ENGINEERING STANDARD

FOR

CONTROL VALVES

SECOND EDITION

JANUARY 2015

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

Standards and Research department

No.17, Street14, North kheradmand

Karimkhan Avenue, Tehran, Iran.

Postal Code- 1585886851

Tel: 021-88810459-60 & 021-66153055

Fax: 021-88810462

Email: Standards@nioc.ir

GENERAL DEFINITIONS:

Throughout this Standard the following definitions shall apply.

COMPANY:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract documents.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

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1. SCOPE

This engineering standard covers the minimum requirements for control valve bodies, actuators and accessories, designed, constructed and tested in accordance with the References outlined herein.

Note 1:

This is a revised version of the standard specification for control valves, which is issued as revision (1). Revision (0) of the said standard specification is withdrawn.

Note 2:

This is a revised version of this standard, which is issued as revision (2)-2015. Revision (1)-2003 of the said standard specification is withdrawn.

2. 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.

ISA (INSTRUMENT SOCIETY OF AMERICA)

ANSI/ISA 75.01.01	"Industrial-Process Control Valves - Part 2-1: Flow capacity - Sizing equations for fluid flow under installed conditions"
ANSI/ISA 75.02.01	"Control Valve Capacity Test Procedure"
ANSI/ISA 75.08.01	"Face-to-Face Dimensions for Flanged Globe-Style Control Valve Bodies: ANSI Classes 125, 150, 250, 300 and 600"
ANSI/ISA 75.08.02	"Face-to-Face Dimensions for Flanged and Flangeless Rotary Control Valves (Classes 150, 300, and 600)"
ANSI/ISA 75.08.06	“Face-to-Face Dimensions for Flanged Globe-Style Control Valve Bodies (Classes 900, 1500, and 2500)”
ANSI/ISA 75.05.01	"Control Valves Terminology"
ANSI/ISA 75.19.01	"Hydrostatic Testing of Control Valves"

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

ISO 21011	“Cryogenic Vessels - Valves for Cryogenic Service”

API (AMERICAN PETROLEUM INSTITUTE)

6FA	“Specification for Fire Test for Valves”
RP 553	"Refinery Valves and Accessories for Control and Safety Instrumented Systems"
598	"Valve Inspection and Testing

600 "Steel Gate Valves-Flanged and Butt-welding Ends, Bolted Bonnets"

607 "Testing of Valves - Fire Type-testing Requirements"

608 "Metal Ball Valves - Flanged, Threaded, and Welding Ends"

609 "Butterfly Valves: Double-flanged, Lug- and Wafer-type"

6D "Specification for Pipeline Valves"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

ASME B1.20.1 "Pipe Threads, General Purpose (Inch)"

ASME B16.5 "Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard"

ASME B16.10 "Face to Face and End-to-End Dimensions of Valves"

ASME B16.34 "Valves - Flanged, Threaded and Welding End"

ANSI / FCI-70.2 "Control Valve Seat Leakage"

BSI (BRITISH STANDARDS INSTITUTION)

BS EN 593 "Industrial Valves - Metallic Butterfly Valves"

BS EN 12266 "Industrial valves - Testing of metallic valves"

IEC (INTERNATIONAL ELECTROTECHNICAL COMMISSION)

IEC 60034-5 "Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification"

IEC 60529 "Degrees of protection provided by enclosures (IP Code)"

IEC 60534-1 "Industrial-process control valves - Part 1: Control valve terminology and general considerations"

IEC 60534-8-3 "Industrial-process control valves - Part 8-3: Noise considerations - Control valve aerodynamic noise prediction method"

IEC 60085 "Electrical insulation - Thermal evaluation and designation"

IEC 60079-1 Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"

NACE (NATIONAL ASSOCIATION FOR CORROSION ENGINEERS)

ANSI/NACE MR0175/ISO15156-1 "Petroleum and natural gas industries - Materials for use in H_2S- containing environments in oil and gas production - Part 1: General principles for selection of cracking-resistant materials"

NFPA (NATIONAL FIRE PROTECTION ASSOCIATIONS)

70 "National Electrical Code"

UL (UNDERWRITERS LABORATORIES)

UL 1203 "Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations"

BASEEFA (BRITISH APPROVALS SERVICE FOR ELECTRICAL EQUIPMENT IN FLAMMABLE ATMOSPHERES)

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-G-SF-900 "General Standard for Noise and Vibration Control System"

IPS-E-EL-110 "Engineering Standard for Electrical Area Classifications"

IPS-E-IN-100 "Engineering Standard for General Instrumentation"

IPS-C-IN-160 "Construction and Installation Standard for Control Valves"

IPS-M-IN-160 "Material Standard for Control Valves"

3. UNITS

This standard is based on international system of units (SI), as per IPS-E-GN-100 except where otherwise specified.

4. CONTROL VALVE DESIGN REQUIREMENTS

The following description is primarily intended to indicate the general and minimum requirement of the control valves design criteria. Control valve design considerations are outlined such as valve selection, material selection, flow characteristic valuation, and valve accessories. It also discusses control valve sizing, fugitive emissions, and consideration of the effects of flashing, cavitation, and noise. The supplier's design calculations, drawings, and material selection shall be approved by the purchaser before order placement.

4.1 Valve types shall be selected by taking into account such factors as differential pressure, operating and design conditions, fluids being handled, rangeability required, allowable leakage, noise and other special requirements.

4.2 Control valves shall be equipped with necessary devices to adapt to control system.

4.3 In most application control valves shall be furnished with pneumatic type (or d.c. electro pneumatic) positioners in the following applications:

a) Temperature control valve other than minor applications.

b) Valves 4 inches body size and over.

c) More than one valve on a single controller.

d) Critical pressure drop service for valve trim 1 inch and larger.

e) Line pressure exceeding 20 bar.

f) Extension bonnets (includes radiation fins and belows seals).

g) Butterfly valves (rotary action).

h) Sounders patent bodies.

i) Three-way valves.

j) Slow system, such as mixing, thermal, or level process.

k) For fast systems, detailed stability analysis should be presented and if required boosters will be added.

l) On duties where the controlled liquid will vaporize across the ports.

4.4 In gas pressure let down stations when high differential pressure is present across the valve, special low noise valve shall be used. In this case the noise level should not exceed certain limits as specified in IPS-G-SF-900 (Noise and vibration control standard) or through the requirement of data sheets.

4.5 The action of valves on failure of the operating medium shall be determined by process requirements with regard to safe operation and emergency shut-down requirements.

4.6 For globe body control valves, the trim construction shall be either single-seated with heavy duty top guiding for the plug, Double-seated with top and bottom guiding for the plug, or cage type. For liquid services with a high pressure drop i.e., (boiler feed water), and gas service (pressure let down), cage trims shall be specified to have the plug supported at the critical area.

Balance type control valve in place of single seat valve in high pressure service shall be considered.

4.7 Control valves for steam heated reboilers shall be located in the steam lines and not in the condensate lines, unless otherwise agreed by the user.

4.8 Where control valves are liable to freezing due to operating or ambient conditions, they shall be insulated or heat-traced.

4.9 SIS (Safety Instrumented System) valves in hydrocarbon service should either be fire safe per API 607 (soft-seated valves), API 608 (metal seated valves), API 6FA or be located in a fire safe area.

5. CONTROL VALVE BODIES

5.1 General

5.1.1 A control valve consist of two major sub-assemblies, a valve body sub-assembly and an actuator. The valve body sub-assembly is the portion that actually controls the passing fluid. It consist of a body, internal trim, bonnet and sometimes a bottom flange.

This subassembly shall meet all of the applicable pressure, temperature, and corrosion requirements of the connecting piping.

5.1.2 Body sub-assemblies occur in many shapes and working arrangements depending upon the individual service conditions and piping requirements. Each type has certain advantages and disadvantages for given service requirements and should, therefore, be selected with care.

5.1.3 Control valves operate by one of two primary motions: Reciprocating (sliding stem) motion or rotary motion. The selection of a valve for a particular application is primarily a function of the process requirements. Some of the more common types of control valve bodies are discussed in the following sections.

5.1.4 Valves with shut-off function shall be single seated.

5.1.5 Three-way valve shall be capable of operating against the maximum differential pressure that can exist across a single port. Each 3-way valve shall be specified as flow-mixing or flow spiliting in accordance with the intended application.

5.1.6 Extended bonnets should be considered when process temperatures are below the freezing point of water 0 °C (32 °F) or above the temperature limits of the packing materials specified in API RP 553. The control valve manufacturer should be consulted for guidelines on temperature limitations.

5.2 Sliding Type Control Valves

Sliding stem valves require longitude motion of stem to be opened or closed. The most used type of sliding control valves is globe valves.

5.2.1 Globe body control valves

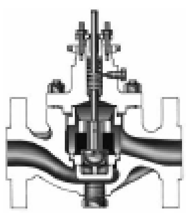
The most common control valve body style is in the form of a globe such a control valve body can be either single or double-seated:

5.2.1.1 A single-seat construction, for minimum leakage in the close position shall be employed.

5.2.1.2 A double-seat or balance construction when requiring less actuator force, but allowing some leakage in the close position, shall be used. Reduced dynamic forces acting on plug might permit choosing a smaller actuator than would be necessary for a single-ported valve body with similar capacity.

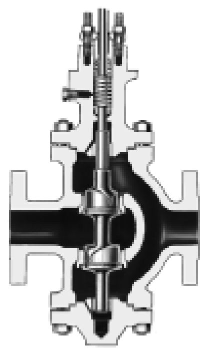
5.2.1.3 Three way valves are a design extension of a typical double-ported globe valve which are used for throttling mid-travel position control of either converging or diverging services and mixing or combining services.

5.2.1.4 Control valve with a globe body shall be considered for all applications, (throttling or on-off control) except where adverse operating conditions such as high pressure drops or high capacities make other types more suitable.



SINGLE-PORTED GLOBE-STYLE VALVE BODY

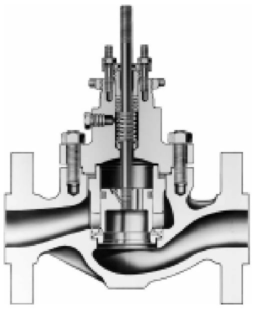
Fig. 1a



REVERSE-ACTING DOUBLE-PORTED GLOBE-STYLE VALVE BODY

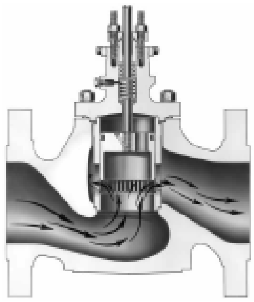
Fig. 1b

5.2.1.5 Top entry or cage guided valves have the advantages of easy trim removal. Valves of this type usually have stream lined body passages to permit increased flow capacity. Cage style single seated valve bodies can also be easily modified by change of trim parts to provide reduced-capacity flow, noise attenuation, or reduction or elimination of cavitation.



VALVE BODY WITH CAGE-STYLE TRIM, BALANCED VALVE PLUG, AND SOFT SEAT

Fig. 2a

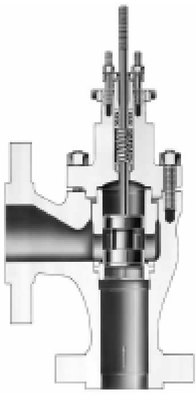


HIGH CAPACITY VALVE BODY WITH CAGE-STYLE NOISE ABATEMENT TRIM

Fig. 2b

5.2.2 Angle body valves

Angle body valves should be considered for hydrocarbon services with a tendency for high pressure drop or coking and erosive services such as slurries and applications where solid contaminants might settle in the valve body and where the piping design can take advantage of the valve geometry (in piping schemes where space is at a premium and the valve can also serve as an elbow). Angle valves are nearly always single ported.

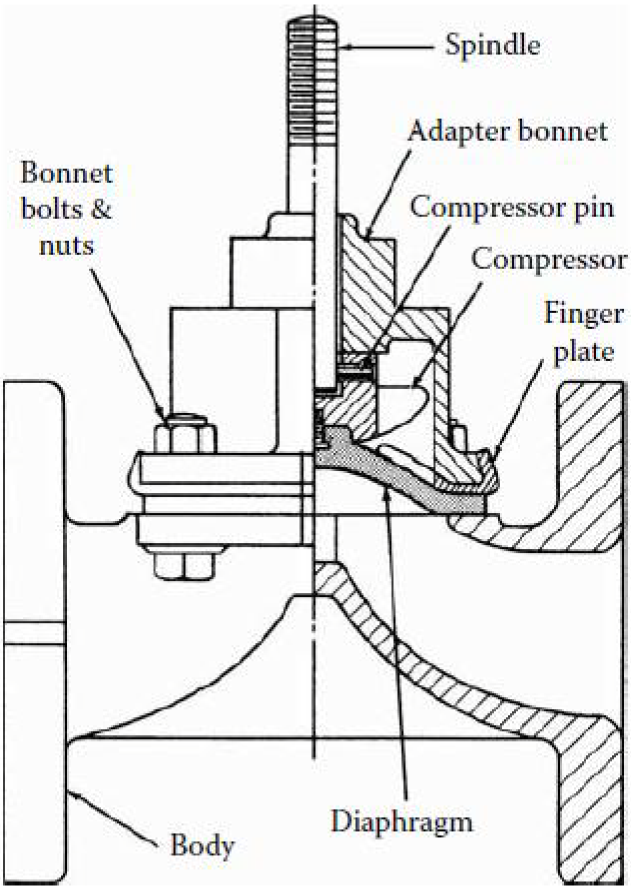


FLANGED ANGLE-STYLE CONTROL VALVE BODY

Fig. 3

5.2.3 Diaphragm valves

Diaphragm valve may be considered for simple services and applications where the body lining in a standard valve becomes economically unattractive. When used for throttling service a characterized positioner may be required for obtaining the required valve-characteristic (Fig. 4).



DIAPHRAGM VALVE

Fig. 4

5.3 Rotary Type Control Valves

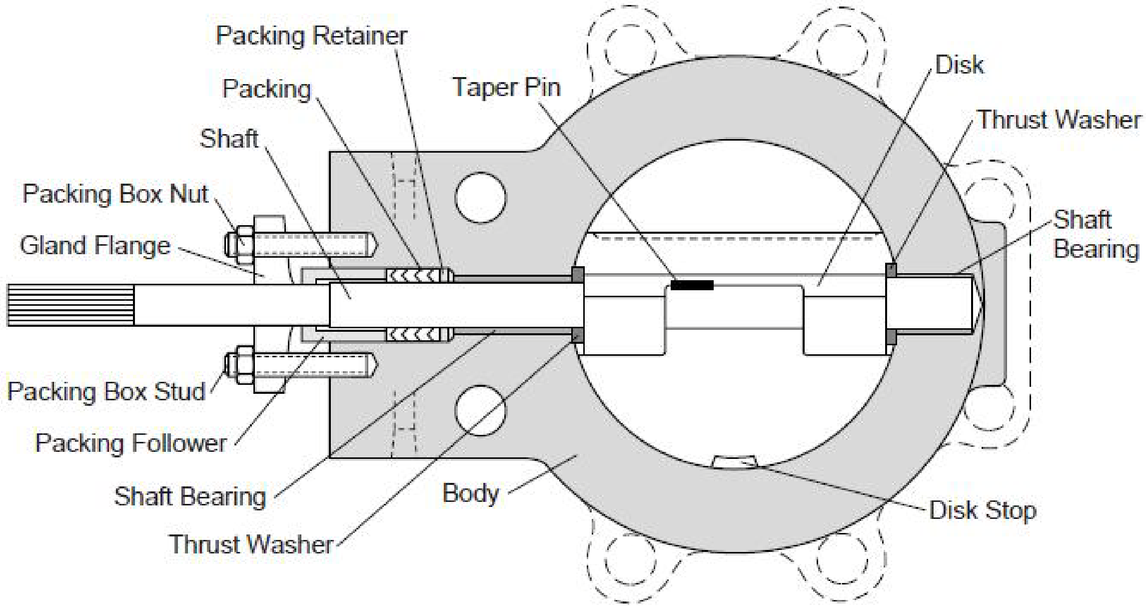
All types of rotary valves share certain basic advantages and disadvantages among the advantages are low weight, simplicity of design, high relative CV, more reliable, and friction-free packing, and generally low initial cost. They are generally not suitable in size, below 2 inches and pressure-drop ratings are limited.

5.3.1 Butterfly valves

The most common type of rotary valve, is the butterfly valve. Butterfly valves shall be considered for high capacity with low pressure loss through the valves and where no tight shut-off is required (Fig. 2). Although not normally used in minimum leakage applications, it is available with piston ring, pressurized seat or various types of elastomer seating surfaces if minimum leakage is required.

Heavy pattern butterfly valves shall be used where they are practical and economical. Conventional contoured disks provide throttling control for up to 60-degree disk rotation. Butterfly valves typically have the narrowest control range, they are generally best suited for fixed-load applications. In addition, they must be carefully sized for optimal performance at fixed loads.

They shall normally be furnished with diaphragm or piston actuators. Where handwheel is required, the shaft mounted declutchable type is preferred. Long stroke position actuators shall be used where practical.



