be direct insertion 'in-situ' type with accuracy of $\pm 1\%$ of reading or better with auto and manual calibration having zirconia probe as sensing element. Accessories like back purge system etc., shall be provided. Material for flue gas carrying parts shall be of SS 316. Protection tube shall be provided to prevent erosion of the probe. Maintenance requirement shall not be more than once a week. Local indicating meter for read out to be provided. Alarm on abnormalities and self-diagnosis features shall be provided.

1. Measurement Range : 0 to 25% oxygen programmable up to min 0.5% of O₂
2. Accuracy : $\pm 1\%$ of Full Scale
3. Linearity : $\pm 1\%$ of F.S.
4. Repeatability : $\leq 0.5\%$ of Span
5. Response time(up to 90% of full scale : ≤ 5 secs
6. Zero Drift : $< 1\%$ span week
7. Span Drift : $< 1\%$ measured value/week
8. Operating Temperature Range : 0-450 deg.C
9. Filter : Suitable filter to be provided

10. Temperature : Automatic temperature control of heating circuit through thermostat.

I) Accessories

- i) Electronic unit housed in a rugged sheet steel enclosure (IP65) houses transmitting system, probe heater control circuit etc. Electronic unit shall be separate from the probe and not be head mounted.
- ii) Calibration gas cylinder & accessories, reference air set, rotameters
- iii) Shield (316 SS), special cables, electronic control panel and Provision of SS 316 stainless steel diffuser assembly for the protection of Zirconia cell.
- iv) Ownership certificate, pressure test certificate, explosion proof certificate for standard gas cylinders shall be given and these will be used for next filling up of standard gases.
- vi) Moisture separator unit along with AFR for reference air shall be installed for long life of Zirconia cell.
- vii) Any other accessories as required.

10.3.28 Opacity Analyzer

Accessories like back purge system etc., shall be provided. Material for flue gas carrying parts shall be of SS. Protection tube shall be provided to prevent erosion of the probe. Local indicating meter for read out to be provided. Alarm on abnormalities and self-diagnosis features shall be provided. The air purging systems shall keep the windows free from dust and deposits.

The measurement shall conform to EPA regulations. Bidder shall indicate the procedure for zero opacity setting at site for calibration purpose.

All cables for connecting the converter unit to the transceiver shall be furnished to integrate the system.

- | | |
|--|---|
| a) Type | : In-Situ dry type visible light (through LED) |
| b) Principle of Measurement | : Transmission and absorption |
| c) Measurement Range | : 0 to 999mg/m ² , (Programmable) |
| d) Accuracy | : 2% of F.S. |
| e) Linearity | : +/-1% of F.S. |
| f) Repeatability | : ≤ 1% of span |
| g) Response time(up to 90% of full scale): | ≤ 5 secs |
| h) Temperature Drift | : Automatic temp compensation |
| i) Zero Drift | : <1% span week |
| j) Span Drift | : < 1 % measured value/week |
| j) Operating Temperature Range | : 0-300 deg.C |
| k) Filter | : To be provided |
| l) Accessories purging system | : Purging system to be provided with heavy duty blowers and shutter mechanism for Automatic isolation of lens during purge air failure. |
| j) Temperature compensation/measurement | Yes.(Temperature measurement using thermocouple and transmitter with a 4-20ma flue gas temp signal to PLC in addition to Opacity monitor) |
| d) Process connection | : ANSI flange |
| m) Accessories | : i) Control unit complete with small setting up meter and miniaturized red and green indicating lamps.
: ii) Remote indicating and mounting unit for flush panel mount.
: iii) Ever clean windows
: iv) Projector transformer |

- v) Mounting flanges, bolts, hoses, clamps and alignment tools
- vi) Special cable up to control room (if required)
- vii) Trans-receiver and reflector assemblies with weatherproof housing
- viii) Other accessories as required

10.3.29 Junction Boxes

Bidder shall note that the Analog and digital signals shall be wired to different junction boxes.

