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CONTROL AND SHUTOFF VALVES

(PROJECT STANDARDS AND SPECIFICATIONS)

TABLE OF CONTENT

SCOPE

This Project Standard and Specification provides a guide to the selection and use of control and shutoff valves. It contains sections that have general application to the provision of regulating and isolating valves and associated actuation. These include general principles and documentation requirements.

This Project Standard and Specification is concerned with the Control Engineering applicable to main process valves, in particular control valves and the actuation and actuator system for all main process valves.

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1.	ISO 5208	Industrial Valves - Pressure Testing for Valves
2.	ANSI B16.5	Pipe Flanges and Flanged Fittings.
3.	BS 1560	Specification for Steel Pipe Flanges (Nominal Sizes 1/2 in to 24 in) for the Petroleum Industry Part 2: Metric Dimensions
4.	BS 1655	Specification for Flanged Automatic Control Valves for the Process Control Industry (Face-to-Face Dimensions)
5.	NACE MR-01-75(90)	Sulphide Stress Cracking Resistant Metallic Materials for Oil Field Equipment

DEFINITIONS AND TERMINOLOGY

Contract - the agreement or order between the purchaser and the vendor (however made) for the execution of the works including the conditions, specification and drawings (if any) annexed thereto and such schedules as are referred to therein.

Cost of ownership - the life cost of a system including initial supply contract value, installation cost, ongoing support costs (e.g. spares, maintenance and service charges).

Works - all equipment to be provided and work to be carried out by the vendor under the contract.

SYMBOLS AND ABBREVIATIONS

SYMBOL/ABBREVIATION	DESCRIPTION
ANSI	American National Standards Institute
API	American Petroleum Institute
BS	British Standard
DN	Nominal Diameter
EC	European Community
EN	European Standards issued by CEN (European Committee for Standardization) and CENELEC (European Committee for Electrotechnical Standardization)
ESD	Emergency Shutdown
HVAC	Heating, Ventilation and Air Conditioning
ISA	Instrument Society of America
ISO	International Organization for Standardization
NACE	National Association of Corrosion Engineers
NPS	Nominal Pipe Size
PTFE	Polytetrafluorethylene
QA	Quality Assurance
SI	Systeme International d'Unites

UNITS

This Standard is based on International System of Units (SI) except where otherwise specified.

REGULATING CONTROL VALVES

General Requirements

1. The minimum size of globe and ball valve bodies shall be NPS 1 (DN 25). Body sizes corresponding to NPS 1 1/4 (DN 32), NPS 2 1/2 (DN 65), NPS 3 1/2 (DN 90) and odd sizes above NPS 4 (DN 100) shall not be used.
2. The minimum nominal sizes of eccentric plug valves shall be NPS 2 (DN 50) and of butterfly valves NPS 4 (DN 100).
3. The pressure ratings of globe valves and ball valves with bodies up to NPS 8 (DN 200) shall be at least Class 300.

   There is no economic advantage in insisting on bodies and flanges in cast steel dimensioned to Class 150, as this usually involves machining down a standard Class 300 casting.
4. All valves shall be drilled and tapped to accept gland lubricators.
5. The shaft on a butterfly valve shall be continuous, through the vane. The vane shall be rigidly locked to the shaft. The shaft shall be supported in outboard bearings.
6. The direction of flow through a valve shall be permanently marked on the body or flanges.
7. The contractor shall specify the acceptable degree of seat leakage for each valve as appropriate to the application

   Remember that the degree of seat leakage is not only dependent upon the relative finish of the plug and seat but also on the strains imposed on the installed trim. Leakage rate should be specified to either ISO 5208 or ANSI B16.104.
8. Control valves with soft seats (such as PTFE) shall only be employed where the specified degree of tight shut off cannot be achieved using metal seats.
9. The application and design of extension bonnets may be specified in the following circumstances:
   a. Extension bonnet - for fluid temperatures down to -100°C (-148°F) or above +230°C (+446°F).
   b. Cryogenic bonnet - for fluid temperatures below - 100°C (-148°F). The design should allow plug and seat to be withdrawn through the bonnet.

c. Bellows seal bonnets - should be specified only when no stem leakage can be tolerated. They should be provided with a monitor for bellows leakage, e.g. small pressure gauge and excess flow valve.

10. Welded ends may be specified where high temperatures and pressures are expected, or where the controlled fluid is highly toxic. The valve body material shall be weld compatible with the adjoining pipe material.

11. Where the valve body is to be welded into a pipeline, the valve trim should be completely replaceable through the bonnet. Precautions shall be taken during installation to avoid damage to the inner valve.

12. The contractor shall specify the required action of each valve on failure of its control signal or operating medium; with due regard to safe operation and shut down.

13. Where control valves and accessories are to be installed in locations susceptible to seismic disturbances, all components shall be designed to sustain the anticipated stresses and to function normally after the disturbances have passed.