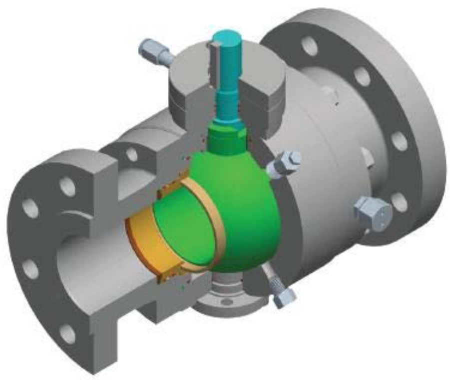
TYPICAL CONSTRUCTION DETAILS OF 2 THROUGH 12 - INCH BODY SIZES FOR BUTTERFLY VALVES

Fig. 5

5.3.2 Ball valves

Ball valves may be considered for on-off and throttling services under moderate operating conditions. Characterized ball valves may be used for fluids containing suspended solids or fluids likely to polymerize or crystallize.

For emergency shut-off valves on fuel service Ball Valve shall be used for temperature up to 150°C. Above this temperature single seated tight shut-off globe valves should be used unless otherwise specified.



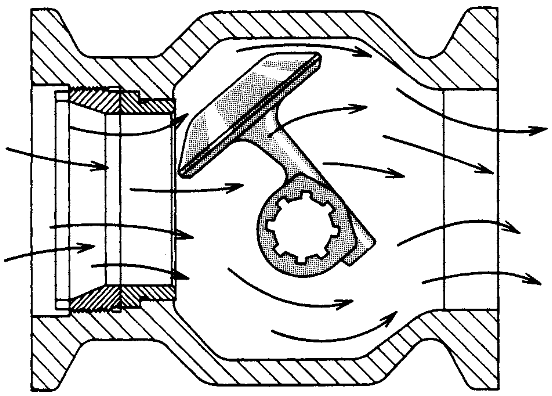
BALL VALVE

Fig. 6

5.3.3 Plug valves

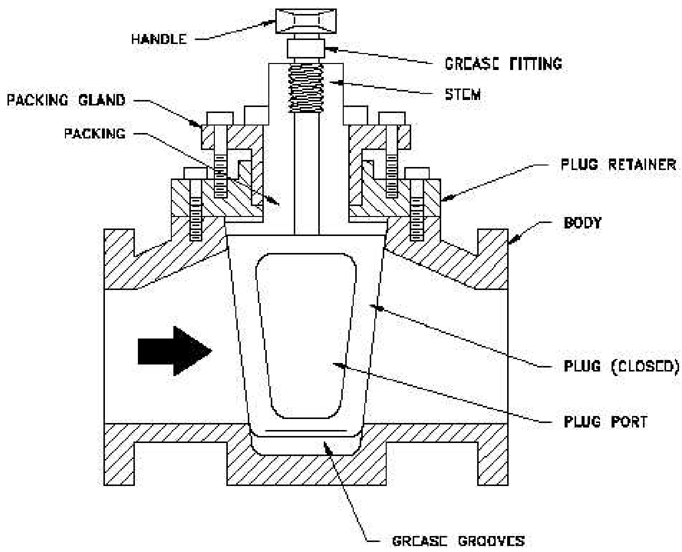
Plug valves may be considered for special applications such as throttling control on slurry services in chemical plants.

Eccentric rotating-plug valves are suitable for throttling services with performance between globe and butterfly valves (Fig. 7a). This style of rotary control valve suits erosive, coking and other hard-to-handle fluids, services.



ECCENTRIC PLUG VALVE

Fig. 7a



PLUG VALVE

Fig. 7b

5.4 Special Type Control Valves

Special body types, such as angle, split body, low noise low flow valves shall be considered where the process fluid may be erosive, viscous or carrying suspended solids and or high differential pressure is required. Flushing connection shall be provided on slurry services.

For services at high pressure drops, the application of a conventional valve trim often results in very high fluid velocities and unacceptable high noise levels.

Where this would be the case, the fluid velocity must be controlled by using a valve trim having specially designed multiple orifices in series and/or in parallel, or having a tortuous path forcing the fluid to change the direction continuously, causing high turbulence friction.

Where control valves with a very low capacity factor (CV) are required, these may be of the miniature valve type with flanged or threaded connections and a needle trim. The special trim is typically made up of a seat ring and valve plug that have been designed and machined to very close tolerances to allow accurate control of very small flows.

In this regard the recommendations of API 553 shall be followed.

6. CONTROL VALVE BODY SIZE AND FLANGE RATING

6.1 Globe Body Valves

6.1.1 Body sizes

Nominal body sizes for the globe body, shall be selected from the following series;

(Inches) 1 1½ 2 3 4 6 8 10 12 etc.

The use of sizes such as 1¼", 2½", 5", 7", 9" etc., shall be avoided. 1½ " and 3" valves are less common in petroleum industries.

6.1.2 The minimum globe control valve body size to be used shall be 1 inch and the internal trim size shall be in accordance to the requirements as specified in data sheet.

6.1.3 Body sizes smaller than 1 inch may be used for special applications, and pressure regulation services. For valve sizes smaller than 1 inch, reduced trim in 1 inch size bodies normally will be preferable.

6.1.4 The flange rating shall generally be in accordance with the piping class, but for carbon steel bodies the flange rating shall be class 300 minimum.

6.1.5 All globe body control valve manifolds and by pass valves shall follow the piping class and ratings based on piping material specification of the project.

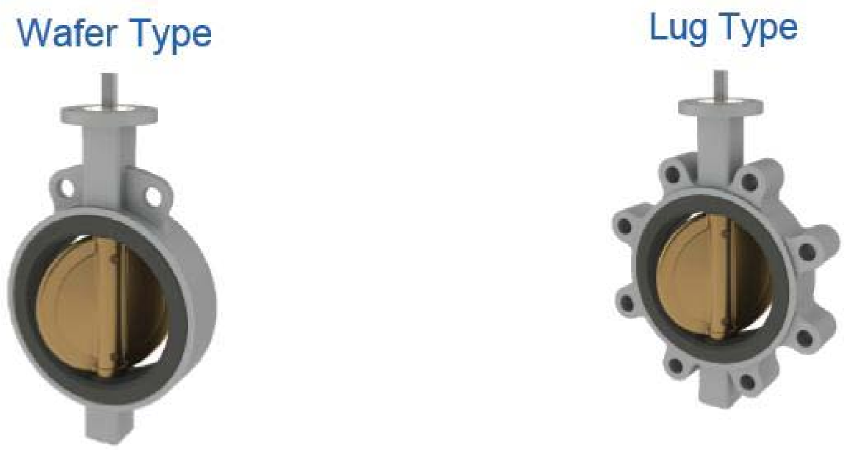
6.2 Butterfly Body Valves

6.2.1 Lug-type, wafer-type and double flange type butterfly valves shall have body pressure-temperature ratings for the selected American Society of Testing and Materials (ASTM) material specification in accordance with the applicable ASME B-16 standard as listed in Clause 2 of this Standard (Fig. 8).

6.2.2 The wafer type butterfly valves, other than lugged type, shall be provided with or without holes for the passage of bolts securing the connecting flanges dependent up on valve design.

Butterfly valves with lug bodies shall have threaded or unthreaded bolt holes. Unthreaded bolt holes are preferred, as threaded bolt holes tend to gall over time requiring bolts to be cut to permit valve removal. In those applications where allowed, wafer (unflanged) valves should have centering holes or clips to ensure proper valve and gasket alignment. Long pattern valves having longer stud bolts with greater exposure should be insulated for fire protection.

6.2.3 The end flanges of double flanged steel butterfly valves shall be cast or forged integral with the body.



LUG AND WAFER TYPE BUTTERFLY VALVES

Fig. 8

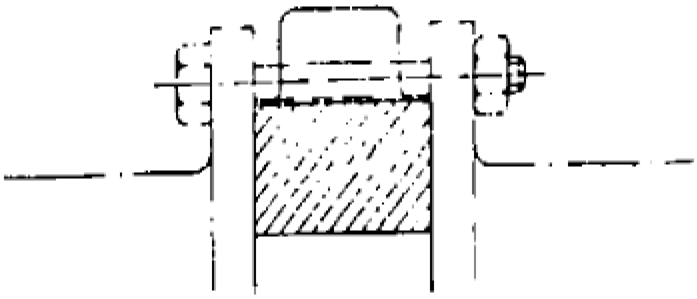
6.2.4 Butterfly valves shall be one of the following types shown in Figs. 9 to 11, with metal or resilient seating or linings:

a) Double flanged: A valve having flanged ends for connection to pipe flanges by individual bolting.

BUTTERFLY VALVE: DOUBLE FLANGED TYPE

Fig. 9

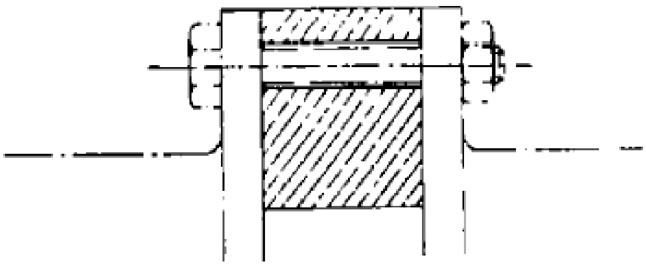
b) Wafer (Flangeless): A valve primarily intended for clamping between pipe flanges using through bolting.



BUTTERFLY VALVE: FLANGELESS WAFER TYPE

Fig. 10

c) Lug (Single Flange): A valve having single flanged end for connection to pipe flanges by individual bolting.



BUTTERFLY VALVE: SINGLE FLANGE TYPE
Fig. 11

6.3 Face-to-Face Dimensions

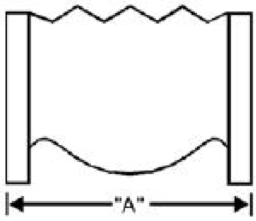
6.3.1 Face-to-face dimensions of flanged-bodies globe style control valves shall comply with the standards ANSI/ISA 75.08.01 and ANSI/ISA 75.08.06 (Table 1 and 2).

6.3.2 Face-to-face dimensions and relevant tolerances of Butterfly valves shall be in accordance with the recognized standard such as API 609 and BS EN 593.

6.3.3 Flange dimensions of Butterfly body control valves shall be in accordance IPS-M-PI-110.

TABLE 1 - FACE-TO-FACE DIMENSIONS FOR FLANGED GLOBE-STYLE CONTROL VALVES (UP TO CLASS 600)

Nominal valve Size		PN 20 (Classes 125 and 150)		PN 50 (Classes 250 and 300)		PN 110 (Class 600)		Tolerance	
		Dimension "A"		Dimension "A"		Dimension "A"			
mm	Inches	mm	Inches	mm	inches	mm	inches	mm	inches
15	½	184	7.25	190	7.50	203	8.00	±1.6	±0.062
20	¾	184	7.25	194	7.62	206	8.12	±1.6	±0.062
25	1	184	7.25	197	7.75	210	8.25	±1.6	±0.062
40	1-1/2	222	8.75	235	9.25	251	9.88	±1.6	±0.062
50	2	254	10.00	267	10.50	286	11.25	±1.6	±0.062
65	2-1/2	276	10.88	292	11.50	311	12.25	±1.6	±0.062
80	3	298	11.75	318	12.50	337	13.25	±1.6	±0.062
100	4	352	13.88	368	14.50	394	15.50	±1.6	±0.062
150	6	451	17.75	473	18.62	508	20.00	±1.6	±0.062
200	8	543	21.38	568	22.38	610	24.00	±1.6	±0.062
250	10	673	26.50	708	27.88	752	29.62	±1.6	±0.062
300	12	737	29.00	775	30.50	819	32.25	±3.2	±0.125
350	14	889	35.00	927	36.50	972	38.25	±3.2	±0.125
400	16	1016	40.00	1057	41.62	1108	43.62	±3.2	±0.125



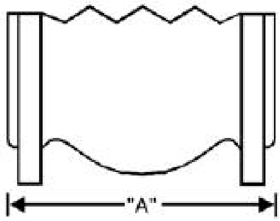
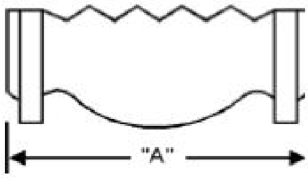


TABLE 2 − FACE-TO-FACE DIMENSIONS FOR FLANGED GLOBE-STYLE CONTROL VALVES (CLASSES 900, 1500 and 2500)

Nominal Valve Size		PN 150 (Class 900)				PN 250 (Class 1500)				PN 420 (Class 2500)				Tolerance	
		Dimension "A"				Dimension "A"				Dimension "A"					
		mm		inches		mm		inches		mm		inches			
mm	inches	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	mm	inches
15	1/2	273	292	10.75	11.50	273	292	10.75	11.50	308	318	12.12	12.50	±1.6	±0.062
20	3/4	273	292	10.75	11.50	273	292	10.75	11.50	308	318	12.12	12.50	±1.6	±0.062
25	1	273	292	10.75	11.50	273	292	10.75	11.50	308	318	12.12	12.50	±1.6	±0.062
40	1-1/2	311	333	12.25	13.12	311	333	12.25	13.12	359	381	14.12	15.00	±1.6	±0.062
50	2	340	375	13.38	14.75	340	375	13.38	14.75		400		16.25	±1.6	±0.062
65	2-1/2		410		16.12		410		16.12		441		17.38	±1.6	±0.062
80	3	387	441	15.25	17.38	406	460	16.00	18.12	498	660	19.62	26.00	±1.6	±0.062
100	4	464	511	18.25	20.12	483	530	19.00	20.87	575	737	22.62	29.00	±1.6	±0.062
150	6	600	714	21.87	28.12	692	768	24.00	30.25	819	864	32.25	34.00	±1.6	±0.062
200	8	781	914	30.75	36.00	838	972	33.00	38.25		1022		40.25	±1.6	±0.062
250	10	864	991	34.00	39.00	991	1067	39.00	42.00	1270	1372	50.00	54.00	±1.6	±0.062
300	12	1016	1130	40.00	44.50	1130	1219	44.50	48.00	1321	1575	52.00	62.00	±3.2	±0.125
350	14		1257		49.50		1257		49.50					±3.2	±0.125
400	16		1422		56.00		1422		56.00					±3.2	±0.125
450	18		1727		68.00		1727		68.00					±3.2	±0.125



7. CONTROL VALVE SIZING AND CHARACTERISTICS

7.1 Control Valve Sizing

7.1.1 Control valve sizing is necessary to optimize operation, provide sufficient rangeability, and minimize cost. The key to correct control valve sizing is the proper determination of the required valve capacity coefficient (C_V).

By definition (C_V) is the number of gallon per minute of water at 15°C that will pass through a given flow restriction with a pressure drop of 1 pound per square inch. For example, a control valve that has a maximum flow coefficient (C_V) of 12 has an effective port area in the full open position such that it passes 12 gallons per minute of water with a pressure drop of 1 pound per square inch.

Determination of required (C_V) for a given application may be accomplished through formula or slide rule methods. For detailed information regarding control valve sizing equations refer to ANSI/ISA 75.01.01.

7.1.2 Working equations are derived from the fundamental hydraulic equation and is converted to customary engineering units, then, equation becomes,

$$Q = C_V \sqrt{\frac{\Delta P}{G}}$$

Where:

C_V is the experimentally determined coefficient,

ΔP is the differential pressure across the valve,

G is the specific gravity of the liquid,

Q is the flow rate of liquid (Gallon/min).

7.1.3 The equations of this Standard are based on the use of experimentally determined capacity factors obtained by testing control valve specimen according to the procedures of ANSI/ISA 75.02.01 "Control Valve Capacity Test Procedure".

7.1.4 The equations are used to predict the flow rate of fluid through a valve when all factors, including those related to the fluid and its flowing condition, are known. When the equations are used to select a valve size it is often necessary to use capacity factors associated with the fully open or rated condition to predict an approximate required valve flow coefficient (C_V).

7.1.5 In using these methods, full knowledge of actual flowing conditions is essential. The primary factors that should be known for accurate sizing are:

1) The generic identity of process fluid.

2) The fluid phase (gas, liquid, multiphase) and the density of the fluid (specific gravity, specific weight, molecular weight);

3) The valve inlet and outlet pressures at the flow rates being considered;

4) The temperature of the fluid;

5) Cleanliness of fluid (entrained particule/catalyst);

6) The viscosity (liquids);

7) The vapor pressure and critical pressure (liquids);

8) Specific heat ratio (gas);

9) The compressibility factor (gas);

10) Flow rates required (maximum, normal, minimum);

11) Pressure drop at shutoff;

12) Maximum permissible noise level, if pertinent, and the measurement reference point;

13) Inlet and outlet pipe size and schedule;

14) Alternate process conditions including items like start-up, regeneration, or other modes of operation;

15) Any significant temperature differentials the valve will see in case of an upset.

7.1.6 Valve sizing shall be based on a maximum sizing capacity of 1.3 times the normal maximum flow or 1.1 times the absolute maximum flow, whichever is greater. The sizing pressure drop (ΔP sizing) shall be sufficient to obtain good regulation at the normal maximum case, maintain maximum quantity as well as the normal minimum quantity within the rangeability of the selected valve.