- (i) No. of ways 12/24/36/48/64/72/96/128 with 20% spare terminals.
- (ii) Material 4mm thick fibre glass reinforced polyester.
- (iii) Type Screwed at all four corners for door. Door handle shall be self-locking with common key. Door gasket shall be of synthetic rubber.
- (iv) Mounting clamps and structures etc Suitable for mounting on walls, columns,. accessories

The brackets, bolts, nuts, screws, double compression glands and lugs required for erection shall be of brass, included in Bidders scope of supply. Race ways for routing of cables inside JB's shall be provided.
- (v) Type of TB Rail mounted maxi termi or cage-clamp type suitable for terminal conductor size upto 2.5 mm². A M6 earthing stud shall be blocks provided.
- (vi) Protection class IP:65 minimum and Explosion/Flame Proof as per area classification.

10.3.30 Interposing Relays (IPR)

Electromagnetic type IPRs with modular design, plug-in type connections, suitable for channel/DIN rail mounting in cabinets; coil rating 24V D.C; 2 set of change over contacts rated for 0.5A 220 V DC / 5A 240 V AC. Freewheeling diode across relay coil and self-reset type status LED indicator flag (electronic) shall be provided. Manual forcing/override facility is required. The test voltage for relay shall not be less than 4 KV with operating temperature from -20 deg. C to 60 deg. C. The relay shall have the necessary approvals like V0 inflammability class in accordance with UL94", IEC60664/ IEC60664A/DIN VDE 0110.

10.3.31 Digital Indicator

- Type : Programmable electronic digital indicator with floating point decimal.
- Input : 4-20 mA DC/1-5V DC/RTD/T/C.

Number of inputs	: One
Range	: As per requirement/adjustable by end user through key pad available on the indicator.
Number of digits	: Four plus sign
Digit height	: 20 mm or larger
Display	: Fluorescent red
Input over range/open	: All digits to flash sensor (T/C)
Input hold time	: 0.7 seconds max.
Accuracy	: $\pm 0.05\%$ of span
Power supply	: 240V AC, 50Hz
Mounting	: Flush panel, compatible for mounting on mosaic grid panel
Size	: 96x48 mm
Other Particular	: Indicator receiving thermocouple Signal shall have automatic cold junction compensation. Retransmission Output 4-20 mA isolated required. : 24 V DC inbuilt power supply : Alarm contact with 2 NO/NC contact (rating 5A/230 V AC)

10.3.32 Receiver Indicators (Single/Dual Channel)

Type	: Analogue indicator
Input Signal	: Universal input (T/C, RTD, 4-20 mA, Voltage)
Scale	: Range fully configurable and programmable
Measurement Accuracy	: $\pm 0.2\%$ of span + 1 count
Resolution	: 0.5% Span
Dead band	: $\pm 0.2\%$ of span
Repeatability	: 0.2% of span
Full scale response time	: Less than two (2)seconds
Power Supply	: 240V AC, 50 Hz
Connection	: Plug in type
Accessories	: Mounting Bracket for Bins
Other Particulars	: Indicator receiving thermocouple Signal shall have automatic cold Junction compensation.

		: Retransmission Output 4-20 mA Isolated required.
10.3.33	Ammeters (AMM)	
	Input	: 4-20 mA DC
	Mounting	: Flush panel, compatible for mounting on mosaic grid panel
	Face Dimensions	: 96 x 96 mm
	Scale/Type	: Moving coil, circular, FSD 240
	Zero adjustment	: Screw on meter face
	Accuracy	: ± 1 percent (class 1)
	Indication	: Pointer with scale
	Magnetic Shield	: Shielded Case
	Quantities	: For all HT Motors & LT motor with rating ≥ 30 KW and other critical application motors/drives.
10.3.34	Voltmeter	
	Input	: 4 – 20 mA DC
	Mounting	: Flush Panel, compatible for mounting on mosaic grid panel
	Face Dimension	: 96x96 mm
	Range	: As per requirement
	Accuracy	: $\pm < 0.5$ %
	Indication	: Digital type 4 1/2 digit
	Magnetic Shield	: Shielded Case
	Connection	: Plug in type
	Quantities	: For 240 V AC input power supply, UPS power supply, 24V DC interrogation voltage & 220 V DC.
10.3.35	Push Buttons (PB)/ ILPBs for On/Off, Open/Close	
	Type	: Momentary / Miniaturised suitable for mosaic grid 24x48 Mm with 2 PB and 3 coloured LED.
	Contact Configuration	: 2 NO + 2 NC
	Contact Material	: Hard Silver Alloy

