

**B. Control Valve Design & Sizing**

1. The design of all valve bodies shall meet the specification requirements and shall conform to the requirements of ANSI for dimensions, material thickness and material specification for their respective pressure classes.
2. The valve sizing shall be suitable for obtaining maximum flow conditions with valve opening at approximately 80% of total valve stem travel and minimum flow conditions with valve stem travel not less than 10% of total valve travel. All the valves shall be capable of handling at least 120% of the required maximum flow. Further, the valve stem travel range from minimum flow condition to maximum flow condition shall not be less than 50% of the total valve stem travel. The sizing shall be in accordance with the latest edition of ISA Handbook on control valves. While deciding the size of valves, Supplier shall ensure that valves outlet velocity does not exceed 8 m / sec. for liquid services, 150 m/sec. for steam services and 50% of sonic velocity for flashing services. Supplier shall furnish the sizing calculations clearly indicating the outlet velocity achieved with the valve size selected by him as well as noise calculations, which will be subject to Consultant's / Owner's approval during detailed engineering.
3. Control valves for steam and water applications shall be designed to prevent cavitations, wire drawing, flashing on the downstream side of valve and down stream piping. Thus for cavitations / flashing service, only valve with anti-cavitations trim shall be provided. Detailed calculations to establish whether cavitations will occur or not for any given application shall be furnished.
4. Trim shall be multistage type having sufficient number of discrete pressure drop turns (stages) to ensure elimination of vibration, erosive – action, cavitations. Bidder shall identify the number of pressure drop turns in proposed equipment and shall also provide calculation demonstrating compliance to the trim exit velocity.
5. To prevent flow induced vibration and to protect the valve internals from foreign particles such as weld slag flow, direction shall be a flow to close (over the plug) configuration for liquid applications. To maximize noise attenuating benefits and to allow for constant fluid expansion, flow direction will be under the plug for steam and gas applications.
6. Control valves for application such as SH spray control, RH spray control, Heavy oil pressuring & control system shall have permissible leakage rate as per leakage class V. All other control valves such as low and high range feed control valves etc shall have leakage rate as per leakage class IV.
7. 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.

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8. The characteristic of the control valves shall be determined based on the application / service.
9. On supply air or electrical failure for pneumatic / electrical drive, the valve shall remain full closed, open or stay – put position as per process safety requirement.

C. Valve Construction

1. Proper selection of valve type and material of construction to meet operating requirement.
2. All valves shall be of globe body design and straightaway pattern with single or double port unless otherwise recommended by the manufacturer to be of angle body type. Rotary valve may alternatively be offered when pressure or pressure drops permit.
3. Valves with high lift cage guided plugs & quick change trims shall be supplied.
4. Cast iron valves are not acceptable.
5. Bonnet joints for all control valves shall be of the flanged and bolted type for easy dis – assembly. Bonnet joints of internal threaded or union type will not be acceptable.
6. Plug shall be of one – piece construction either 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.
7. All valves connected to vacuum on down stream side shall be provided with packing suitable for vacuum applications (e.g. double vee type chevron packing).
8. Valve characteristic shall match with the process characteristics.
9. Extension bonnets shall be provided when the maximum temperature of flowing fluid is greater than 280 °C.
10. Flanged valves shall be rated at not less than ANSI pressure class of 300 lbs.
11. Teflon shall be used for valve gland packing to suit process requirement.
12. The valve body shall be marked to show direction of flow.

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**D. Valve Materials**

1. The control valve body material shall be
 - Carbon steel as per ASTM – A216 GR WCB for non – corrosive, non – flashing and non – cavitations services below 275 deg c temperature like Auxiliary Steam flow to Deaerator, CRH flow to Deaerator, Condensate flow to Deaerator etc.
 - Alloy steel as per ASTM – A217 GR WC 9 for severe flashing / cavitations services like low load and full load feed water control, HP and LP heaters emergency drains, Deaerator overflow drain to Hotwell etc.
 - Alloy steel as per ASTM A – 217 GR WC 6 for low flashing / cavitations services like HP heaters & LP heaters normal drain control, drain cooler normal level control, gland steam cooler minimum flow etc.
 - 316 SS for condensate service below 300 deg C like condensate normal and emergency make – up controls etc.
2. The control valve trim material shall be
 - 17 – 4 PH SS for severe services listed under item D.1, 2nd point & 3rd point above
 - 316 SS for services listed at D.1, 4th point above and
 - 316 SS with stellite faced guide parts and bushings for remaining applications.
3. However, Supplier may offer valves with body and trim materials better than specified materials and in such cases Supplier shall furnish the comparison of properties including cavitations resistance, hardness, tensile strength, strain energy, corrosion resistance and erosion resistance etc. of the offered material vis – a – vis the specified material for Owner's / Consultant's consideration and approval.