If in primary design stage maximum flow is not available, then valves shall be selected to have twice the C_V required for normal design flow at specified conditions.

7.1.7 Control valves with inherent high pressure-recovery characteristics can cause cavitation when fluid pressure and temperature conditions would indicate. Valves with low pressure recovery, special trim should be used to minimize or prevent cavitation.

7.1.8 Flashing, like cavitation, can cause physical damage and decreased valve capacity. Manufacturers should be consulted for recommendations.

7.1.9 The pressure drop across the control valve at maximum process flow shall be at least 20% of the pressure drop across the control valve at normal flow.

a) The control valve shall be sized such that the C_V value of the control valve for maximum process flow with the pressure drop across the control valve at maximum process flow is approximately 80% of the maximum C_V value for that control valve. Furthermore, the control valve shall never have less than 25% lift for minimum process flow at the specified pressure drop.

If neither a maximum nor a minimum process flow is stated, these flows shall be assumed to be 120% and 80% respectively of the normal process flow.

Sizing calculations should be checked for at both extremes to assure controllability over the entire range of the flowrates and pressure drop.

7.1.10 Butterfly valves shall be sized for maximum angle operating of 60 degree at maximum flow. Proposals to use angles greater than 60 degrees shall be submitted to the Company for approval.

7.1.11 Shafts of rotary actuated valves shall be sized for pressure drop equal to maximum upstream pressure.

7.1.12 Control valve body size normally shall not be less than half that of normal line size.

7.1.13 Flashing

Flashing occurs where the downstream pressure is at or below the vapor pressure of the fluid. See Figure 12 and Figure 13. Flashing, like cavitation, can cause physical damage and decreased flow capacity. Velocity is the major concern. The outlet flow increases velocity due to the fluid changing from a liquid to a gaseous state. A larger control valve body size with reduced trim and larger size outlet piping can be applied to prevent choking and excessive velocity problems. Other solutions to reduce or eliminate flashing damage are; hardened trim, flow down angle valves with sacrificial liner, and reverse flow rotary valve positioned for outlet to flow directly into a large volume (such as a tank), or sacrificial spool piece. Manufacturers should be consulted for recommendations.

Flashing damage is usually less severe than the damage from cavitation. However, restricted piping configurations at the valve outlet can cause the flashed vapor to cavitate and cause piping damage downstream of the control valve. Manufacturers should be consulted for recommendations.

Control valves in flashing services shall be sized using valve recovery coefficient (K_m) and critical pressure correction factor (r_c) and are defined as follows:

$$K_m = \frac{\Delta p_m}{\Delta p_{vc}} = \frac{\Delta p_m}{p_1 - p_{vc}}$$

and

$$r_c = \frac{p_{vc}}{p_v}$$

Where:

ΔP_m = Pressure drop across the valve body required to produce choked flow in Psi.

ΔP_{vc} **=** Pressure drop between valve inlet and vena contracta at choked flow in Psi.

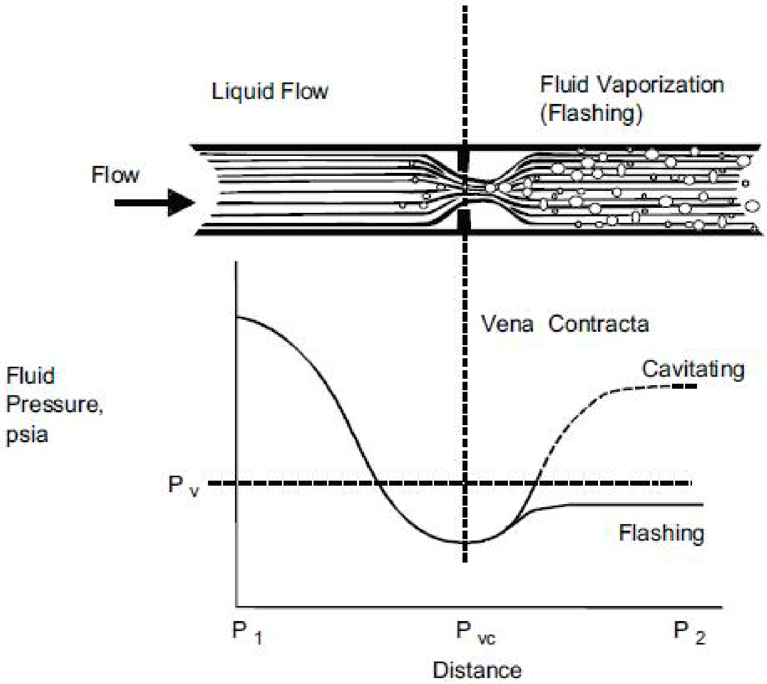
P_1 = Valve inlet pressure in Psia.

P_{vc} = Vena contracta pressure at choked flow in Psia.

Δr_c = Theoretical critical pressure ratio.

P_v = Vapor pressure of fluid in Psia.

For more details, reference should be made to ISA Handbook of control valves (Chapter 6) or equivalent methods.



(Courtesy of Emerson Process Management)

PRESSURE-DROP THROUGH A RESTRICTION

Fig. 12

FLASHING DAMAGE

Fig. 13

7.1.14 Cavitation

Cavitation is the generation of bubbles (vapor cavities) in the lowest pressure portion of the valve, and the subsequent collapse of these bubbles. See Figure 12. The bubble collapse (implosion) imparts a mechanical attack on the metal surfaces that can destroy a control valve in a short time. See Figure 14 and Figure 15. It is easily recognized by a characteristic sound described as “like rocks flowing through the valve.” High purity materials (single component) generally are the most likely to cause damage when cavitation takes place. Hydrocarbon mixtures with various vapor pressures for different components make it difficult to predict the onset or the severity of cavitation. Special cavitation control trims are offered by manufacturers that can reduce or prevent cavitation. Some of these trims are subject to plugging in dirty services and should be reviewed for suitability to each service.

Valves with low-pressure recovery should be used to minimize or prevent cavitation. In some cases it may be necessary to use special components, or stage the pressure reduction through specially design elements.

Cavitation effects on flow in control valves due to reduction of the calculated liquid flow coefficient of a valve C_V, will be observed if pressure drop is increased beyond a certain limit at a constant up-stream pressure.

The cavitation index, Kc, defines the first point where reduction of C_V can be observed from experimental data. The recovery coefficient km approximates the second point where flow becomes choked.

$$K_{sc} = \frac{\Delta p}{p_1 - p_v}$$

Where:

K_{sc} = System cavitation parameter

Δp = Pressure drop across the valve, psi

p_1 = Absolute upstream pressure, psia

p_v = Absolute vapor pressure of fluid flowing, psia

K_m and K_c can be considered as two values of the system cavitation parameter K_{sc}

(Courtesy of Flowserve)

CAVITATION DAMAGE TO VALVE PLUG
Fig. 14

(Courtesy of Flowserve)

CAVITATION DAMAGE TO SEAT RING
Fig. 15

7.1.15 Control valves installed in pipe lines should normally be at least one pipe size smaller than the computed line size. This is to allow margin for future expansion and a better controlability of the process.

7.1.16 Where it is necessary to reduce from line size to control valve size, swaged reducers shall be used between the block valves and the control valve. Sufficient spacing between block valves shall allow for installation of larger size control valves.

7.1.17 Over sized bodies with reduced trims shall be used for valves in severe flashing or cavitating service. Angle type or multiple seat type valves may be considered for this service.

7.2 Control Valve Characteristics

Control valve flow characteristics are determined principally by the design of the valve trim. The three inherent characteristics available are quick opening, linear, and equal percentage. These are shown in Fig. 16. A modified percentage characteristic generally falling between the linear and equal percentage characteristics is also available.

The three inherent characteristics can be described as follows:

1) Quick Opening

As the name implies, this characteristic provides a large opening as the plug is first lifted from the seat, with lesser flow increase as the plug opens further. This type is most commonly used where the valve will be either open or closed with no throttling of flow required.

2) Linear

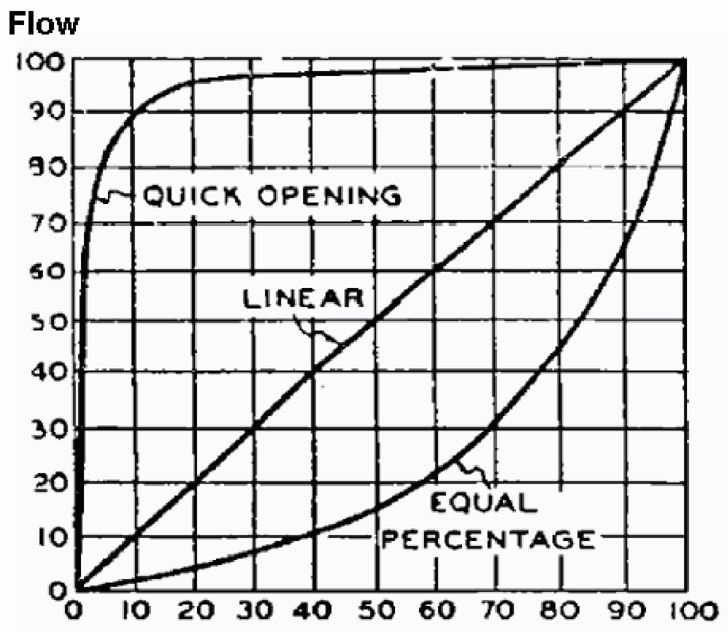
Linear trim provides equal increases in C_V for equal increases in stem travel. Thus the C_V increase is linear with plug position throughout its travel.

3) Equal Percentage

Equal percentage trim provides equal percentage increases in C_V for equal increments of stem travel. This is accomplished by providing a very small opening for plug travel near the seat and very large increases toward the more open position. As a result, a wide rangeability of C_V is achieved.

The pressure difference across the valve often varies with flow. This results in an "installed characteristic", which will differ from the inherent characteristic.

Positioners may use mechanical cams or be programmed to provide other desired characteristics.



PERCENT OF VALVE OPENING REPRESENTATIVE INHERENT FLOW CHARACTERISTIC CURVES
Fig. 16

7.2.1 Characteristic of the inner valve shall normally be equal percentage except where system characteristics indicate otherwise. Linear and quick opening characteristics shall be used where required. In general linear trim shall be used only for Split-Range service or where control valve pressure drop remains constant over the range of 10% to 100% of flow capacity.

7.2.2 Shut off valves should normally have quick closing or equal percentage characteristic, but another characteristic (such as modified equal percentage) may be required for special cases, e.g. to avoid or reduce the consequence of hydraulic shock.

7.2.3 Characteristics of valves may change due to particular requirements.

7.2.4 Butterfly and angle valves and characterized ball valves ("V-Ball") shall normally have equal percentage characteristics.

7.2.5 Three-way valves in control services shall normally have linear characteristics.

7.2.6 Valves used in pairs, as 3 way valves, including rotary actuated valves such as Ball or Butterfly types, shall have linear characteristics. Characterized positioners may be used to meet this requirement. In this case calibration for the required characterization must be done by the valve manufacturer.

7.2.7 Two-way control valves should be specified to have an equal percentage characteristic especially as noted below:

1) Gas compressor recycle control valves (Based on the vendor recommendations);

2) Valves in pressure-reducing service;

3) Valves in level control service.

8. CONTROL VALVE MANIFOLD DESIGN

8.1 Control valves and bypass valves are mostly manifolded in piping systems to allow manual manipulation of the flow through the systems in those situations when the control valve is not in service. For more information, reference should be made to IPS-C-IN-160.

8.2 For application information and guidance reference shall be made to ISA Handbook of control valves, API RP 553 or other relevant publications.

8.3 Dimensions for flanged globe control valves shall be used as per ANSI/ISA 75.08.01 standard.

9. CONTROL VALVE BLOCK AND BYPASS VALVES

9.1 Where significant future expansion is not anticipated, a less flexible but more economical approach that gives a minimum acceptable design is to make the block valves one size larger than the control valve (but not larger than line size).

The bypass line and valve should normally have a capacity at least equal to the calculated or required C_V of the control valve, but not greater than twice the selected C_V of the control valve.

9.2 The bypass valves shall be globe type unless otherwise stated by Company.

9.3 Where block valves are provided, vent valves shall be fitted between them so that pressure may be relieved and the control valve drained when the block valves are closed. Suitable drain lines shall be provided where necessary.

9.4 Vent and drain connections shall not be less that ¾ inch nominal bore.

9.5 A by-pass connection and valve shall be installed around each control valve unless other means are available for manual control when the control valve is out of service.

9.6 Block and by-pass valve assemblies should be avoided in the following instances:

9.6.1 On hydrogen service.

9.6.2 Around three-way valves.

9.6.3 Around self-acting steam pressure reducing valves.

9.6.4 Around control valves forming part of a protective system.

9.7 Block and by-pass valve assemblies shall be provided in the following instances:

9.7.1 Where a valve controls a service common to a number of plants.

9.7.2 Where valves are in continuous operation and there is not sufficient assurance of reliability over the anticipated period between plant overhauls, e.g., on erosive or corrosive service or where the temperature is below 0°C or above 180°C. The cost of a failure shall also be taken into account.

9.7.3 Where failure of the control valve would necessitate continuous operator attention, e.g., on the fuel control to heaters.

9.8 Where by-pass valves are not provided, a permanent side-mounted hand wheel shall be fitted to the control valve. Where the cost of the hand wheel is greater than the cost of block and by-pass valves, the latter shall be provided except on hydrogen service and protective service.

9.9 Where block and by-pass valves are not fitted initially adequate space should be allowed for possible future installation.

9.10 When control valves are placed in pre-stressed lines they shall be in a by-pass assembly to the main pipeline.

9.11 Manual Loading Type Hand Operators shall be considered in lieu of a side mounted handwheel in relatively low pressure/pressure drop applications where block and bypass valves are not provided and/or a handwheel may cause a hazardous condition for automatic start-up or shutdown of the related equipment. These hand operators shall consist of a three way air switch and a handwheel operated air regulator. The handle and ports shall be clearly marked as, MAN-AUTO. The regulators may be common to other components.

10. CONTROL VALVE PACKING AND SEALING

10.1 All valves shall be drilled and tapped to accept a gland lubricator except when otherwise specified in data sheet.

10.2 The bottom flange or the bottom of the body of a control valve shall not be drilled and tapped.

10.3 For special duties as specified in data sheet, e.g., toxic, control valve stems should be bellows sealed, with an independent gland seal, the enclosed space being monitored for bellows leakage.

10.4 When sealing by bellows is not possible, a purge should be used, monitored for flow failure. Bellows seals may also be required to prevent leakage of penetrating liquids.

10.5 On clean fluids, interlocking self lubricating gland packings with spring followers may be used.

10.6 On higher temperature duties or where carbon or other deposits may settle on the stem, special packing should be used.

10.7 If dangerous fluids are encountered, horizontal lines shall be fitted with suitable drains on the bottom. This does not replace the vent.

10.8 Packing materials for control valves shall be suitable for the specified service conditions.

10.9 Where the controlled liquid contains particles or materials which would damage the valve guide, stem or packing, a purge system shall be considered.

11. CONTROL VALVE NOISE AND VIBRATION CAUSED BY SONIC FLOW

11.1 Sonic flow occurs when the velocity of the fluid reaches the speed of sound in that medium.

At subsonic velocities the flow is characterized by turbulent mixing and this is responsible for the noise produced. This noise best described as a "hiss" for small jets or as a roar for larger jets has no discrete dominating frequency. Its spectrum is continuous with a single, rather flat maximum.

As pressure ratio increases past the critical ratio and the fluid reaches its sonic velocity, the sound emanating undergoes a fundamental change, while the roaring noise due to the turbulent mixing is still present, it may be almost completely dominated by a very powerful "whistle" or "serooch" of a completely different character. This noise is rather harsh and of a confused nature, becoming much more like a pure note.

At sonic flow, vibration can be caused in various, frequency bands due to vertical/horizontal movement of control valve components (20-80 KHz), impingement of fluid on control valve internals at high velocities (400-1600 Hz) aerodynamic noise from shock waves by the sonic velocities, (1200-4000 Hz), internal components vibrating at their natural frequencies (3000-6000 Hz) and high pressure drop gas services (above 8000 Hz). For guidance in specifications the permissible noise exposure, is noted below:-

Note:

For maximum allowable sound pressure level and other information in relation with noise control and vibration see IPS-G-SF-900.

Duration hours per day	Sound level dB slow response
8	85
4	88
2	91
1	94

11.2 Cause of Noise and Vibration

High pressure drop gives rise to sonic flow. Sonic flow generates shock waves which in turn produce high frequency noise and vibration (1.2 to 4.8 KHz). The noise has a characteristic whistle or scream at its peak frequency, is directional in nature when discharged into the atmosphere and even more dependent upon fluid jet pressure than the turbulent mixing noise of subsonic flow.

The most dangerous vibration occurs in frequency band 3 to 7 KHz and is the result of resonance by the valve parts. This can lead to failure due to metal fatigue.