	Contact Rating	:	500V / 10 A
	Insulation Voltage	:	2 KV for 1 minute between terminals and earth
	Lamp Rating	:	a) Voltage : 240 V AC b) Watt : 2 Watt (approx.)
	Colour	:	Red, Green, Amber, Yellow
10.3.36	Push Button For Desk Release,		
	Push button for desk release	:	Momentary mosaic grid mounted
	Desk lamp test desk ack	:	24x48 mm size, single PB 18x40 mm
10.3.37	Push Button for Sequence Start/Release		
	Push Button for Sequence Start/Release	:	Momentary (Miniaturised) suitable for mosaic grid 24x48 mm 3 PB + 5 LED
10.3.38	Push Button for Annunciation		
	Contacts		
	- Number & Type	:	As per requirement
	- Breaking capacity	:	0.5 Amp, 220V DC 10 Amp, 600V AC Different colours for Accept/Ack – Green, reset Grey, test – Yellow & Audio Ack – Black.
10.4.0	Control Valves, Actuators & Accessories		
10.4.1	General Requirements		
	The control valves and accessories equipment furnished by the Bidder shall be designed, constructed and tested in accordance with the latest applicable requirements of code for pressure piping ANSI B 31.1, the ASME Boiler & pressure vessel code, Indian Boiler Regulation (IBR), ISA, and other standards specified elsewhere as well as in accordance with all applicable requirements of the "Federal Occupational Safety and Health Standards, USA" or acceptable equal standards. All the Control Valves, their actuators and accessories to be furnished under this Subsection will be fully suitable and compatible with the modulating loops covered under the Specification. All the control valves and accessories offered by the Bidder shall be from reputed, experienced manufacturers of specified type and range of valves.		
10.4.2	Control Valve Sizing & Construction		
	The design of all valve bodies shall meet the specification requirements and shall conform to the requirements of ANSI (USA) for dimensions, material thickness and material specification for their respective pressure classes. Control valves for steam and water applications shall be designed to prevent cavitation, wire drawing, flashing on the downstream side of valve and downstream piping. Thus for cavitation/flashing service, only valve with anti-cavitation trim shall be provided. Detailed calculations to establish whether cavitation will occur or not for any given application shall be furnished. Control valves shall have leakage rate as per leakage Class-IV.		

The control valve induced noise shall be limited to 85 dBA at 1 meter from the valve surface under actual operating conditions. The noise abatement shall be achieved by valve body and trim design and not by use of silencers.

10.4.3 Valve Construction

All valves shall be of globe / Butterfly body design & straightaway pattern with single or double port, unless otherwise specified or recommended by the manufacturer to be of angle body type. Rotary valve may alternatively be offered when pressure and pressure drops permit.

Valves with high lift cage guided plugs & quick-change trims shall be supplied. Cast Iron valves are not acceptable.

Bonnet joints for all control valves shall be of the flanged and bolted type or other construction acceptable to the Owner. Bonnet joints of the internal threaded or union type will not be acceptable.

Plug shall be of one-piece construction cast, forged or machined from solid bar stock. Plug shall be screwed and pinned to valve stems or shall be integral with the valve stems.

All valves connected to vacuum on downstream side shall be provided with packing suitable for vacuum applications (e.g. double vee type chevron packing) Valve characteristic shall match with the process characteristics.

Extension bonnets shall be provided when the maximum temperature of flowing fluid is greater than 280 deg. C,

Flanged valves shall be rated at no less than ANSI press class of 300 lbs

10.4.4 Valve Materials

- 1) The exact body and trim materials shall be finalized during detailed engineering depending on the service applications.

Valve material shall be as specified in Supplier's approved Control Valve Specification sheets. The following table defines abbreviations used for valve materials:

S.No.	Abbreviations	Description
a)	BR	Bronze ASTM B 61
b)	CS	Carbon Steel Forged - ASTM A 105 Cast - ASTM A 216 Grade WCC
c)	1 - 1/4 CR	1-1/4 percent chromium alloy steel Forged - ASTM A182 Grade F11 Cast-ASTM A17 Grade WC6
d)	2 - 1/4 CR	2-1/4 percent chromium alloy Steel Forged - ASTM A 182 Grade F22

		Cast - ASTM A 217Grade WC9
e)	5CR	Five percent chromium alloy steel Forged - ASTM A 182Grade F5 Cast - ASTM A 217 Grade C5.
f)	SS	Stainless Steel AISI Type 316 ASTMA351 Grade CF8M

- 2) Body material shall be selected by the bidder to be compatible with the nature of the fluid, service conditions, and piping material to which it is welded and shall be subjected to Owner approval. In general, cast or forged carbon steel bodies shall be provided for non-corrosive process applications up to 275 Deg.C. Alloy Steel castings shall be provided when the media is non-corrosive and the temperature exceeds 275 Deg.C and is within 550 Deg.C. Stainless Steel of suitable grade shall be provided when media is corrosive and the temperature is below 300 Deg.C.