E. End Preparation

Valve body ends shall be either butt welded / socket welded, flanged or screwed as finalized during detailed engineering and as per Owner's / Consultant's approval. The welded ends wherever required shall be butt welded type as per ANSI B 16.25 for control valves of sizes 65 mm and above. For valves sizes 50 mm and below welded ends shall be socket welded as per ANSI B 16.11. Flanged ends wherever required shall be of ANSI pressure – temperature class equal to or greater than that of the control valve body.

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F. Valve Actuator

1. The regulating control valves shall be furnished with pneumatic actuators. The supplier 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 °C continuously.
2. 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 / cm² per linear millimeter of seating surface, shall be provided in the selection of the actuator to ensure tight seating unless otherwise specified.
3. The travel time of the pneumatic actuators shall not exceed 10 seconds.
4. For quick opening / closing services (such as fuel oil shut – off valve), the actuator shall be pilot solenoid operated pneumatic drive; the rating of solenoid shall be 24 V DC.
5. Selection of actuator shall be such that it meets the requirements of thrust / torque, stroke length, angular movement, full scale travel time, repeatability & accurate positioning for successful operation of final control element.
6. All the actuators shall have also provision for manual operation during emergency / maintenance along with graduated local position indicator.

G. Control Valve Accessory Devices

All control valve accessories such as air locks, hand wheels / hand-jacks, limit switches, SMART positioners, diffusers, external volume chambers, reversible pilot for positioners, tubing and air sets, solenoid valves and junction boxes etc. shall be provided as per the requirements.

**Table 9.24(i)
Specification for E-to-P converter**

S.N	Feature	Minimum Requirement
1	Air Supply	1.5 Kg/Sq. cm
2	Input Signal	4-20 mA DC
3	Output Signal	0.2 to 1.0 Kg/ Sq. cm
4	Linearity	0.5 % of span or better
5	Hysteresis	0.1 % of span or better
6	Ambient Temperature	<0.2 % of span per Degree centigrade

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S.N	Feature	Minimum Requirement
	Effect (-20 to +60 *C)	
7	Mounting	Close to Actuator
8	Protection class	IP-65
9	Enclosure	Die cast Aluminium
10	Drift	+/- 2% of set point per hour

**Table 9.24(ii)
Specification for Smart Positioners**

S.N	Feature	Minimum Requirement
1	Input	4-20 mA DC
2	Power Supply	24 V DC Loop powered
3	Type of Electronics	Microprocessor based with self diagnostic facility & digital communication by means of HART Protocol
4	Valve position sensing	Non-Contact type with 4-20 mA DC Output
5	Enclosure Type/Material	Weather & Dust proof to IP-65/ Die cast Aluminium
6	Ambient conditions	Suitable for - 30 to +80 *C temperature & 0-95% Humidity
7	Operating Range	Suitable for Full range & Split Range operation
8	Modes of operation	Suitable for Direct & reverse valve action
9	Flow characteristics	Suitable for Linear & Equal percentage Characteristics
10	Fail safe/Freeze feature	Required
11	Air Capacity	Sufficient to handle the Valves Selected/Boosters to be supplied if required.
12	Air supply pressure	To suite the Air Supply Pressure / Quality available
13	Process Connection	1/4" NPT
14	Characteristic Deviation	< = 0.5% of span
15	Ambient Temperature effect	< = 0.01%/Deg C or better
16	Configuration	Remote Calibration, Auto & Manual Calibration shall be possible
17	Cable Entry	½" NPT, Side or Bottom Entry to avoid water ingress
18	Accessories	a) Display with push buttons for configuration and Display on the positioner itself (Password Protected / Hardware Lock).
		b) For Supply & Output Pressure, Filter Regulator and other accessories shall be provided as on required basis for making system complete
		c) Valves Mounting Assembly For Sliding Stem / Rotary / Single Acting / Double Acting on required basis