11.3 The most effective method of solution is to remove the cause that is the high pressure drop. Values of safe pressure drop may be taken from:-

for subsonic conditions $\Delta P < 0.5 \quad Cf^2 P_1$

for sonic conditions, $\Delta P < 0.5 \quad Cf^2 P_2$

ΔP = Pressure drop across valve, (P_l-P_2) bar

P_l = upstream pressure, bar Abs.

P_2 = downstream pressure, bar Abs.

C_f = critical flow factor for valve, dimensionless (obtained from valve manufacturer).

The absence of sonic flow means an absence of its effects of noise and vibration. In cases where pressure drop must remain high, a special type of "low-noise" control valve is recommended.

If the calculated sound pressure level (SPL) value of a reducing valve under maximum load exceeds the stated limit by only 5 to 10 dB, then one of the following simple cures must be considered:

a) Increase the pipe wall thickness downstream (doubling the wall thickness will decrease the SPL by 5 dB).

b) Use acoustical isolation downstream. This will reduce SPL by 0.2 to 0.5 dB per mm of insulation, depending on the density of the insulating material.

11.4 If the valve noise is 10 dB above the selected limit, then one must choose a different approach such as the use of downstream, in line silencers. The silencers generally attenuate between 10 to 20 dB depending on the frequency range. The silencers must be installed directly adjacent to the valve body and that the valve outlet velocity is below sonic; (Say 1/3 match). Otherwise the silencer will act as a pressure-reducing device for which it is not suitable.

11.5 The use of expansion plates downstream of valves is recommended. The primary function of these plates is not to attenuate the valve noise, but to absorb some of the pressure reduction over the whole system. In this way the pressure across the control valve can be kept below critical. In a typical installation the expansion plate downstream flow area must be increased to compensate for the changes in the density due to pressure drop. For more information see IPS-G-SF-900.

12. CONTROL VALVE ACTUATORS

Control valves are operated by actuators which can be electrical, pneumatic, hydraulic or a combination type. Actuators are limited by travel, torque, or thrust.

12.1 Control valve actuators should be selected, so that on failure of the operating medium, the valve will automatically take a position (open, closed or locked) that will result in the safest configuration for the operating unit.

12.2 In the opening direction, a stop shall be engaged before the valve plug reaches its travel limit. The stop shall have sufficient contact area to absorb any force transmitted to it. In the closing direction, the valve plug shall seat before the actuator reaches its travel limit.

12.3 Valve connection to the actuator shall be adjustable, with positive locking of the adjustment.

12.4 Rotary actuated valves (such as butterfly, ball) shall have shaft keyways that allow the action of the valve to be changed.

12.5 For Rotary actuated valves in cryogenic service, shaft thrust bearings shall be provided.

12.6 Standard spring range shall be 0.2-1 barg.

12.7 Handwheels, when specified, shall be mounted considering the clause 15.6 recommendations.

12.8 Pneumatic actuators should have as low as an operating pressure as practicable in order to minimize the need for spare capacity in the instrument air system. In no case may the operating pressure exceed 4 bar.

12.9 For shut-off valves, the actuators shall be capable of opening the valve against the full upstream pressure, with the downstream pressure assumed to be atmospheric.

12.10 For butterfly valves, the actuators shall have sufficient force for coping with all operating conditions from the fully closed position to the fully open position, and for coping with all pressure drop and torque requirements.

12.11 The stroking time of control valves shall be evaluated on the basis of the process control requirements. For critical analogue control systems such as surge control of compressors, the stroking time shall be less than 5 seconds. For other analogue control systems, longer stroking times may be acceptable. In these cases compressor manufacturer recommendations shall be followed.

12.12 For valves having spring-to-close action, the stroking time is determined by the spring force, the diameter of air exhaust ports in the actuator and solenoid valve, and the mechanical inertia of moving parts.

12.13 The action of the valves on failure of the operating medium shall be determined by process requirements with regard to safe operation and emergency shut-down.

12.14 Pressure Balanced Valves of the double diaphragm type may be considered for use on fuel gas to heaters in temperature control systems.

13. TYPES OF CONTROL VALVE ACTUATORS

There are many types of actuators for stroking control valves. These actuators may be classified into five general types:

a) Pneumatically operated diaphragm actuators.

b) Piston (cylinder) actuators.

c) Electro-Hydraulic actuators.

d) Electro-Mechanical actuators.

e) Motor operated actuator.

Actuators may be direct acting (an increase in air loading extends the actuator stem) or reverse acting (an increase in air loading retracts the actuator stem). Some actuators are field reversible. They can be changed from direct to reverse acting with no additional parts. Most manufacturers publish tables that allow selection of actuator size based on valve size, flow direction, air action, pressure drop, packing friction, and available air pressure.

The valve, actuator, and associated accessories, regardless of manufacturer(s), should be assembled, piped (tubing), aligned, tested, and shipped as a unit by the valve manufacturer. Tests may include hydrostatic, stroke test, leakage, or accessory calibration.

13.1 Pneumatically Operated Diaphragm Actuators

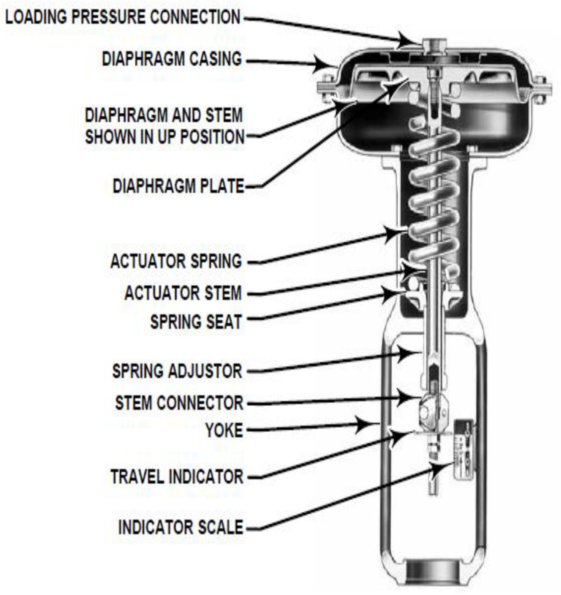
Control valves are normally operated by pneumatic diaphragm actuators. The actuator shall be operated between 0.2-1.0 bar. In special cases 0.4-2.0 bar may be used as specified for full stroke. Where the control signal is electric, the electro-pneumatic convertor shall be used.

13.1.1 There are two types of diaphragm actuators:

- Direct acting

- Reverse acting

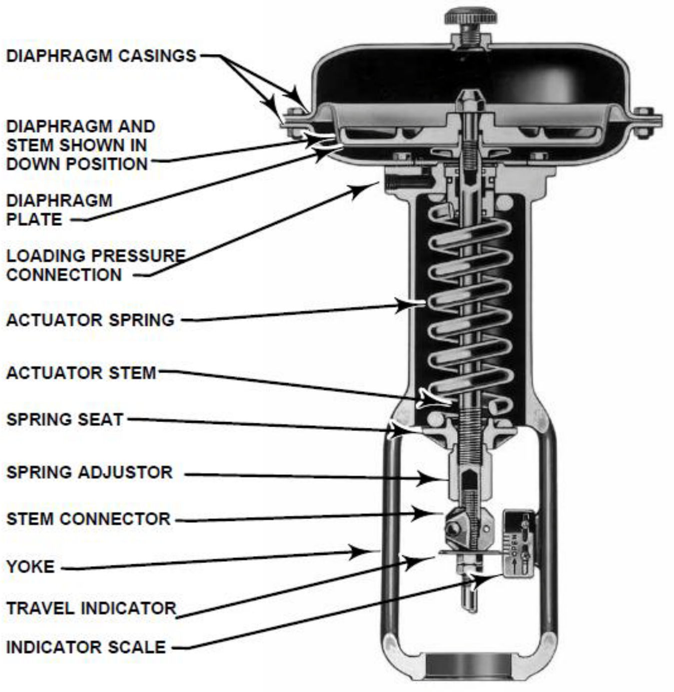
The actuator shall be designed to provide dependable on-off or throttling operation of automatic control valve.



DIRECT-ACTING

DIAPHRAGM ACTUATOR

Fig. 17



REVERSE-ACTING

DIAPHRAGM ACTUATOR

Fig. 18

13.2 Piston (Cylinder) Actuators

13.2.1 Cylinder actuators shall be used where a long stroke and high force is required, such as for dampers and louvers in large ducting for combustion air or flue gas services.

Single-acting piston actuators apply air pressure to one side of the piston against a spring or springs. Upon loss of air the spring will move the valve to the desired failure position. Double-acting piston actuators are considerably stiffer than single-acting designs and can therefore be used to control higher pressure drops. Double-acting piston actuators apply air to both sides of the cylinder. Double-acting piston actuators without springs require an external volume tank and trip system to achieve the desired failure position. Springs can be added to double-acting piston actuators to provide the air failure mode. See Fig. 19.

Linear type piston actuators are used for globe style control valves. They are also used for rotary valves with adapter linkage. Scotch yoke or rack-and-pinion type piston actuators are normally used for on/off control, but may be used for regulatory control if control degradation is not critical.

13.2.2 Piston actuators may be pneumatically or hydraulically operated.

13.2.3 The cylinders shall be connected directly to the valve as an integral part.

13.2.4 For throttling applications the cylinder actuator shall be provided with a positioner mechanism and, where necessary, with a position transmitter. A pair of oil filter with isolating valves shall be installed as close as possible to the positioner.

13.2.5 Cylinder actuators on valves with provisions for manual (local) control shall be provided with external bypass valves if these are not integral with the actuator. Four way valves are often required in the piping of the cylinder to allow local operation.

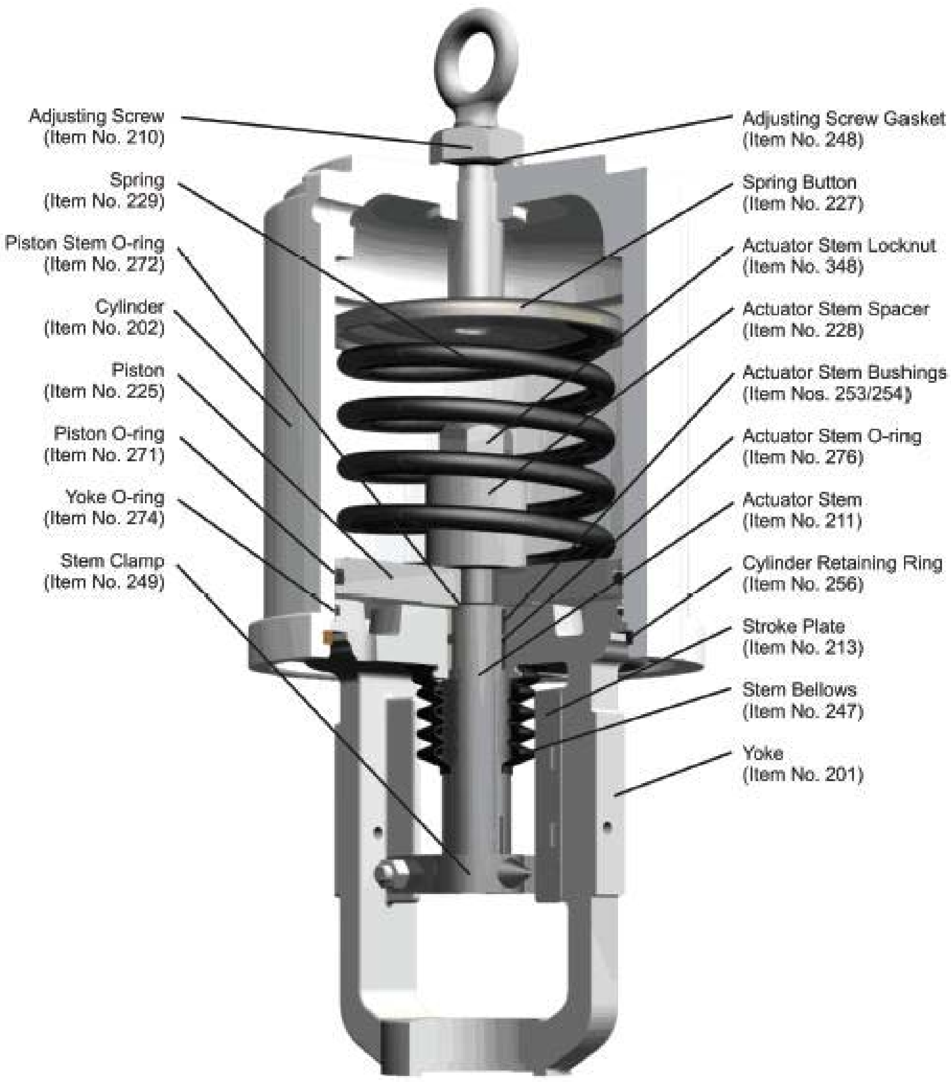
13.2.6 For hydraulic cylinders, the following points should be considered:

a) If the hydraulic manifold is rigidly piped, it should be connected to the hydraulic fluid supply and return headers by flexible metalic hose.

b) To assure a continuous supply of hydraulic to actuators, it is advisable to provide both an oil filter or strainer and a spare suitably valved and piped so that either unit may be removed and cleaned without shutting off the supply.

c) Vent valve should be provided at high points in the hydraulic fluid system.

d) Depending upon whether the valve served by the actuator will move if the hydraulic oil pressure is lost, it may be necessary to use automatic fluid trapping valves that lock the hydraulic fluid in the cylinders upon failure of the hydraulic system.



Piston Cylinder Linear Actuator

DOUBLE-ACTING SPRING RETURN PISTON

Fig. 19

13.3 Electro-Hydraulic Actuators

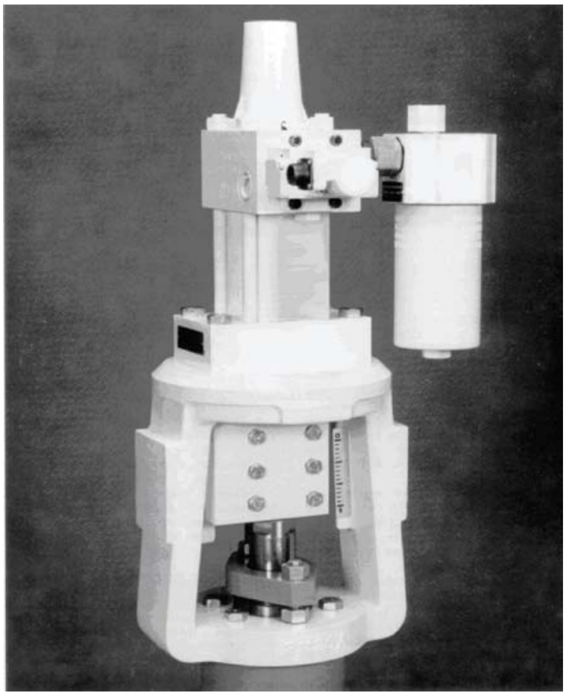
A variation of the piston actuator is the electro-hydraulic, actuator which uses an electric motor to drive a pump and supply hydraulic pressure for the piston. For multiple valve installations, electro-hydraulic actuators may be supplied by a common electric motor/pump skid. See Fig. 20 and Fig. 21.

13.3.1 Electro-hydraulic actuators may be used to operate a large rotary and sliding stem valves. Electrical signal of 4-20 mA shall be used.

13.3.2 Electro-hydraulic actuators shall be used for an electronic control loop, where fast stroking speeds, high thrust and long stroke are required.

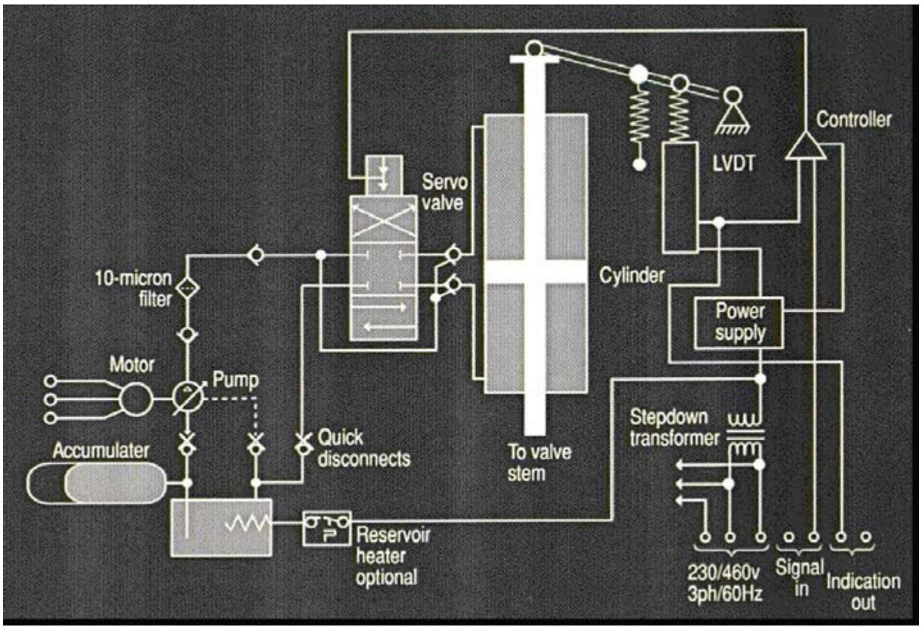
13.3.3 Electro-hydraulic actuators may be used at locations where a suitable air supply is not available.