Sr. No.	Service	Body Material
1.	Non Corrosive, Non Flashing, and non cavitations service for process temp. up to 275 deg. C	Cast Carbon Steel ASTM A216 Gr. WCB/WCC
2.	Non Corrosive, Non Flashing, and non cavitations service for process temp. above 275 deg. C. and up to 550 deg. C.	Cast Alloy Steel ASTM A217 Gr. WC9
3.	Severe Flashing/ cavitations service	Cast Alloy Steel ASTM A217 Gr. WC9
4.	Low Flashing/ cavitations service below 275 deg. C.	Cast Alloy Steel ASTM A217 Gr. WC6
5.	DM Water Application	Cast type 316 Stainless Steel ASTM A351 Gr. CF8M

- 3) Unless otherwise specified, all control valves shall have stems, guide bushings, plugs, seat rings, stem lock pins, stuffing box parts, and other trim, all made of stainless steel. Valve guide posts and bushings shall be Stellite faced for valves where specified. Stellite faced guide posts and bushings shall be differential hardened. For applications involving high pressure drop as also for flashing and cavitation services, trim material shall be properly chosen to ensure required degree of hard facing (such as 17-4 PH SS) so as to avoid erosion.

Sr. No.	Service	Trim Material
1.	Non Corrosive, Non Flashing, and non cavitations service for process temp. up to 275 deg. C.	SS316 Stellite
2.	Non Corrosive, Non Flashing, and non cavitations service for process temp. above 275 deg. C. and up to 550 deg. C.	SS316 Stellite
3.	Severe Flashing/ cavitations service	440 SS
4.	Low Flashing/ cavitations service	17-4 PH SS
5.	DM Water Application	17-4 PH SS

- 4) Where stellite facing is not specified, hardened stainless steel shall be furnished for all surfaces subject to wear.
- 5) Manufacturer recommended materials for cage guided valves may be substituted for materials specified provided they satisfy the specified service conditions. Also where substitutions are made, the manufacturer shall guarantee performance of

recommended materials to be equal to or better than the specified materials for conditions specified.

Bidder may offer valve with body and trim material better than the specified material and in such case, bidder shall furnish the comparisons of properties including cavitations resistance, corrosion resistance, temp. resistance, erosion resistance, hardness etc. of the offered material vis a vis specified material for owner approval.

10.4.5 End Preparation

- 1) Valve body ends shall be butt-welded type.
- 2) Flanged ends shall be of a pressure class equal or greater in pressure-temperature rating to the body design pressure and temperature indicated on the control valve. Unless otherwise specified, steel flanges shall be raised face type. Flanged ends for valves shall be in accordance with ANSI B 16.5.
- 3) Welded end for control valves where specified shall be socket-weld per ANSI B 16.11 for control valves of sizes 50 mm (2") and below and Butt welded connections per ANSI B16.25 for control valves 65 mm (2-1/2") and above. The end preparation for butt welded control valves shall be matched to the corresponding details for the piping on which the valve is installed.
- 4) All end preparations shall be as per Owners requirements indicated during Contract stage.

10.4.6 Valve Actuators

All Control Valves shall be furnished with Pneumatic Actuators. The Bidder shall be responsible for proper selection and sizing of valve actuators in accordance with the pressure drop and maximum shut off pressure and leakage class requirements. The valve actuators shall be capable of operating at 60 deg.C continuously.

Valve actuators and stems shall be adequate to handle the unbalanced forces occurring under the specified flow conditions or the maximum differential pressure specified. An adequate allowance for stem force, at least 0.15 Kg/sq.cm. per linear millimeter of seating surface, shall be provided in the selection of the actuator to ensure tight seating unless otherwise specified.

The travel time of the pneumatic actuators shall not exceed 10 seconds.