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1. SMART positioner shall be a Double stage positioner. The first stage of the positioner shall be typically a flapper-nozzle that serves as a high-gain pre-amplifier. This sensitivity shall be maintained over a wide range of dynamic conditions. Second stage shall be a power amplifier that provides power to drive the actuator. Preferably this shall be a pneumatic relay. Spool Driven type SMART positioners are not preferred due to Higher Dead Band and Poor responsiveness. The SMART positioner shall have pressure sensors to measure the pneumatic outputs to the actuator.
2. The control algorithm for the positioner shall use feedback signal from the motion of the pneumatic relay beam instead of pressure feedback to minimize pneumatic related effects and for stable and smooth response of the control valve. The SMART positioner shall have user adjustable tuning sets to identify the optimum tuning for the total valve assembly. SMART Positioner with HART Communication facility shall communicate all the valve diagnostics to Plant DCS.

**Table 9.24(iii)
Specification for Air Filter Regulator (AFR)**

S.N	Feature	Minimum Requirement
1	Type	Constant Bleed type
2	Inlet Pressure	10 Kg/Sq. cm (maximum)
3	Output	Adjustable from 0-2 Kg/Sq. cm or 0-7 Kg/Sq. cm (Continuous) as required
4	Filter Element	5 microns
5	Filter Element Material	Phosphor Bronze
6	Bowl Material	Metallic
7	Enclosure Protection class/ Material	IP-65/ Die cast Aluminium
8	Process connection	¼ " NPT
9	Accessories	All mounting accessories. 2" dial size Pressure gauge.

**Table 9.24(iv)
Specification for Position Transmitter**

S.N	Feature	Minimum Requirement
1	Power Supply	24 V DC Loop powered
2	Type	Non-Contact/ LVDT type
3	Output	4-20 mA DC/ Linear
4	Accuracy	+/- 1 %
5	Enclosure Protection class/ Material	IP-65/ Die cast Aluminium
6	Cable Entry	½ " NPT, Side or Bottom Entry to avoid water ingress.

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S.N	Feature	Minimum Requirement
7	Accessories	All mounting accessories

**Table 9.24(v)
Specification for Limit Switch (Non Contact Type)**

S.N	Feature	Minimum Requirement
1	Type	Non-contact type inductive Proximity
2	Sensing distance	10 mm minimum
3	Hysteresis	Maximum 10% of sensing distance
4	Indicator	LED indication
5	Protection class	IP 67
6	Integral Cable	1 mtr.
7	Power supply	24 V DC/ 8 V DC
8	Mounting	Flush mounting with check nut
9	Other Feature	Explosion proof enclosures shall be provided wherever required by the application. Shock & Vibration proof.

G. Test & Examination

- All valves shall be tested in accordance with the quality assurance programme agreed between the Owner / consultant and the bidder which shall meet the requirement of IBR and other applicable codes.
- The tests shall include but not but limited to the following:
 - Non-destructive test as per ANSI B – 16.34.
 - Hydrostatic shell test in accordance with ANSI B16.34 prior to seal leakage test.
 - Valve closure test and seal leakage test in accordance with ANSI B16.34 and as per the leakage class indicated under clause no. B.6.
 - Functional test: The fully assembled valves including actuators control devices and accessories shall be functionally tested to demonstrate times from open to close position.
 - All control valves shall be tested with the positioners for accuracy of positioning and reproducibility over the full range of travel.
 - CV Test : CV test shall be carried out as type test on each size, type and design of the valves as per AISA 75.02 standard and test report shall be furnished for Owner's / consultant's approval.

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- Magnetic particle inspection shall be performed on all machined surfaces of valves having ASA rating of 1500 lbs ASA or greater. All carbon steel valves with 1500 lbs ASA or greater shall receive 100% radio graphic examination in accordance with ASTM – E71.
3. Bidder shall submit test certificates for the tests mentioned in above paragraphs in accordance with ASME and ASTM requirements. In addition supplier shall also submit for the above equipment, certificate of manufacture and test as required by the Indian Boiler Regulations. The certificate shall be in the prescribed forms III A & III C and shall be endorsed by an Inspection Authority recognized by the Indian Boiler Regulations.