13.3.4 For manual operation a local manual hydraulic hand pump or standby hydraulic accumulator backup hydraulic system is needed.



ELECTRO-HYDRAULIC ACTUATOR

Fig. 20



ELECTRO-HYDRAULIC ACTUATOR SCHEMATIC

Fig. 21

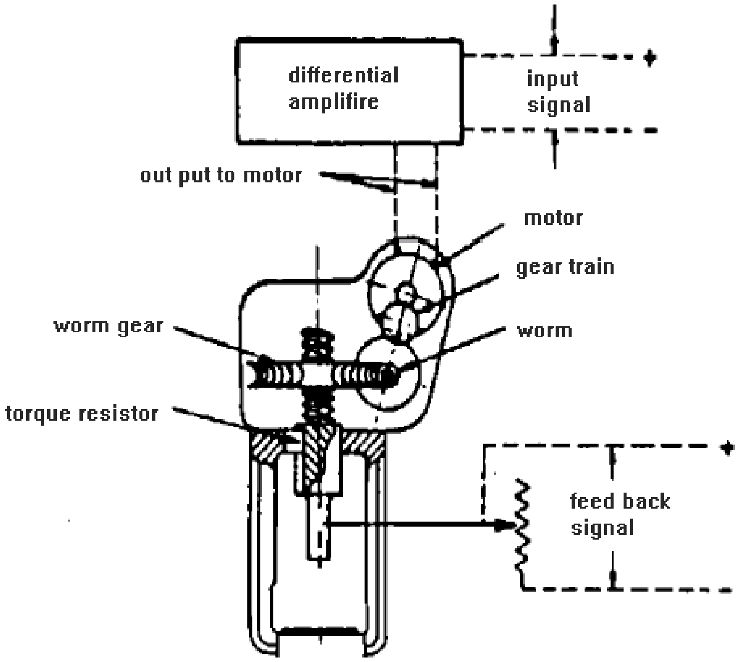
13.4 Electro-Mechanical Actuators

13.4.1 The electro-mechanical valve actuator has essentially the same advantages as the electro-hydraulic actuator with respect to field use. It is capable of being used over long distances with only inconsequential signal transmission delays.

It is also immune from the pneumatic system problem of freeze-up in extremely cold ambient conditions. Electromechanical actuators are still, however, generally more expensive, although more efficient, than electro-hydraulic units.

13.4.2 An Electro-Mechanical valve actuator is composed of a motorized gear train and screw assembly which drives the valve stem or rotary shaft valves. A typical example is shown schematically in Fig. 12. The varying input signal, whose magnitude corresponds to the required position of the inner valve stem, is fed into the positioner (usually a differential amplifier) and produces a voltage to actuate the motorized gear train and screw.

The resultant movement of the stem and the take-off attached to it and to a potentiometer or linear differential transformer, produces a voltage that increases with stroke, and is sent into the positioner. When the input signal voltages and feed back voltages are equal, the output voltage to the motor goes to zero and the motor stops with the valve stem at the required position. Conversely, when the voltages are not equal, the motor is run in the direction to make them equal.



AN ELECTRO-MECHANICAL VALVE ACTUATOR

Fig. 22

13.5 Motor Operated Actuators

Motor operated actuators should be used in On-Off services.

13.5.1 The actuator shall consist of a motor driven, reduction gearing, thrust bearing where applicable, handwheel and local position indicator, together with torque and limit switches, space heaters terminals, control power transformer, and integral motor starter controls, all furnished as a self-contained, totally enclosed unit.

13.5.2 Motor starter for remote mounting shall be specified.

13.5.3 The motor shall be sized for torque requirement according to the valve size, operating differential pressure and temperature, and speed operation.

13.5.4 The actuator terminal box should be double-sealed in such a way that when the actuator terminal box cover is removed for the connection of incoming cables, the remaining electrical components are still protected by the watertight enclosure.

13.5.5 The valve and actuator mounting bracket must be capable of withstanding the stall torque of the actuator, with torque and limit switches disconnected.

13.5.6 The actuator shall provide both torque and position limitation in both directions. An automatic over-ride shall be provided to prevent the torque switches from tripping the motor on initial valve unseating.

13.5.7 The actuator shall be capable of operating at any mounting angle.

13.5.8 The actuator shall be designed so that there will be no release of high stem thrust of torque reaction spring forces when covers are removed from actuator gear box, even when the valve is under full line pressure conditions.

13.5.9 Failure of the motor, power, or motor gearing shall not prevent manual operation of the valve through the use of the handwheel. When the motor drive is declutched, the handwheel drive shall be engaged safely, with the motor running or stopped.

13.5.10 A means of locking the actuator in either the manual or motor condition shall be provided. If not locked in either position, starting of the motor shall automatically restore the power drive.

13.5.11 The actuator shall be capable of functioning within the ambient temperature range as specified in the job specification.

13.5.12 Clockwise rotation of the actuator handwheel shall close the valve. The handwheel drive must be mechanically independent of the motor drive, and gearing should be such as to permit emergency manual operation in a reasonable time.

13.5.13 The motor shall be of sufficient size to open and close the valve against maximum cold working pressure when voltage to motor terminals is within 10% of rated voltage. Motor nameplate rating shall be 400 volts, 3 phase, 50 Hz, unless otherwise specified.

13.5.14 Local pushbuttons shall be provided for "Open-Stop-Close" control of valve, with a lockable selector switch providing positions "local", " remote" and "off" position.

13.5.15 Provision shall have made for the addition of extra sets of limit switches in each actuator. Each set shall be adjustable to any point of valve position. Each unit shall be provided with auxiliary contacts for remote position indication. They shall be adjustable continuously in the range of open to close positions.

13.5.16 Actuators shall have an output speed of 0.4 rev/s unless otherwise specified on the data sheets (e.g., for high speed emergency isolation). No valve shall be required more than two (2) minutes for full operation, i.e., from closed to fully open or open to fully closed.

13.5.17 In the case of high speed actuators a pulse timer should be included which will give variable slow down times for fast closing and fast opening, normally set to operate over the last 25% of the valve closure.

13.5.18 Provision shall also be made for remote operation through interposing relays supplied with d.c. power of 24 V unless otherwise specified.

13.5.19 Mechanical dial indication of valve position shall be incorporated in the actuator. Indication shall be continuous if valve is specified to be in regulating device.

13.5.20 Position limit switches shall be provided at each end of travel for remote indication and sequencing.

13.5.21 Torque and limit switches shall be easily adjustable without special tools or removal of switch assembly from the actuator. Repeatability of switch actuation shall be better than ±5% of set point.

Limit switches and linkage devices used to detect valve stem position should not have a dead band exceeding the lesser of 10 % of valve travel or 3 mm (0.125 in.). Rotary valve limit switch dead band should not exceed 5.0 degrees rotation of the valve disk shaft.

13.5.22 Control power transformers when used, shall have fuse protection on the secondary. Fuses shall be readily accessible for replacement or deactivation at the terminal board.

13.5.23 An electrically and mechanically interlocked motor starter shall be provided in the actuator housing, unless the motor starter is specified for remote mounting.

13.5.24 All electrical components shall be prewired by the actuator vendor to a legibly marked terminal strip. Power and control wiring shall be segregated and insulated from each other. All wiring shall be identified by the Vendor, and access for maintenance provided.

13.5.25 Motor overload protection shall be provided. One or more winding temperature detectors embedded in the motor winding, or three thermal overload relays in the motor controller are acceptable. Either must be capable of being deactivated at the terminal board.

13.5.26 For Emergency Block Valve (EBV) service, it is more important to close the valve than to protect the actuator motor. Therefore, the following wiring precautions should be observed.

a) The closing torque switch should be bypassed and the valve should close to make closed position limit switch.

b) The control circuit fuse should be bypassed.

c) The thermal overloads should be bypassed.

d) Any thermistor in the motor windings should be bypassed.

13.5.27 All motor operators shall be explosion proof approved in accordance with the requirements of the National Fire Protection Association latest edition (NFPA No. 70) for use in the hazardous area classification, or unless otherwise specified in individual data sheets.

13.5.28 All electrical equipment and motors shall be totally enclosed for outdoor services with IP 67 according to IEC 60034-5 and IEC 60529.

13.5.29 All electrical equipment used in hazardous area, shall also meet the electrical area classification requirements as per IPS-E-EL-110, and IPS-E-IN-100.

13.5.30 Vendor shall supply the valve actuator compatible with the valve. All information required for sizing the actuator shall be obtained from the purchaser and/or Valve Supplier.

13.5.31 Torque requirements of valve and torque characteristics of the actuator shall be supplied to the Purchaser for approval.

13.5.32 All gearing shall be totally enclosed and continuously lubricated. All shafts shall be mounted on ball or roller bearings. Limit switch drive shall be stainless steel or bronze.

13.5.33 Power terminals shall be of stud type, segregated by an insulating cover. Four cable entrance taps shall be provided as a minimum. Each tap will be provided with standard electrical connections in metric type such as M20.

13.5.34 The actuator shall have an integral motor starter, Local controls and lamp indication. Provide phase discriminator relay.

13.5.35 The starter shall include a mechanically and electrically interlocked reversing contactor, with control transformer having a grounded screen between primary and secondary windings. The common point of contactor coils and secondary winding shall also be grounded, so that any ground fault will cause contactors to drop-out. Terminals for remote controls shall be provided.

13.5.36 The starter components shall be readily accessible for inspection without disconnecting external cables. Internal wiring shall be number-identified at both ends.

13.5.37 Lamp indication of "close" (Green), intermediate (white) and "open" (Red) positions shall be provided.

13.5.38 Open and close torque and/or position limit switches, plus two auxiliary limit switches at each end of travel shall be provided. Switch ratings shall be 5 Amps at 230 V.a.c or as specified in data sheet.

13.5.39 Internal control wiring of 5 Amp tropical grade PVC cable shall be provided, terminating in a separately sealed housing with stud terminals. The 3 phase leads of the motor shall be brought to separately stainless studs.

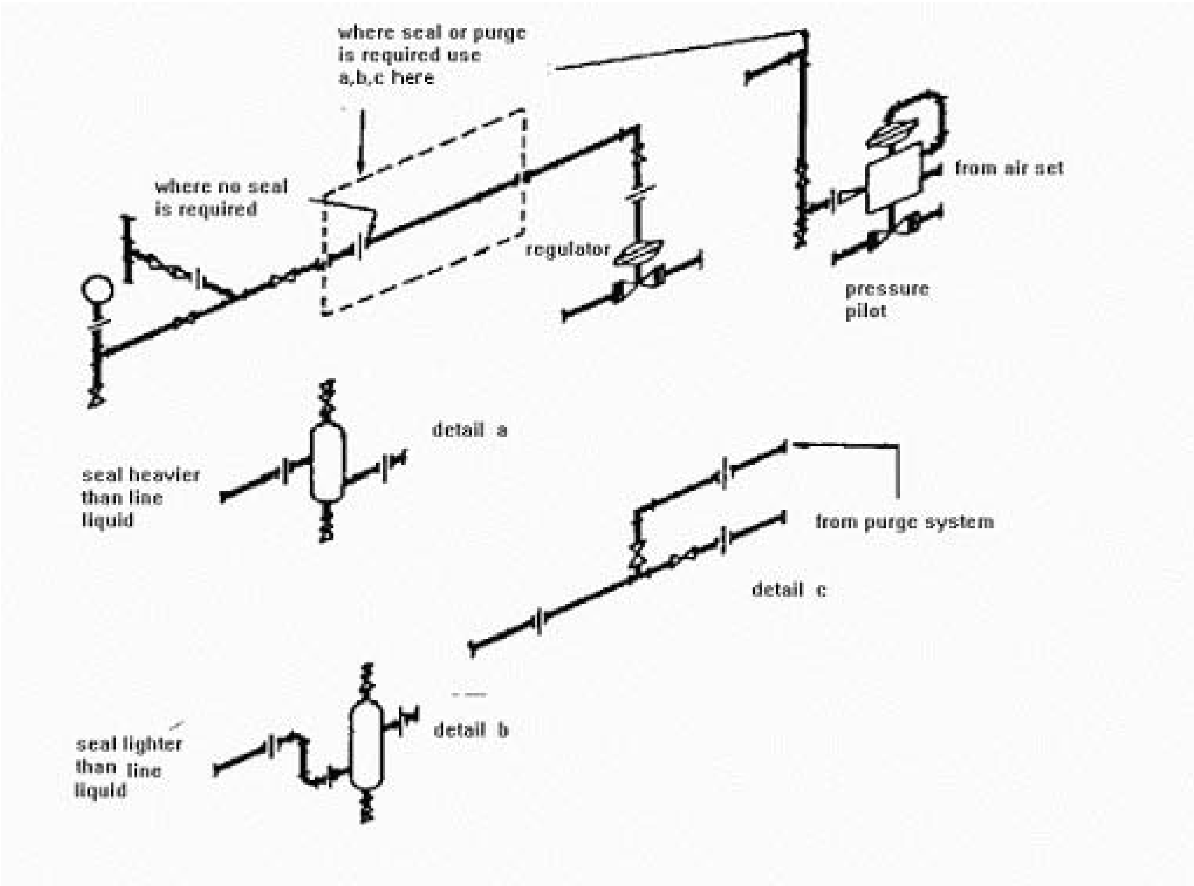
13.5.40 The motor shall be pre-lubricated and all bearings shall be of anti-frictions type.

13.5.41 The motor shall be sized for the torque requirements according to the valve size, operating pressure and temperature, and speed operation.

13.5.42 The motor shall have class "B" insulation, short time rated, with burn-out protection provided.

14. SELF-ACTUATED REGULATORS

The self-actuated regulator is a variation of the diaphragm actuator and normally uses the process fluid as the operating medium. For pressure applications, some self-actuated regulators use bellows instead of diaphragms for the actuator. For temperature applications, bellows with a filled system and bulb shall be used instead of diaphragms. Piping arrangements are shown in Fig. 23.



PIPING AT REGULATOR VALVE OR PRESSURE PILOTS

Fig. 23

14.1 Definitions

A regulator is a very simple control device in which all of the energy to operate it is derived from the controlled system. Self actuated regulators can be used in the following services:

- Pressure control

- Level control

- Flow control

- Temperature control

All regulators, whether they are being used for pressure, level of flow control, fit into one of the following two basic categories:

1) Direct-operated

2) Pilot-operated

a) Pilot-Operated

b) Direct-Operated

REGULATOR TYPES

Fig. 24

14.1.1 Characteristically, direct-operated regulators are adequate for narrow-range control, and where the allowable change in outlet pressure can be 10 to 20 percent of the outlet pressure setting.

14.1.2 Pilot-Operated regulators are preferred for broad-range control, or where the allowable change in outlet pressure is required to be less than 10 percent of the outlet pressure setting. They are also commonly used when remote set point adjustment is required for a regulator application.

14.1.3 The globe-style pilot operated backpressure regulators or relief valves are used in gas or liquid service to maintain pressure on oil and gas separators and in pressure relief application in gas distribution systems.

With the pilot, pressure can be controlled, and set pressure is varied to individual requirement by the adjusting screw on the pilot. Pilot exhaust can be piped into the down-stream line or vented to the atmosphere on gas service, but must always be piped downstream on liquid service.

14.1.4 Direct-Operated regulators are used to provide constant reduced pressure to pneumatic instrumentation and other control equipments.

14.1.5 Pilot-Operated service regulators are ideal for applications involving pressure factor measurement.

14.2 Self-Actuated Pressure Regulator Characteristic

14.2.1 All regulators should be installed in accordance with local and international standards and regulations.

14.2.2 Adequate over pressure protection should be installed to protect the regulator from over pressure, and also to protect all downstream equipment in the event of regulator failure.

14.2.3 The recommended selection for port diameter shall be the smallest port diameter that will handle the flow.

14.2.4 Spring cases must be protected against the accumulation of water caused by condensation or other sources.

14.2.5 Control line connections (where required) should be made in a straight run of pipe 8 to 10 pipe diameters downstream of any area of turbulence such as elbows or block valves.