10.4.7 Control Valve Accessory Devices

All pneumatically actuated control valve accessories such as air locks, hand Wheels/hand-jacks, limit switches, Microprocessor based Positioner, diffusers, external volume chambers, position transmitters (capacitance or resistance type only), reversible pilot for Positioner, tubing and air sets, solenoid valves and junction boxes etc shall be provided as per the requirements.

1) Specifications for Microprocessor Based Positioners:

1	Electrical	a) Input signal	4-20 mA
		b) Power Supply	Loop powered from the output card of Control system.
		c) Hart Protocol	Compatibility for remote calibration & diagnostics (Super-imposed Hart signal on input signal (4-20 mA))
		d) Valve position	Non-contact type position sensing with 4-20 mA output signal

2	Environment	a) Operating temp	-30 to 80 Deg C
		b) Humidity	0-95 %
		c) Protection Class	IP-65 Minimum
3	Test reports / Certificates	Factory Valve Signature Tests reports (Pr vs valve travel and reports/ travel vs I/P signal) are to be provided.	
		Test certificates as per manufacture standard / relevant standard are to be submitted	
4	Configuration / Calibration	Remote calibration, auto & manual calibration shall be possible. Universal HART calibrator to be provided.	
5	Operating	Operating Range	Full range & split range signal.
6	Modes	Valve Action	Direct & Reverse valve action(selectable)
		Flow characterization	Possible to fit valve characteristic curve – Linear & Equal Percentage.
7	Fail safe / Fail Freeze	Fail safe/Fail freeze feature is to be provided. (In case, the fail freeze feature is not intrinsic to the positioner, Bidder shall achieve the same externally through solenoid valve connected in the pneumatic circuit).	
8	Pneumatic	Air capacity	Sufficient to handle the valves selected/ boosters to be supplied if required.
		Air supply pressure	To suit air supply pressure/quality available.
		Process connection	1/4 inch NPT
9	Electrical cable entry	1/2-NPT, side or bottom entry to avoid water ingress.	
10	Performance	Characteristic Deviation	<=0.5 % Of Span
		Ambient Temp Effect	<=0.01 % / Deg C Or Better
11	EMC & CE Compliance	Required to International Standard like EN/IEC.	En50081-2& En50082 Or Equivalent
12	Accessories	In-built operator panel	Display with push buttons for configuration and display on the positioner itself (password protected/hardware lock).
		Press gauge block	For supply & output pressure.
		Mounting assembly	On as required basis.

2) Limit Switches:

Valves shall be provided with limit switches. Switches shall have not less than two normally open and two normally closed contacts in both open and close directions. Electrical rating of the limit switch contacts shall be 240V AC, 5 amp or 220V DC, 0.5 amp, limit switches should be micro switch type or owner approved equal. The enclosures of the limit switches shall be as per NEMA-4 Standard. Limit switches shall be constructed to withstand the temperatures encountered in the actual service. Explosion proof construction shall be furnished where required by applicable code or these specifications. Limit switches shall be factory mounted on the valves with check limit s w i t c h operation prior to shipment.

Limit/micro switches can be offered as an integral part of Smart valve Positioner.

3) Solenoid Valves:

- a) Solenoid valves shall be selected to incorporate body construction, trim materials and internal arrangements suitable to the application and shall be acceptable to the Owner. Solenoid enclosures shall be NEMA-4 / IP 65 unless otherwise

specified. Solenoid coils shall be Class-H High temperature construction and shall be suitable for continuous duty.

- b) Each solenoid valve shall be furnished with form U internal valve arrangement, Class H high temperature coil, threaded conduit connection, and other electrical and mechanical requirements as specified. The complete data such as material of construction, coil ratings, connection sizes, body rating etc shall be furnished along with the proposal. These shall be subject to Owner approval during detailed engineering stage.
- c) Solenoid valves shall be provided with pneumatic operated control valves/dampers hooked up with process interlock requirements and where direct tripping is involved. The number of ways for solenoid valve shall be provided as indicated below, however the no. of ways for solenoid valve shall be based on client approval during detail engineering and same has to be supplied by bidder without any commercial or price implication.
 - Two (2) way solenoid valves shall be provided, where process line of less than 50mm with low pressure and temperature application.
 - Three (3) way solenoid valve shall be provided commonly, where the pressure is admitted or exhausted from a diaphragm valve or single acting cylinder, e.g, Pneumatic operated spray water block valve.
 - Four (4) way solenoid valve shall be provided for operating double acting cylinders, e.g, Pneumatically operated on-off type dampers.
 - All solenoid shall be with varistor, LED indication, surge suppress diode and circuits and with plug in connector connection.