H. General Requirements

1. Bidder shall furnish all the control valves as finalized during detailed engineering stage without any price repercussions whatsoever depending on the process requirements.
2. Following documents to be furnished by the Supplier after the award of contract.
 - a. Final data sheet for all control valves.
 - b. Detailed dimensional and cross-sectional drawing of control valves, indicating end to end dimensions, various clearances required, weight etc.
 - c. Test certificate for the following :
 - Hydrostatic test for all control valves
 - Magnetic particle inspection for all control valves.
 - Radiographic examination of control valves.
 - Seal tightness test for control valves
 - Materials test certificate for control valves.

9.26 Pneumatic Power Cylinder

**Table 9.25
Specification for Pneumatic Power Cylinder**

S.N	Feature		Minimum Requirement
1	Applicable standard		ISO 6431
2	Mounting Type		Fixed Position mounting/ Trunion mounting
3	Material	Cylinder	Seamless Steel Tube
		Piston rod	Hard Chrome Plated Steel

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- f) The work shall include the erection of sub-trays conduits for the cabling between probe head to the analyzer cabinet and the tubings for test gas, from analyzer cabinet to the probe.
- g) While installing the analyzer cabinet care shall be taken to locate the same within the specified maximum distance from the probe.
- h) All earthing continuity tests, insulation tests etc. shall be done as per manufacturer's recommendation.

13.5 Control Valves & Accessories

Bidder's scope of work shall include erection of control valves along with all related accessories like air filter regulator, valve positioners, limit switches, position transmitters and indicators, solenoid valves, airlock relays, volume chambers etc. Bidder's scope of work shall also include all related interconnecting tubing work for the above accessories and terminating all electrical connections up to local junction box. Any supporting structures, pedestals etc. required to make the installation complete shall be considered part of erection activity. Bidder's scope of work also includes testing and commissioning of all pneumatic control valves.

- 1. The general conditions laid down for erection of field instruments shall also be valid for control valves (wherever applicable).
- 2. Slight reorientation of flanges, if necessary, shall be considered a part of erection activity.
- 3. Control valve should be identified with regard to their tag number, control action, CV value, flow direction etc. as inscribed on the tag plate vis-à-vis the data sheet.
- 4. The orientation and position of the control valve shall be such that difficulties shall not arise while removing, repairing or servicing the valve after installation.
- 5. Bidder shall install valves only after ensuring proper flow direction.
- 6. The preferred position of a control valve is diaphragm up.
- 7. Air supply line shall be drawn from nearest air header by means of a GI sub-header to the vicinity of the installation. Isolation / needle valve to be provided on air line to each control valve / damper.
- 8. Tubing work shall generally comprise of tubing between I/P converter to valve positioner / solenoid valve / actuator, air supply to filter regulator from nearest CS sub-header, filter regulator to positioner / actuator.
- 9. Bidder's scope of cabling pertaining to control valve erection shall include cabling from solenoid valves, limit switches and electronic position transmitter up to local junction box.
- 10. Bidder shall include gaskets, nuts, bolts, site fabricated clamps and other erection items required to complete the installation.

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11. All air piping / tubing shall be blown clean with compressed air at 3.5 Kg/sq. cm and complete lines along with fittings must be tested for leakage with soap bubbles.
12. After installation, the control valves shall be greased at greasing nipples wherever applicable.
13. After completing the installation satisfactorily in all respect, Bidder shall perform the following tests.
 - Linearity of stem movement shall be checked at four points (inputs 25%, 50%, 75%, 100% of spring range) while rising and while falling.
 - Hysteresis shall be checked.
 - Response time shall be noted.
 - Operation of airlock relay shall be checked.
 - Operation of stay put conditions (under electrical signal failure shall be checked).
14. After testing, the valve shall be boxed up with blind gaskets at both ends to prevent entry of foreign materials and clogging of plug and seat.
15. During steam blowing / acid cleaning it may be necessary to remove the valve as a whole or in part breaking a part of top-work and reconnect the spool piece. The removal, reinstallation, dismantling and reconnection of tubing and cabling shall be in Bidder's scope of work.