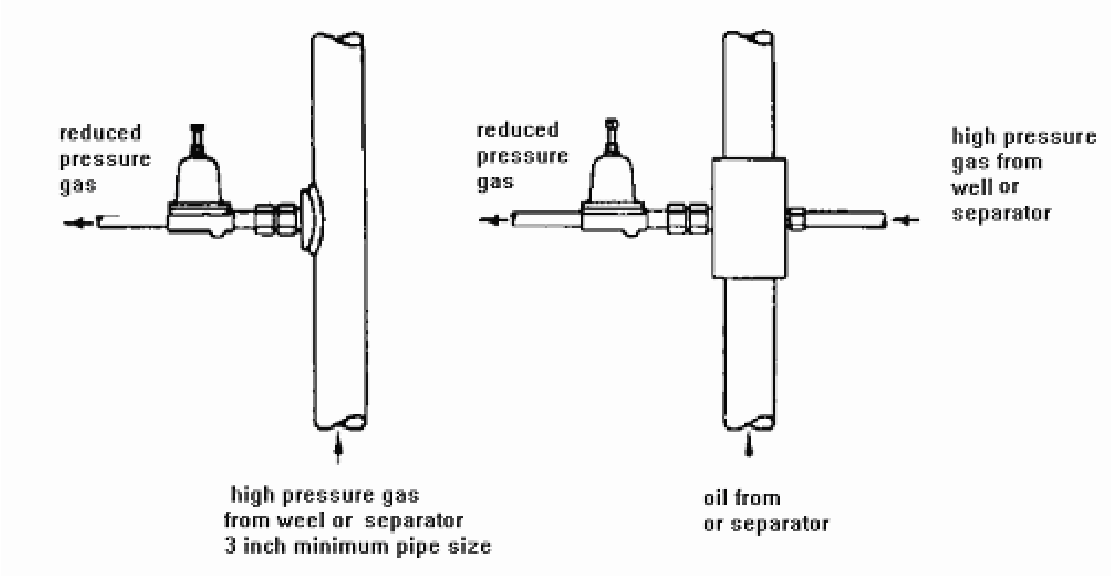
14.2.6 Regulator body size should never be larger than pipe size. In many cases, the regulator body shall be one size smaller than the pipe size.

14.2.7 The self-operated regulators generally have faster response to quick flow change than pilot-operated regulators.

14.3 Anti Freeze-Up Regulators

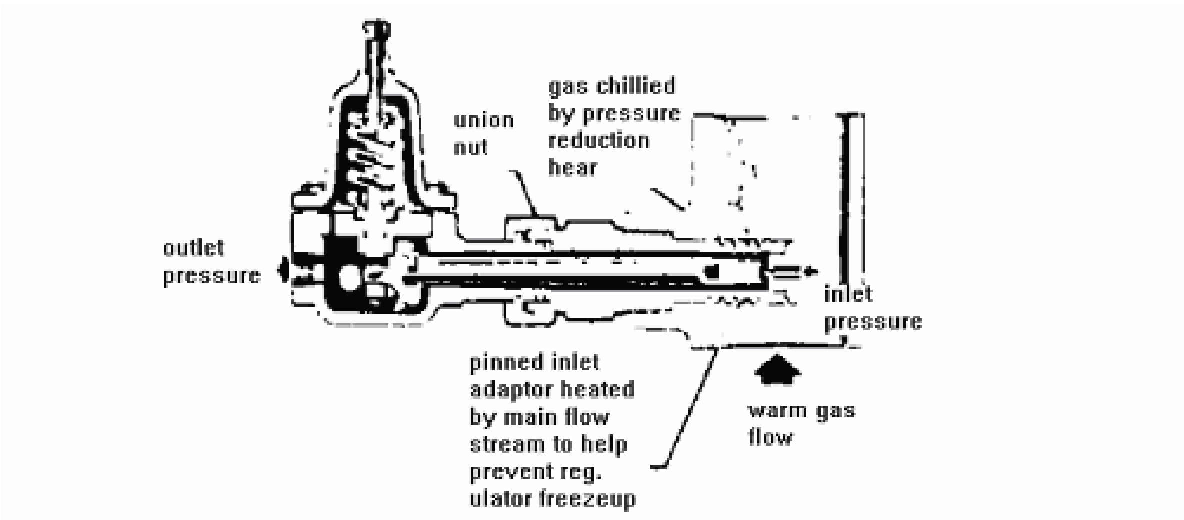
These regulators are self operated, pressure reducing regulators that resist hydrate formation and regulator freeze up. These regulators are suitable for service with natural gas, air, propane, and other gases compatible with the internal parts. They are used on high pressure lines from wellheads and separators.

Regulator freeze-up resistance occurs as the pipe line gas warms the finned inlet adaptor and the seat ring area. As the gas cools within the inlet adaptor due to pressure drop and volume expansion, the warm inlet adaptor helps keep the gas temperature above the freezing point of water and the hydrate formation temperature (see Figs. 25, 26, 27).



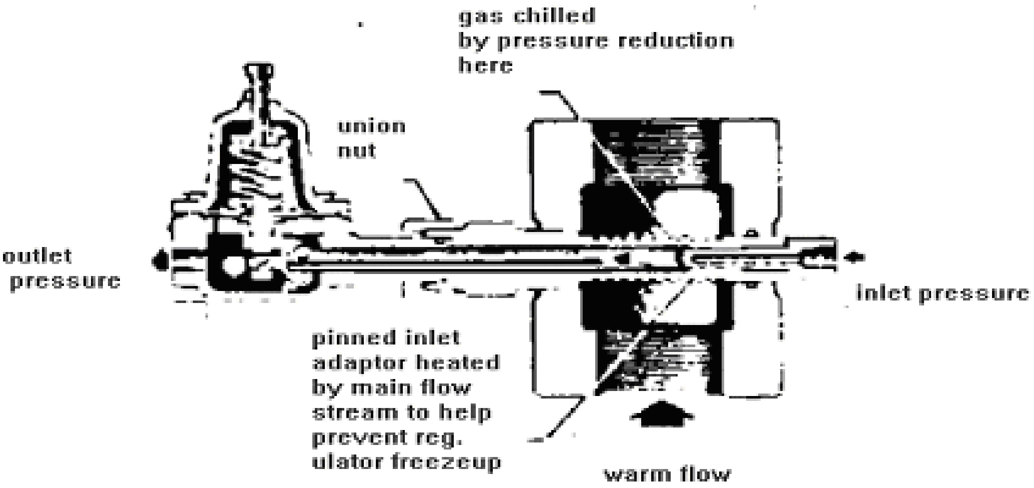
TYPICAL REGULATOR INSTALLATION

Fig. 25



TYPE 1 - REGULATOR

Fig. 26



TYPE 2 - REGULATOR

Fig. 27

14.4 Self-Actuated Temperature Regulators

14.4.1 For temperature applications, bellows with a filled system and bulb are used.

14.4.2 The tube system assembly consist of the sensitive bulb, capillary tubing and the bellows assembly, the indicating dial thermometer and the cap.

14.4.3 Self-operating temperature regulators are generally used on installations that require full pressure drop through the valve, the inlet pressure should not exceed the maximum allowable pressure drop.

14.4.4 The regulator should be suitable for installing in an accessible location on horizontal piping. Possible damage from moving parts, splashing of corrosive liquids, vibration, heat etc., should be considered in deciding the location.

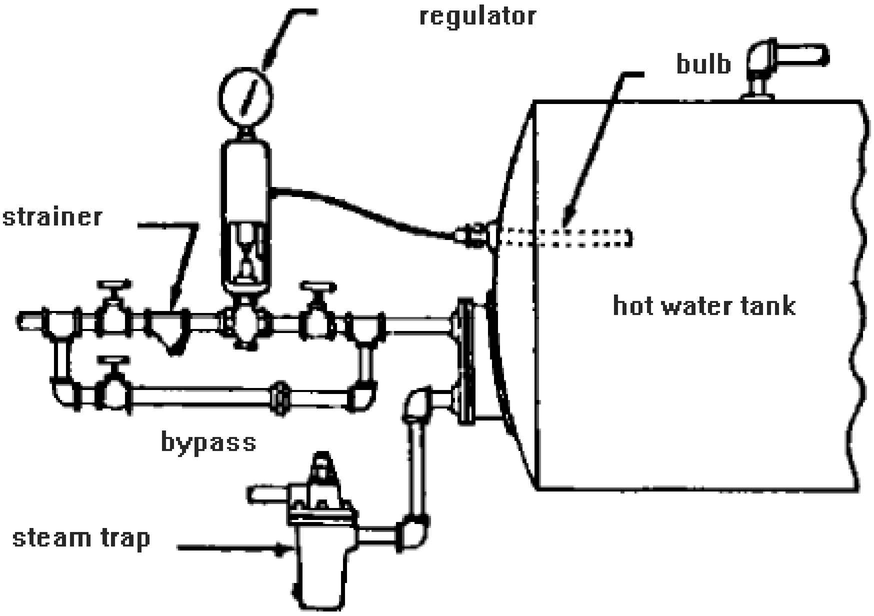
14.4.5 Similar consideration should also be given to the capillary tubing and bulb. The capillary tubing on high range instruments should be located where the temperature is cooler than the control point, as specified by manufacturer.

14.4.6 Self operating regulators are regularly furnished with sensitive temperature range unless otherwise specified. The most sensitive range span (approximately 10°C) may be changed to the corresponding wide span range (approx. 32°C) by replacing the sensitive range spring with the wide span range spring.

14.4.7 The maximum external pressure allowed on standard bulbs and sockets are 35 bar for copper or brass, and 70 bar for steel or stainless steel, or unless otherwise specified by data sheets.

14.4.8 Stainless steel trim valves are recommended on installation having pressure over 35 bar.

INSTALLATION OF TEMPERATURES REGULATOR IN STORAGE TYPE H.W. HEATER



TYPICAL APPLICATION OF SELF ACTUATED TEMPERATURE REGULATOR

Fig. 28

15. CONTROL VALVE ACCESSORIES

The most common types of pneumatic control valve accessories which may be supplied with the control valve are, Solenoid Valves, Convertors, Positioners, Booster Relays, Extension Bonnets, Handwheels, Air Filter regulator, Limit Switch and etc.

15.1 Positioners

15.1.1 Definition

A valve positioner is a device which precisely positions, the valve by comparing control signal with the valve stem position (feed back).

15.1.2 The valve positioner compares the valve stem position with the demand generated by the controller. If the valve stem is incorrectly positioned, the positioner either increases or decreases the air in the actuator until the correct valve stem position is obtained. The following is a list of seven functions a positioner can accomplish:

1) Provide for split-range operation.

2) Improve speed of response to accommodate large actuator volumes at the end of signal transmission lines.

3) Reverse the valve action without changing the "fail-safe" action of the spring in the actuator.

(Note that this may also be done with a reversing-type relay.)

4) Increase the thrust in spring diaphragm actuators for use in high pressure-drop applications, and allow the same linearity in the installed characteristic as in the "bench setting" characteristic.

5) Change the control valve flow characteristic (cam-type positioner).

6) Improve the resolution or sensitivity of the actuator where high-precision valve control is required. Precision is enhanced by the availability of positioners with various gains, and by the fact that modern packings generally have equal static and dynamic coefficients of friction which eliminate the stick/slip behavior.

In the past a positioner was thought to reduce control loop stability for fast acting loops. Modern positioners with volume or pressure boosters, where required, can be made faster than any actuator without a positioner.

7) Reduce hysteresis.

15.1.3 There are two categories of positioners.

a) Conventional mechanical or electro-pneumatic positioners (Figure 29) that receive their input setpoint from a pneumatic signal or from a DC analog signal. In older process units, it was standard practice for a mechanical positioner's pneumatic input set point to originate from an intermediate device between the Basic Process Control System and the positioner called a “current to pneumatic” transducer—commonly referred to as an I/P transducer. These are very rarely specified anymore with control valves. I/Ps were used to simply convert a DC analog signal (typically 4 mA to 20 mA) to a pneumatic signal (3 psig to 15 psig) that was the input to the conventional mechanical positioner.

b) Digital Valve Controllers (Figure 30) that receive their input setpoint as a DC analog signal or as a pure digital setpoint.

15.1.3.1 Conventional

a) Conventional positioners use a variety of mechanical parts to provide the position control function. Parts such as mechanical cams, springs, balance beams and bellows are commonly found in these assemblies.

b) Electromechanical positioners are conventional positioners that have an integrated electro-pneumatic transducer. The transducer receives the input signal via a DC analog signal and converts it to a proportional pneumatic signal which is then sent to the conventional positioner that performs the position function.

15.1.3.2 Digital valve controllers

a) Digital valve controllers use microprocessors and have become the dominant positioner technology since the mid 1990’s. Commonly referred to as “Smart” or “Digital” positioners, they integrate functionality far beyond the traditional analog or pneumatic positioner. The benefits of using a digital valve controller include availability of equipment alerts to notify the user of pending issues, and automated configuration, calibration and tuning. This provides the benefit of consistent and predictable performance regardless who performs the task.

b) Valve diagnostics have become an integral part of many digital valve controllers. Diagnostics are used to determine physical problems with the entire valve assembly. Most manufacturers offer some type of basic to advanced valve diagnostics functionality with their digital valve controller. The key difference between the level of diagnostics are the use of pressure sensors which monitor and record pneumatic signals from the instrument supply and actuator pressures.

Diagnostics on the control valve assembly can be performed while the valve is in control of the process and responding to the control system setpoint, or they may occur while the valve is shut down and blocked from the process. The information collected provides a direct indicator of the health of the control valve assembly. In many plants, valve diagnostic information is integrated with other equipment diagnostics as part of an overall preventive and predictive maintenance and reliability program. This allows longer running cycles and minimizing plant down time. Large operating units are now delegating this function to the “Reliability/Asset Engineers”.

c) There are a variety of digital communications protocols in use today by digital valve controllers. The most commonly used protocols in the process control industry are HART

(Highway Addressable Remote Transducer), Foundation Fieldbus, and Profibus.

CONVENTIONAL VALVE POSITIONER

Fig. 29

SMART VALVE POSITIONER

Fig. 30

15.1.4 Pneumatic control valves may be operated over only part of the controller output range. This can be accomplished by either changing or adjusting the input spring of the positioner. A common arrangement is to have one valve and positioner operate over 0.2 to 0.6 barg of the controller output, while another valve and positioner operates over 0.6-1 barg of the controller output (split range operation). In the above, it is only necessary to modify the positioner springs.

15.1.5 Valve positioners shall be provided with an integral pneumatic switch to bypass the positioner. The bypass may not be recommended where the valve will not operate without the positioner.

15.1.6 Valve positioners shall be supplied with the requisite number of pressure gages, the controller output pressure, positioner output pressure, and supply pressure to the positioner.

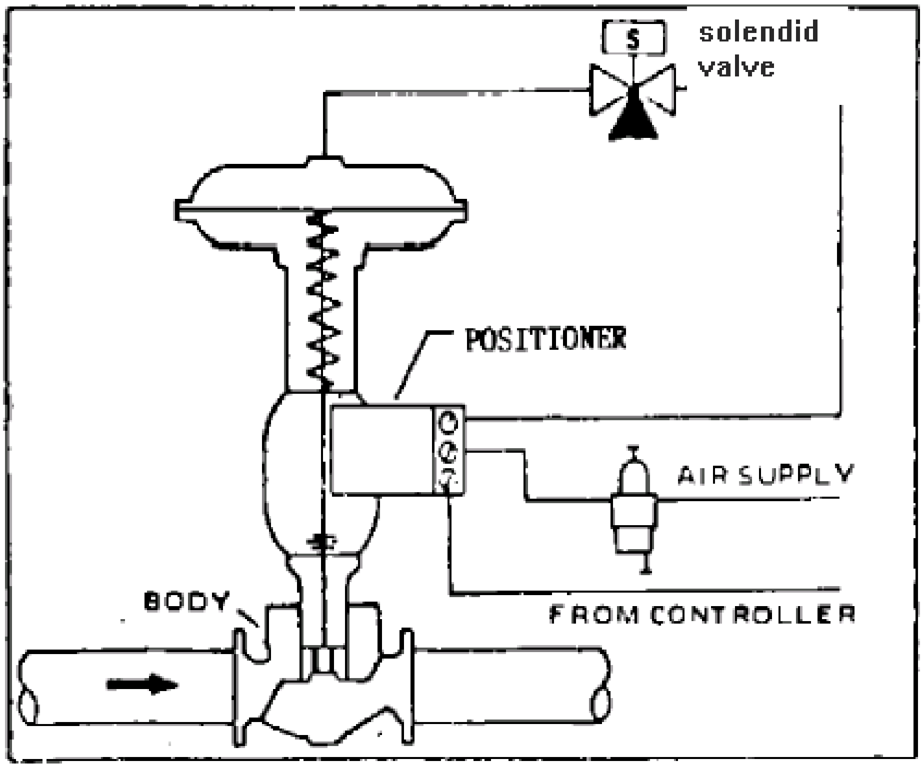
15.1.7 Piston actuator shall be provided with positioners to ensure that the control valve position is always proportional to the control signal. The positioner shall have a weather proof enclosure.

15.2 Solenoid Valves

Flow through an orifice is shut off or allowed by the movement of the core when the solenoid is energized or deenergized.

15.2.1 A common application of a solenoid valve to a diaphragm control valve is illustrated in Fig. 31. In an emergency the solenoid valve can be switched, causing the control valve to go to the safe position.

The solenoid valve is normally open and allows the positioner output to pass into the diaphragm case. Upon a power loss, the solenoid valve closes the port to the valve positioner and bleeds pressure from the diaphragm case of the control valve.



TYPICAL APPLICATION OF A SOLENOID VALVE

Fig. 31

15.2.2 Where solenoid valves are installed in control air supplies to pneumatically operated valves to seal-in diaphragm pressure, in the event of an electrical failure, the solenoid valves shall incorporate a time delay and hand reset to prevent operation resulting from transient interruptions of the electrical supply. The reset may be done by SIS system if specified in job specification.

For more information on solenoid valves, reference should be made to Section 16 of this Standard.

15.3 Convertors (Transducers)

15.3.1 Electro-Pneumatic transducers convert the electrical output signal from electronic controllers into pneumatic signal that may be used to operate diaphragm control valves.