14. Self-acting valves may be used for local, fixed gain control of utilities (e.g. fuel systems).

    Local, fixed gain control can give closer control when the load is nearly constant.

15. The contractor shall specify gland type and packing material in accordance with process conditions. Packing boxes shall be easily accessible for periodic adjustment.

    Where 'Through Body Bolted Control Valves' are considered for use, the following criteria should be taken into account.

    a. The length of the bolts concerned. (The potential for misalignment or leakage with butterfly valves for example is not as great as for valves of significantly greater face to face dimension).
    b. The duty of the pipeline and control valve concerned together with the line size. Great care should be taken when considering 'Through Body Bolted Control Valves' for Hydrocarbon service and in particular where the line size is large.
    c. The fire risk in the immediate area of where the control valve is to be sited and what type of fire protection is available.

    Through Body Bolted Control Valves' are sometimes considered in order to reduce control valve weight and cost and sometimes because of space constraints. The main concern with 'Through Body Bolted Control Valves' is that the increased bolt length leads to an increased potential for misalignment of the valve flange faces. There is also an increased potential for the unintentional loss or relaxation of bolt tension leading to an increased risk of product leakage. There is also the added risk that a small localised fire will add to the potential for bolt expansion and further leakage. Alternatives could be to use lagged valves (where bolts are protected) or sheet steel physical protection.

Valve Characteristics

1. The contractor shall specify the type of control valve trim appropriate to the required flow characteristic for the duty (i.e. quick opening, linear or equal percentage.)

   Quick opening characteristic gives a large flow on opening as the plug initially leaves the seat, but a smaller flow increases as the plug opens further.

   Linear characteristic gives equal increases in valve opening for equal increases in stem travel.

   Equal percentage characteristic gives equal percentage increases in valve opening for equal increments in stem travel.

   The rules outlined cover most cases; a more comprehensive treatment is given in the ISA (Instrument Society of America) Handbook of Control Valves.

2. An adequate allocation of pressure drop across the control valve, in conjunction with the selected characteristic, should be applied to ensure a near linear relationship between valve position and the controlled variable over the entire operating range.

3. When 50% or more of the dynamic pressure drop is allocated to the control valve, the valve should have a linear characteristic; otherwise it should be fitted with equal percentage trim.

Valve Selection

1. The type of control valve shall be specified to satisfy the process conditions. Generally, control valves of globe, butterfly, ball, angle or eccentric rotating plug design shall be employed.

   The globe body is traditionally the most commonly used style of control valve. It offers a greater degree of internal (trim) and external (mounting) flexibility than any alternative style.

2. Large volume flows and high shut-off differential pressures should be controlled by full-bore ball valves or characterized ball valves.

A full-floating ball pattern will give total shut-off but requires a high operating torque. Leakage for a characterized ball pattern is equivalent to a good double seated globe design. A full bore ball pattern has poor low flow control ability whereas a characterized ball pattern exhibits near equal percentage performance for the lower half of its travel. These may be more prone to cavitation.

3. Large volume flow and low pressure drop should be achieved by the use of butterfly valves or eccentric rotating plug valves.

   For low to medium shut-off differential pressures and where a small leakage is acceptable, butterfly valves are an economic alternative to globe and ball valves of size NPS 4 (DN 100) and above.

4. Angle valves may be provided where it is necessary to prevent the accumulation of solids, and on erosive or flashing service.

5. The selection of specialist valves for conditions where cavitation or flashing are likely shall bye determined by the contractor. Account shall be taken of the effects of any particulate matter likely in the process fluid which may result in blockage of small orifices within low noise/anti-cavitation trims.

   Cavitation is the transformation of a portion of liquid into vapor bubbles during rapid acceleration of the fluid inside the valve, and the subsequent implosion or collapse of these bubbles downstream. Cavitation occurs in a control valve once the static pressure at the 'vena contracta' reaches the vapor pressure of the fluid.

   Control valves with inherent high pressure recovery characteristics (streamlined) are more likely to suffer cavitation effects. Low pressure recovery characteristic globe valves and trim are generally used to minimize the risk.

   Flashing occurs when the pressure downstream of the vena contracta remains equal to or less than the vapor pressure of the fluid. Vapor bubbles therefore persist within the fluid and can cause physical damage and decreased valve capacity.

   Again, the degree of flashing depends principally upon the pressure recovery characteristics of the valve.

6. Control valves on discharge lines to flare shall be specified with bubble tight shut off.

7. In selecting control valves consideration shall be given to reduce fugitive emissions from control valve glands.

Valve Materials

1. Control valve trim materials shall be specified to withstand the effects of wear, erosion, pressure drop and corrosion.