13.6 Flow Elements

13.6.1 Orifice Plate

For orifice plates with flange taps Bidder's scope shall include fixing of nipple and first take-off valve, fixing and supporting condensation pot (wherever applicable) and insertion of orifice plate with suitable gaskets, nuts and bolts. For orifice plates with D, D/2 tapping, pipe welded stubs shall be available.

The general guidelines for installation of orifice plates are given below.

1. The length of the take-off nipples shall be sufficient so that the first take-off valve protrudes beyond the thermal insulation.
2. The take-off nipples shall be screwed / welded according to the design requirement.
3. The hand wheel of the take-off valves shall be so oriented that they can be operated conveniently from approach platform, ladder etc. Otherwise approach platform, ladder shall be provided.
4. For steam services, condensation pots shall be connected to the tapping point before or after first take-off valves. Utmost care shall be taken to ensure

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S.N	Instruments/Equipments	Test to be conducted
21	Control valves	• IBR certificate Form III C • Hydrostatic test : IBR/MSS-SP-61/ANSI B 16.34 • Seat leakage test : As per ANSI B 16-104 • CV test : As per ISA procedure • Magnetic particle test : As per ANSI B 16.34 Special class (applicable for pr. > 70 bar & tem < 4000C • Liquid penetration test : As per ANSI B 16.34 Special class (applicable for pr > 70 bar & temp < 4000C • Calibration • Hysteresis test
22	Position Transmitters	• Calibration • Hysteresis • Accuracy test
23	I/P Converters	• Calibration test • Accuracy Test
24	Solenoid Valves	• Hydro test • Seat leakage test • CV test • Coil insulation test
25	Air Filter Regulators	• Calibration test • Accuracy test
26	Junction Boxes	• Test for degree of protection • Material test
27	Transmitter Racks/ Enclosures/Local Panels/Marshalling Cabinets/System Cabinet	• Hydro test • Air leak test for tubing, Piping & fittings Verification of degree of protection • Test for enclosure type • Type tests & routine tests as per relevant Indian standards. • Electrical tests as detailed under "Wiring, Terminations & Accessories"
28	Wiring Termination and Accessories	
a	Routine test	• Conductor resistance test (*) • High voltage test (*) • Impulse dielectric test • Insulation test • Humidity test • Temperature rise tests on power circuits • Short time current tests on power circuits.
b	Type test	• Annealing test (*) • Test for insulation and sheath (*) • Flame retardance test – (a) Oxygen index, (b) Flammability • Test for acid gas generation • Test for water absorption (*) • Wet dielectric test.
		Note (*) – As per IS-1554
29	Test for terminal blocks	• Test for moulding for flame resistant

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**Table 14.2
Type Test Requirement**

S. N	Item	Test Requirement	Standard	Test To Be Specifically Conducted	Approval Req. on Test Certificate	Remarks
1	Transducers	As per standard	IEC-688, IS12784	No	Yes	
2	Thermocouple	Degree of protection test	IS-1247	No	No	
3	RTD	As per standard	IEC-751	No	No	
4	Electronic transmitter	As per standard	BS-6447 / IEC-770	No	Yes	
5	E/P converter	As per standard	Mfr. Standard	No	No	
6	Pressure gauge	Degree of Protection test Temp interference test	IS-2147 IS-3624	No No	No No	
7	Temperature gauge	Degree of protection test	IS-2147	No	No	
8	Pressure & DP switch	Degree of Protection test As per standard	IS-2147 BS 6134	No No	No No	
9	Level switch	Degree of protection test	IS-2147	No	No	
10	Conductivity level switch	Degree of protection test	IS-2147	No	No	
11	Control valves	CV Test	ISA 75.02	Yes	No	
12	Flow Nozzles & Orifice plate	Calibration	ASME PTC , BS1042	Yes	No	
13	SG control System a)I/O modules b) Other modules c)CLCS Systems	SIL-3 CMRR & NMRR verification CMRR & NMRR Verification Model test	As per standard Mfr standard Mfr standard Approved procedure	Yes Yes Yes Yes	Yes Yes Yes Yes	
14	LIE / LIR / Junction Box	Degree of protection test	IS-2147	No	No	
15	Flue gas O2 Analyser	Degree of protection test	IS-2147	No	Yes	
16	Flue gas CO Analyser	Degree of protection test	IS-2147	No	Yes	

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