15.3.2 Electro-Pneumatic convertors shall not be mounted on control valves. Sufficient capacity must be allowed in the pneumatic circuit to prevent interaction between convertors and valve positions. Where there is no possibility of local vibration ruining the valve positioner, consideration shall be given to the use of valve mounted electro-pneumatic valve positioner.

15.3.3 An I/P convertor operating a single valve shall be mounted such that the length of tubing between the convertor and valve does not exceed 3 meters. If a single I/P convertor is used to operate two or more valves, such as in split range service, the valves and convertor shall be mounted such that the total length of tubing from the convertor to the valves does not exceed 3 meters. Where this is not practical, a separate convertor shall be supplied for each valve.

15.3.4 Electro-Pneumatic convertor shall be explosion proof or intrinsically safe and suitable for Electrical area classification as indicated in data sheet.

15.3.5 Housing shall be IP 65 (IEC 60529) as minimum.

15.3.6 Reference accuracy shall be better than ±0.5% of full scale.

15.3.7 Input signals of: 4 - 20 mA d.c or unless otherwise specified.

15.3.8 Output signals: 0.2 - 1.0 bar, 0.4 - 2 bar, as required by data sheet.

15.3.9 Supply pressure: 1.4 bar (Recommended). 3.5 bar maximum.

The supply pressure medium must be clean, dry and filtered.

15.3.10 An air filter-regulator with an output pressure gage for the air supply to each convertor shall be provided. Filter-regulator shall be mounted on actuator.

15.3.11 Connection

The connection sizes shall be according to the job specification or data sheet.

15.3.12 Pressure gage

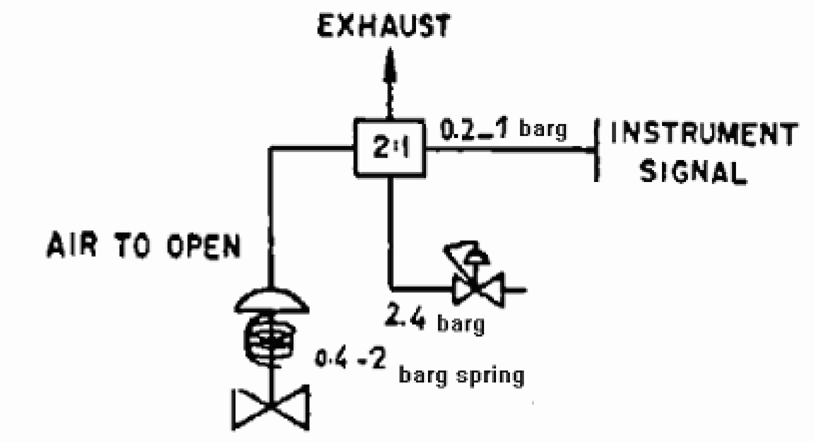
On filter regulator: 2½ inch diameter, dial with brass movement.

15.3.13 Construction material of housing and relay body shall be die cast aluminum, or as requested in data sheet.

15.3.14 Convertor may be integrated with positioner.

15.4 Booster Relays

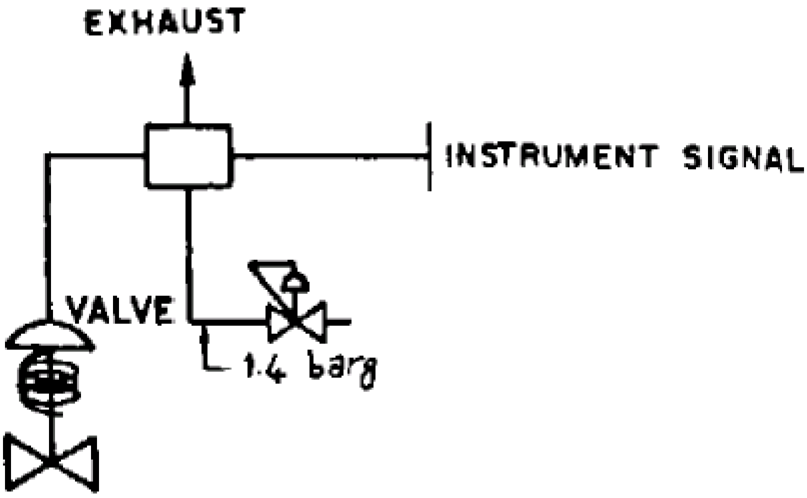
Booster relays may be used to increase the speed of response of the control valve and are especially useful when the valve is remotely located from the controller. The function of the pressure booster is to amplify the signal from the controller to above 1.4 barg in certain applications.



PRESSURE BOOSTER IN A CONTROL VALVE LOOP

Fig. 32

Volume boosters are used to increase the speed of response of the control valve. An application of a booster relay is that on modern positioners with volume or pressure boosters, where required, can be included in the control loop between positionor and actuator to reduce stroke time of a control valve.



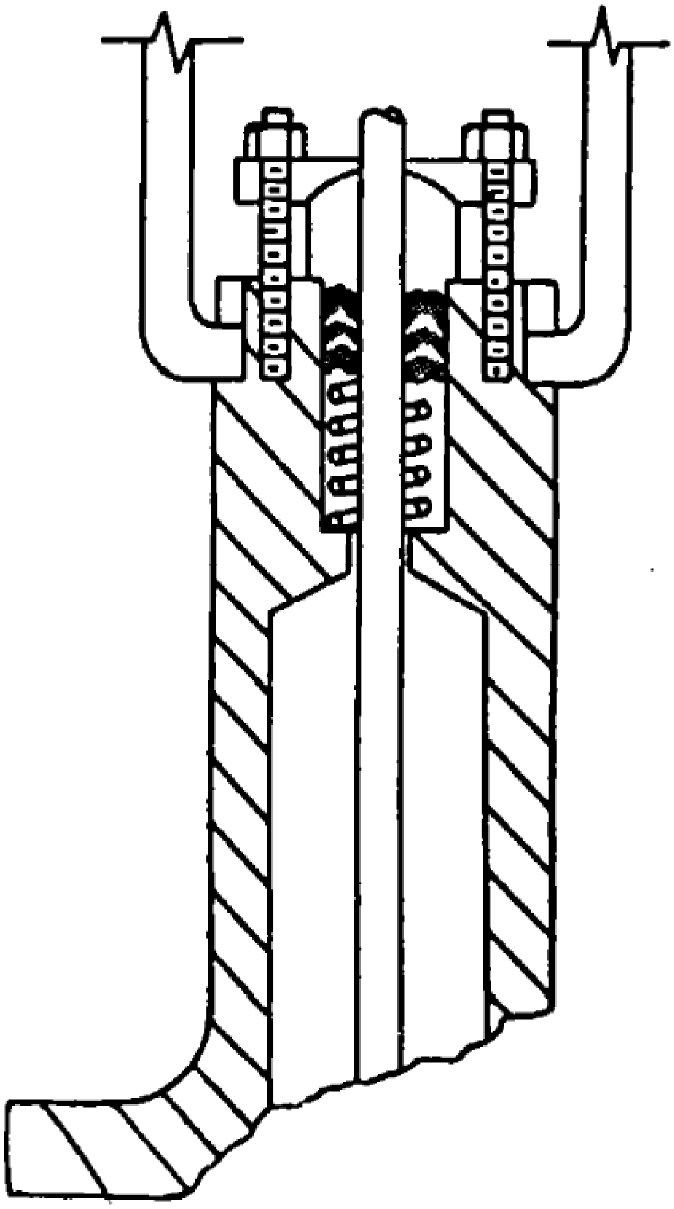
VOLUME BOOSTER IN A CONTROL VALVE LOOP

Fig. 33

15.5 Extension Bonnets

The standard control valve bonnet, with the packing area relatively near the bonnet flange connection, is usually limited to temperatures not exceeding 200°C. For higher temperatures an extension bonnet containing sufficient area to provide radiating heat loss may be used. In no case should such a bonnet be covered with thermal insulating material (Fig. 34).

A similar bonnet design is employed on low-temperature applications (0°C and below). This extension bonnet places the packing far enough away from the cold area of the valve to prevent freeze-up of the packing.



EXTENSION BONNET

Fig. 34

15.6 Handwheels

Manual handwheel operators should be supplied only on specific request by the owner, or where bypass facilities are not installed. Side-mounted, lockable, screw or gear drive manual operators, continuously connected and operable through an integral declutching mechanism, are preferred.

15.6.1 Handwheels can be supplied with most types of valves. They provide the operator with the means to override the control system and to operate the valve manually. Various designs are available, including those that can stroke the valve in either direction and those that stroke the valve in one direction, relying on the valve spring for the return stroke. Some handwheels are continuously connected. Others use a clutch, pin, or other means of engagement, and must be disengaged when not in use or damage may result.

15.6.2 Handwheels when specified, shall be mounted and designed to operate in the following manner.

a) For globe valves, handwheels shall be mounted on the yoke, arranged so that the valve stem can be jacked in either direction.

b) Neutral position shall be clearly indicated.

c) Handwheel operation shall not add friction to the actuator.

d) Clutch/Linkage mechanisms for handwheels on rotary valves shall be designed such that control of valve position is not lost when engaging the handwheel.

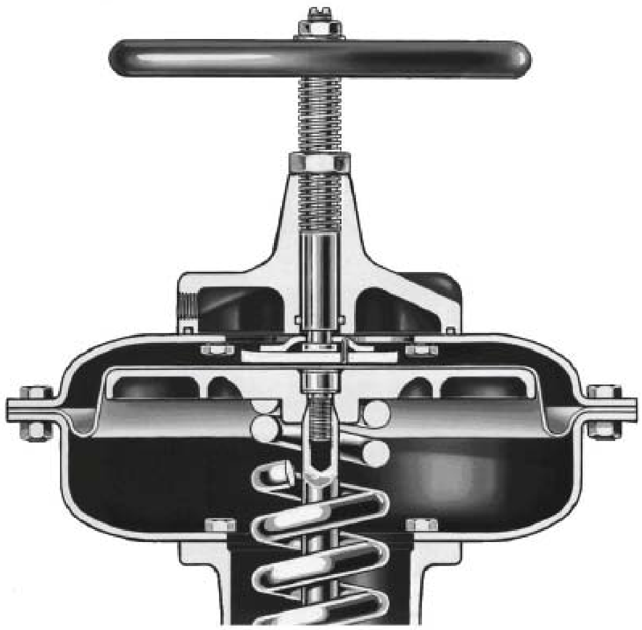
e) Handwheels shall not be used as a travel limit stop.

15.6.3 Top mounted handwheels shall be for the valves mounted relatively low elevations (Fig. 35).

15.6.4 Side mounted handwheels should be chosen for valves at higher elevations.

15.6.5 If necessary the side mounted handwheels may also be operated by a chain fall plus chains to release and rest the locking levers. The valve chains and handwheel on the piping should be oriented away from the fire hazardous location.

Both of these operators can be used to facilitate the start-up of a control system (i.e., to preposition a valve to a given flow). They can also be used as devices to shut off the valve, eliminating the need in some systems for costly bypass valve arrangements.



a) A TOP-MOUNTED HANDWHEEL **b) SIDE MOUNTED HANDWHEEL**

Fig. 35

15.6.6 Where specified the actuator shall be equipped with a permanently attached handwheel of the automatic declutching type that precludes mechanical engagement of the handwheel while the drive is in operation.

The declutching device shall:

a) Allow power-override of the handwheel operation at all times.

b) Permit manual handwheel operation of the valve in the event of a frozen or seized drive.

15.6.7 Handwheel drive shall permit the valve to be stroked open or closed in 15 minutes or less.

15.6.8 Handwheel clockwise rotation shall close the valve.

15.6.9 When a handwheel is used for a piston actuator, a cylinder bypass valve should be included.

15.6.10 When a control valve is equipped with a handwheel, the handwheel should be easily operable from normal personnel access paths or platforms. For ergonomic reasons, handwheels should face the operator access area, and the shaft center should be 1 m to 1.5 m above the elevation of the access area.

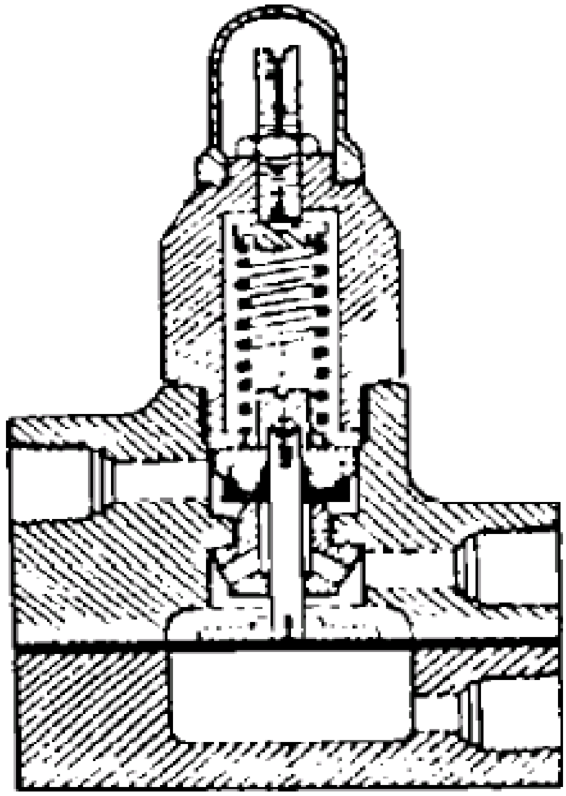
15.7 Air Locks

An air lock device is used for applications that require a control valve to hold its position in the event that the plant air supply pressure falls below a given level. One type is shown in Fig. 36. The plant air supply is fed into a chamber sealed by a spring-opposed diaphragm. In the event that the plant air decreases to a predetermined lower limit, the spring closes the connection to the actuator and locks the existing controller-signal pressure in the line connecting the valve operator.

15.7.1 If air locks are required, they should be installed as close to the valve actuator as possible, unless the control valve is also used in trip/dump applications. In a trip/dump application, the air lock should be installed such that the trip/dump valve moves to its failure state regardless of the air lock state**.**

15.7.2 The air supply for the air lock should be the same as for the valve positioner. The setpoint for the air lock needs to be set at a value above the minimum pressure required by the actuator for the application.

15.7.3 Control valves with an air lock feature should have a pressure gauge indicating actual diaphragm or piston pressure after the air lock.



AIR LOCK

Fig. 36

15.8 Pressure Sensing Trip Valves

15.8.1 Pressure-sensing trip valves are for control applications where a specific valve/actuator action is required when supply pressure falls below a specific point.

When supply pressure falls below the pressure trip point, the trip valve causes the actuator to fail in up position, lock in the last position, or fail in down position. When the supply pressure rises above the trip point, the trip valve automatically resets, allowing the system to return to normal operation.

15.8.2 The trip valve can be top-mounted on a manifold, yoke-mounted, or bracket-mounted to match the application requirements. Simplified sectional view of typical trip valve can be seen in Fig. 37.

15.8.3 Trip valve pressure connections

Read the following information before making pressure connections:

a) Trip valve port A must receive the operating pressure that is intended for the top of the actuator cylinder. Depending on the actuator type and accessories being used, this operating pressure will be from a valve positioner or switching solenoid.