   Commonly used materials include stainless steel, Monel, Hastelloy and Stellite. For valves where severe wear may occur it is common practice to face a base materials (such as stainless steel) with Stellite, particularly at the seating surfaces and guide posts. In a number of severe services the Company has experience of successfully using ceramic trim.

2. Materials for sour service shall conform to the requirements.

3. Butterfly valves should be provided with stainless steel vanes and shafts of precipitation hardened materials.

Valve Sizing

1. All control valves shall be sized to provide adequate range ability at minimum cost.

   The selection of the correct body and trim size for a control valve is ideally based upon a full knowledge of the actual flowing conditions. Where one or more of these conditions is unknown, certain assumptions will need to be made using sound engineering judgment. Generally, the tendency is to make the valve too large (to be on the 'safe' side) resulting in a valve of limited control capability.

2. The size of control valves shall be calculated from the rates of flow and pressure drops under design conditions, as well as other known factors such as fluid temperature, density, viscosity and vapour pressure.

   The flow coefficient, Cv, is accepted as the yardstick of valve capacity. The Cv is defined as the flow through the valve in U.S. gallons per minute of water at 60°F with a pressure drop across the valve of one psi.

   There are two basic sizing formulae, one for incompressible fluids (liquids) and one for compressible fluids (vapours and gases). The formulae for compressible fluids utilises the liquid flow coefficient, Cv, by inclusion of an expansion factor, (K), which also accounts for differences between compressible and incompressible discharge coefficients and critical flow factors. This system of valve sizing requires only one Cv value for each valve body and trim combination, regardless of service.

For more detailed information regarding the sizing of control valves, reference should be made to the applicable codes and standards. In addition, most control valve manufacturers produce sizing handbooks.

3. For pumped circuits, at least 25% of the total dynamic pressure drop at the design flow rate shall be allocated to the control valve.

   A general rule only. In applications where the pressure drop has been determined by other means, this value should be used in the sizing formulae.

4. A control valve shall be selected such that its capacity is between 120% to 140% of design for linear trim and 130% to 160% for equal percentage trim.
5. The effect of any reduced inlet and outlet pipe sizes and valve pressure recovery shall be taken into account when sizing control valves.
6. Control valves should be designed to operate within the limits of 10% to 90% of their stroke. Where the control required is greater than the normal range, two valves in parallel may be used.

   Control greater than the normal range is likely to occur where 'start-up' and 'normal' flow requirements are encountered.

Valve Noise

1. Control valves can develop noise due to mechanical vibration (resonance), cavitation and turbulent flow. All valves shall be assessed for their noise (sound power) level. Noise levels at the operator working positions should be less than 85 (dB(A).
2. Special purpose valves shall be used for noise avoidance.

   Noise due to mechanical vibration can be eliminated by a change in stem diameter, a change in the mass of the plug or sometimes reversal in flow direction. Cavitation noise can be avoided by the use of a suitable trim or valve type. Noise produced by fluid turbulence is almost negligible with liquids but can cause major problems with vapours or gases due to greater than sonic velocities at the valve orifice.

3. Control valves with special trim for noise reduction should have globe bodies and cage trims.

   Ball and butterfly patterns are high pressure recovery valves presenting a small flow area leading to increased velocities and hence noise.

   Cage trims split the flow path and are inherently 'low noise'.

Actuators

1. General Requirements

   The type of control valve actuator shall be specified to suit the choice of operating medium, the thrust and stroke requirements, and the type of control valve body.

   The design of the actuator shall ensure that the action of the control valve on failure of the control signal or operating medium shall be to a predetermined safe position.

   Actuators are usually classified as direct acting or reverse acting. For an air operated direct acting valve, an increase in air loading extends the actuator stem, and for a reverse acting valve, an increase in air loading retracts the actuator stem.

   Selection of direct or reverse action is usually based upon the failure requirements of the control valve, where the spring is used to drive the valve to the desired position in the event of failure of the operating medium.

   All control valves shall be provided with an indicating device to show the position of the valve, whether under the action of the control signal or hand wheel.

   Pneumatic actuators are preferred and shall be designed to give full functionality on a supply of 4 bar g maximum.

   Hydraulic actuators may be used where the pneumatic alternative is impractical or uneconomic (e.g. no air supply unavailable, very high powers involved).

   The purchaser should specify alternatives if the operating environment is likely to affect the commonly used aluminium/aluminium alloy materials used for actuators and accessories (e.g. offshore service).

2. Diaphragm Actuators

   With air as the operating medium, the normal operating range should be 0.2 to 1.0 bar (ga) (3 to 15 psig), but shall not exceed 4.0 bar (ga) (58 psig).

   Diaphragm actuators may be operated by the control signal or through positioners or booster relays.

   'Bench setting' shall be avoided by the use of adequately sized actuators.

   When the valve is working under operating conditions the air pressure required for stroking the valve (operating range) often varies from that experienced at the manufacturers works (bench range) due to the loads induced by the process fluids.