4) Air Filter Regulator (AFR)

Constant bleed type AFR with an accuracy of ± 1.0 % inlet pressure range of 5-8 kg/ cm² and suitable spring ranges (AFR) for use with positioners in control valves, control damper, E/P convertors and shut off valves for phosphor bronze filter element; Filtering particles above five microns. Weather and water proof enclosure. Material of accessories will be SS316.

Air filter regulators shall be provided as follows:

- (a) Air supply line to valve positioners / power cylinders
- (b) Air supply line to electric to pneumatic converters.
- (c) Air supply line to pneumatic interlocked block valves.
- (d) For each instrument rack, field instruments enclosure for purging.

5) Power Cylinders (Pneumatic)

Mounting Type	: a) Fixed position mounting (End mounting). b) Trunnion mounting
Control Signal	: 0.2 to 1 Kg/Sq. cm. from I/P converter for modulating purposes. 24V/48VDC operated solenoid valve operating on pneumatic line. The Pilot solenoid will have separate coils for open closing purpose.
Supply Air	: 0-7 Kg / Cm ² .
Selection	: Based upon thrust / torque, stroke length, angular movement, full-scale travel time,

repeatability, space factor etc. Provision for air-to-open and air-to-close operation

Casing	:	IP-65.
Accessories (as required)	:	a) Air lock relay b) Hand wheel. c) Air filter regulator with gauge. d) Volume Booster. e) Limit Switches. f) Positioner with Input, Output and supply pressure gauges. g) Pilot Solenoid Valve (Double Coil type) h) Position Transmitter (4-20 mA DC linear output, LVDT or non-contact type)
Fail-safe operation	:	Stayput, open or close position on pneumatic / electrical power supply failure as per process safety criteria.
Repeatability	:	Better than 0.5% of full travel.
Hysteresis	:	Less than 1% of full travel.

10.5.0 Flow Elements

The equipment furnished to this specification shall conform exactly to the requirements herein, unless modified by the respective datasheet of the equipment.

a) Orifice Plate

Features	Essential/Minimum Requirements
Type	Concentric as per ASME PTC-19.5 (Part-II), ISA RP-3.2, 1960 or BS-1042
Material	316 SS - Thickness 3 mm for pipe dia. upto 250 mm 6 mm for main pipe dia above 250 mm 10 mm for main pipe dia. 500 & above.
Material of branch pipe	Same as main pipe
Root valve type	Globe
Root valve material	316 SS
Root valve size	1 inch
Impulse pipe of same material up to root valve	Required
Tappings	Flanged weld neck. 3 pairs. of tapping.
Beta Ratio	0.34 to 0.7

Beta Ratio calculation to be submitted	Yes
Assembly drg. and flow Vs DP Curves	Yes
Accessories	Root valves, flanges, Vent/drain hole (As required)

Bidder shall submit certified flow calculation and differential pressure vs. flow curves for each element for Owner's approval. Sizing calculation, precise flow calculation for all the flow elements, fabrication and assembly drawings and installation drawings shall be submitted for Owner's approval. One Flow element of each type shall be calibrated in the test laboratory for validation of computed flow calculations.

b) Flow Nozzle

Features	Essential/Minimum Requirements
Type	Long radius, welded type as per ASME PTC-19.5 (Part-III) or BS-1042
Material	316 SS
Thickness	Suitable for intended application
Material of branch pipe	Same as main pipe
Root valve type	Globe
Root valve material	316 SS
Root valve size	1 inch
Impulse pipe of same material up to root valve	Required
Tapping	D and D/2 (3 Nos. of tapings)
Beta Ratio	Around 0.7
Beta Ratio calculation to be submitted	Yes
Assembly drg. and flow Vs DP Curves	Yes
Accessories	Root valves, vent and drain hole.

Bidder shall submit certified flow calculation and differential pressure vs. flow curves for each element for Owner's approval. Sizing calculation, precise flow calculation for all the flow elements, fabrication and assembly drawings and installation drawings shall be submitted for Owner's approval. One Flow element of each type shall be calibrated in the test laboratory for validation of computed flow calculations.

The design, material, construction features, manufacture, inspection and testing of flow elements shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable standards.