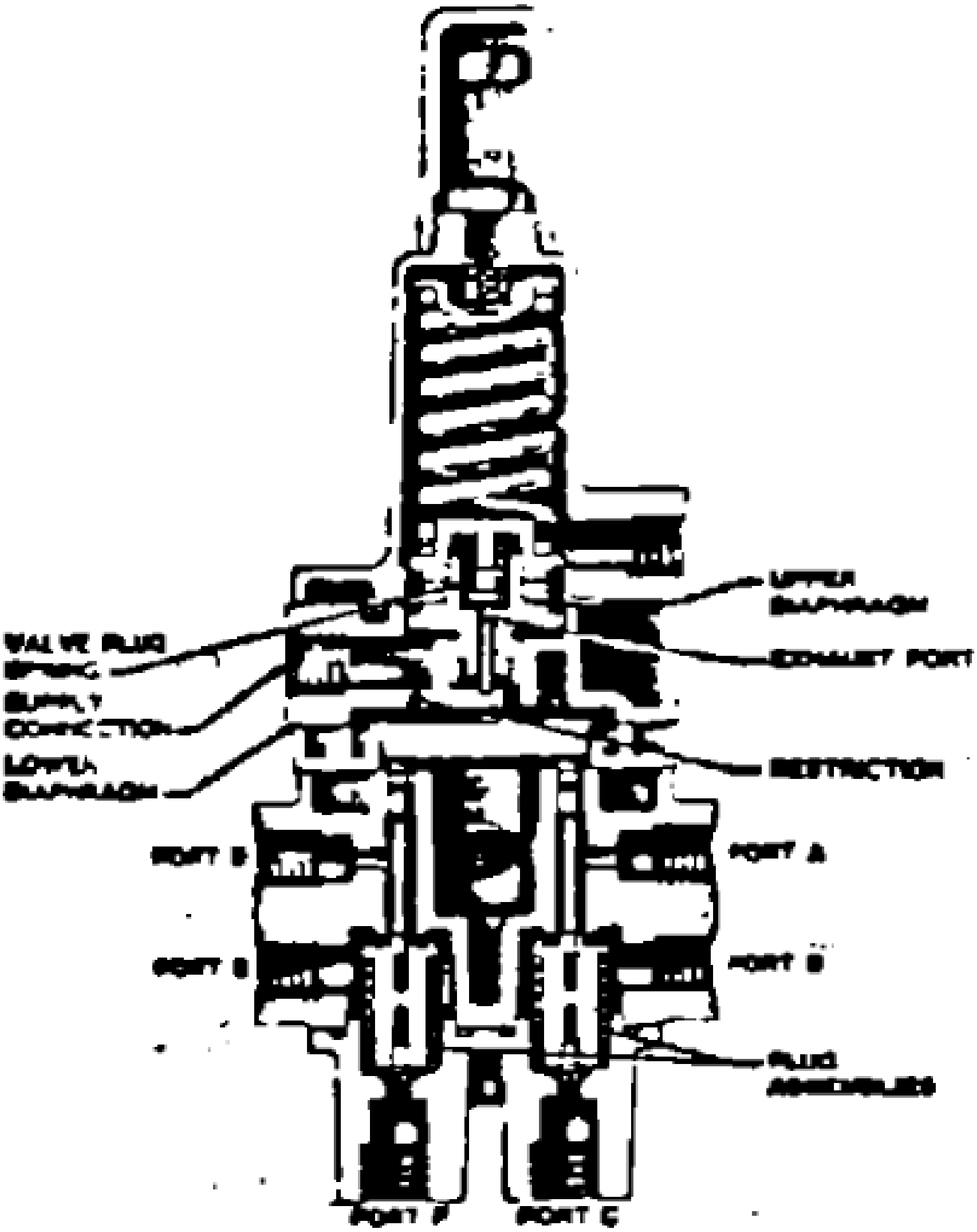
b) Trip valve port B must provide operating pressure to the top of the actuator cylinder. Depending on the actuator type and accessories being used, this port should be connected to the manifold assembly to the top of the cylinder, or to the cylinder connection on the hydraulic snubber (if one is used).

c) Trip valve port C must provide a fail-mode outlet for the operating pressure to or from the top of the actuator cylinder. For the fail-down mode, this port should be connected to the volume tank. For the fail-up mode, this port should vent to atmosphere. For the lock-in-last-position mode, this port should be plugged.

d) Trip valve port D must receive the operating pressure that is intended for the bottom of the actuator cylinder. Depending on the actuator type and accessories being used, this operating pressure will be from a valve positioner or switching solenoid.

e) Trip valve port E must provide operating pressure to the bottom of the actuator cylinder. This port should always be connected to the bottom of the actuator cylinder.

f) Trip valve port F must provide a fail-mode outlet for the operating pressure to or from the bottom of the actuator cylinder. For the fail-down mode, this port should vent to the atmosphere. For the fail-up mode, this port should be connected to the volume tank. For the lock-in-last-position mode, this port should be plugged.



SIMPLIFIED SECTIONAL VIEW OF TRIP VALVE

Fig. 37

16. SOLENOID VALVES

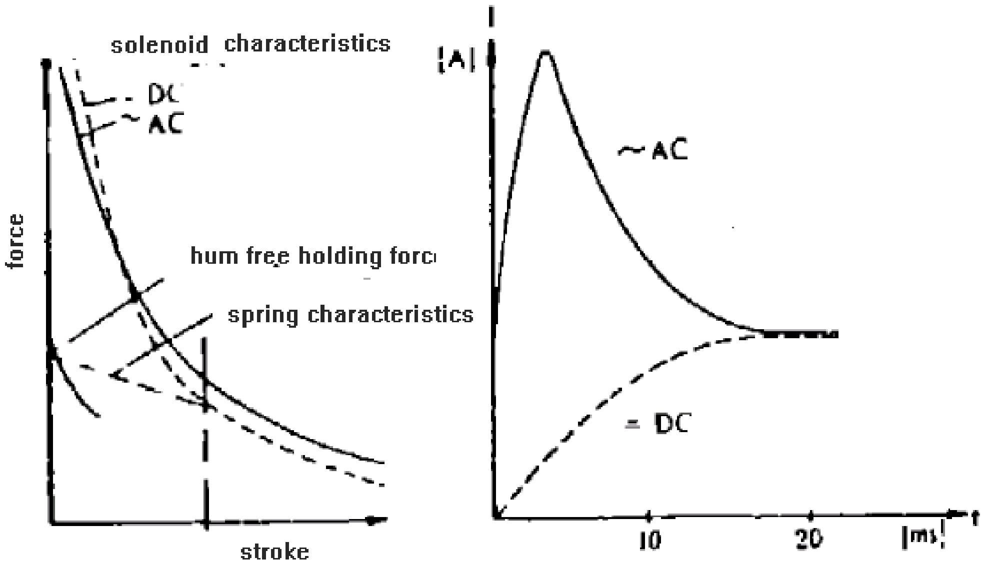
16.1 General

The solenoid valve is basically a valve operated by a build in actuator in a form of an electrical coil (or solenoid) and a plunger. The valve is thus opened and closed by an electrical signal,being returned to its original position (usually by a spring) when the signal is removed. Solenoid valves are produced in two modes, normally open or normally closed (referring to the state when the solenoid is not energized).

16.1.1 d.c. or a.c. solenoids

The d.c. solenoids are generally preferred to a.c. because d.c. operation is not subject to peak initial currents which can cause overheating and coil damage with frequent cycling or accidental spool seizure. A.c. solenoids are preferred, however, where fast response is required, or where relay-type electric controls are used. Response time with a.c. solenoid operated valves is of the order of 8 to 15 milliseconds, compared with the 30 to 40 milliseconds typical for d.c. solenoid operation.

There is an appreciable difference in the working characteristics of a solenoid supplied with d.c. and a.c. D.C. coils are slow in response time and can handle only low pressures. A.C. coils are quicker in response time and can handle higher pressures initially (see Fig. 38). They can thus be cycled at faster rates, if required. Electrical losses are higher, however, and proportional to a.c. frequency. (The power losses in a solenoid operated by a.c. of 60 Hz frequency, for example, is higher than that of the same coil on a 50 Hz supply).



FORCE/STROKE CHARACTERISTICS FOR A TYPICAL SOLENOID VALVE (LEFT); AND A TIME - BASED COMPARISON OF SOLENOID ENERGIZATION BY a.c. AND d.c. (RIGHT)
Fig. 38

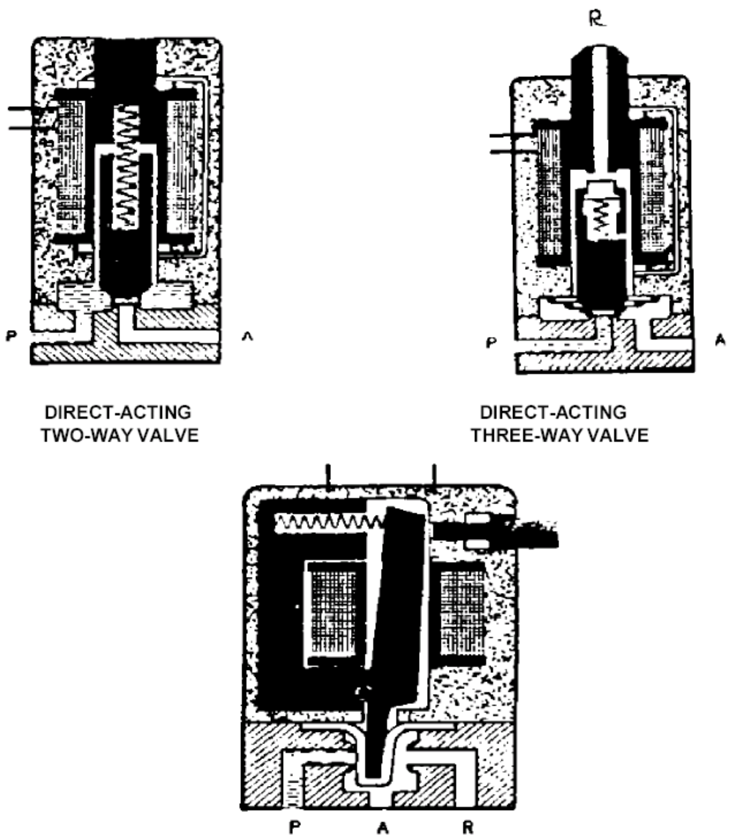
16.1.2 Return spring effect

With a two-way normally closed valve both the spring force and the fluid inlet pressure act to close the valve. As a consequence the return spring can be made relatively weak, and in some designs eliminated entirely. The latter would require mounting the valve so that the solenoid was vertical, return action being by gravity plus fluid pressure.

With a two-way normally-open valve the spring holds the valve open, assisted by fluid pressure. The solenoid force must be sufficient to overcome both spring pressure and inlet pressure to close the valve.

Three-way valves require an upper and a lower spring. The lower spring presses the valve against its seal opened by inlet pressure. The upper spring acts in a direction to force the valve open. The following are the combination of spring strengths required:

	LOWER SPRING	UPPER SPRING
Three-way normally-closed	Strong	Weak
Three-way normally-open	Weak	Strong
Mixer valve	Medium	Medium
Divider valve	Strong	Weak



PIVOTED-ARMATURE THREE-WAY VALVE

Fig. 39

P. Pressure point

A. Supply port

B. Second supply port

R. Exhaust port.

16.2 Special Types of Solenoid Valves

16.2.1 Pilot-Operated valves

In general, direct solenoid operation is restricted to smaller sizes of valves, i.e. up to about in bore size as a maximum. Larger solenoids needed for operating larger valves consume high levels of electricity and generate considerable heat. The pilot-operated valve offers a much more attractive proposition in such cases where a small solenoid is retained to operate a pilot valve, which in turn admits inlet pressure to an appropriate part of the valve to open the main valve. The pilot valve may be accommodated internally (internal pilot-operated) or externally (external pilot-operated).

For a pilot-operated valve to work there must be some differential pressure existing across the main valve for it to operate properly. It will then operate against higher pressures with low electrical input, with the pressure rating of the main valve the same as the pressure rating of the pilot valve, since both are subjected to the same line pressure. Pilot-operated valves have slower response time than direct-acting solenoid valves, although in many designs this is adjustable.

There is a further general class of solenoid-operated valve known as a semibalanced valve. This is a double sealed valve with two plugs mounted on a common stem. The lower plug is slightly smaller than the upper plug. Line pressure is introduced below the lower plug and above the upper plug, creating a differential pressure to hold the valve on its seals, assisted by a spring if necessary. The solenoid force required to open the valve is then only that due to the differential pressure (and the spring force, if present).

16.2.2 Solenoid-Operated hydraulic valves

Preference for the design of a solenoid-operated hydraulic valve is to use the solenoid for a ’push’ operation, utilizing spring action for ’pull’ motions. The solenoid must be powerful enough to override inertia and friction and also the spring and hydraulic forces. The latter may be extremely variable and not completely predictable, calling for a generous margin in the power of the solenoid and springs.

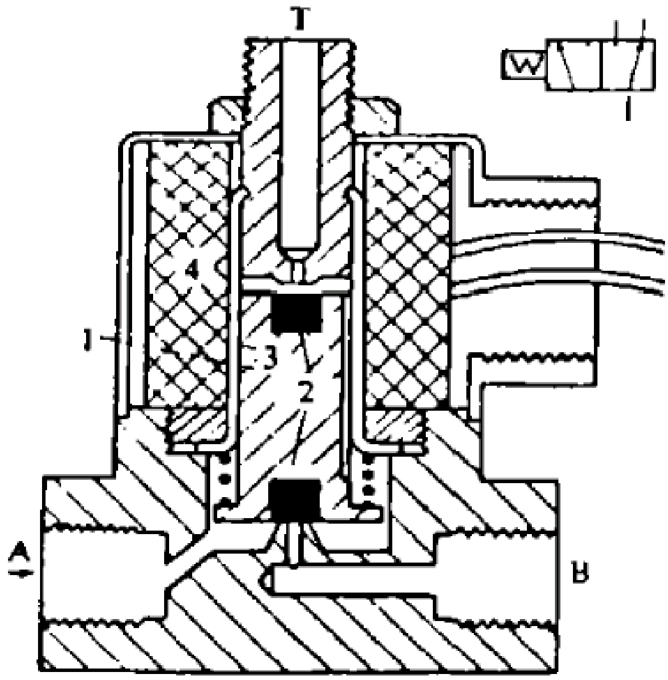
Solenoids may be of the ’dry’ or ’wet’ type. In general, ’wet’ solenoids can be smaller for the same duty because of their lower static and dynamic friction. They also have the advantage that all moving parts are enclosed and lubricated, and seals between the solenoid and valve body are eliminated. They are also described as glandless valves.

The size of directly operated solenoid valves is generally restricted to flow rates up to about 45 l/min - i.e., (1/8 in) and (¼ in) nominal valve sizes. Many of these valves can be switched directly from static systems, the outputs usually being 24 V d.c. and 20 to 65 W, depending on the system.

16.2.3 Glandless solenoid valves

By arranging the solenoid armature to work in a sealed tube with the solenoid coil enveloping it, the sealing glands can be dispensed with, so simplifying the construction and eliminating one possible point of leakage.

This principle has been applied extensively to the smaller valves. A typical type is shown in Fig. 27.



1. Plunger
2. Synthetic seats
3. Sleeve
4. Coil
A. Cylinder
B. Pressure
T. Exhaust

GLANDLESS SOLENOID VALVE
Fig. 40

Glandless valves can be installed in any position and will withstand appreciable shock loads. Response time is extremely short, 5 milliseconds on a.c. supply and 10 to 15 milliseconds on d.c. supply and it is said that speeds of up to several hundred cycles per minute are possible.

For hazardous atmospheres most manufacturers supply explosion-proof materials which are slightly heavier and bulkier than the standard type.

16.3 Solenoid Valves Characteristics

16.3.1 Valve body for solenoid valves shall follow the instrument piping specifications when used in process lines. Manufacturer’s standard bronze material shall normally be used on air service.

16.3.2 Valve body connection sizes shall be 1/8", 1/4", unless otherwise specified in data sheet.

16.3.3 Coils for solenoid valves shall be molded and encapsulated and specified continuous duty Class H insulation at rated voltage and frequency according to IEC-60085.

16.3.4 The solenoid itself may be operated by d.c. or a.c. supply. Electrical rating of standard voltages shall be 24 Volts a.c. or d.c., unless otherwise specified in data sheet.

16.3.5 Solenoid coil shall operate the valves by ±10% of voltage variation, unless otherwise specified in data sheet.

16.3.6 Three-Way and four-way packless solenoid valves which are direct acting and require no minimum operating pressure, may be installed on control valves. Both miniature and standard size solenoid valves are available along with both general purpose enclosure to protect from indirect splashing and dust, or explosion-proof and watertight enclosures. The requirement shall be specified by user in the relevant data sheet.

16.3.7 The enclosure shall be suitable for area classification as specified in data sheet. The weatherproof housing shall be min IP 65 and explosionproof housing shall be EEx-'d' gas group IIB, as per IEC 60079-1 recommendation.

16.3.8 Specification form for solenoid valves extracted from ISA, can be seen in Appendix A.

17. INSPECTION AND TESTS

17.1 When inspection is specified in the purchase order by purchaser, then inspection shall be in accordance with API standard 598. If inspection is not specified, control valves shall meet the requirements for visual examination described in API standard 598.

17.2 Each control valve shall be hydrostatically tested by the manufacturer and the certified test reports shall be provided confirming that the control valve have been tested in accordance with the test standard outlined in ANSI/ISA 75.19.01 test requirements.

17.3 The test requirement and the test procedure for obtaining the control valve various coefficients shall be in accordance with ANSI/ISA 75.02.01 (control valve capacity test procedure).

17.4 After testing, each valve shall be drained of test liquid, cleaned of any extra matter and suitably protected in preparation for storage and transportation.

18. LEAKAGE SPECIFICATIONS & CLASSES

18.1 Seat leakage is defined as the quantity of test fluid passing through an assembled valve in the closed position under the test conditions as defined.

18.2 The maximum allowable seat leakage as specified for each class shall not exceed the seat leakage in fig. 41 using the test procedure as defined in Section 5 of ANSI/FCI 70.2.

18.3 Leakage Classes

18.3.1 CLASS I. A modification of any Class II, III or IV valve where design intent is the same as the basic class, but by agreement between user and supplier, no test is required.

18.3.2 CLASS II. This class establishes the maximum permissible leakage generally associated with commercial double-seat control valves or balanced single-seat control valves with a piston ring seal and metal-to-metal seats. Use test procedure Type A.

18.3.3 CLASS III. This class establishes the maximum permissible leakage generally associated with Class II (18.3.2), but with a higher degree of seat and seal tightness. Use test procedure Type A. **18.3.4** CLASS IV. This class establishes the maximum permissible leakage generally associated with commercial unbalanced single-seat control valves and balanced single-seat control valves with extra tight piston rings or other sealing means and metal-to-metal seats. Use test procedure Type A.**18.3.5** CLASS V. This class is usually specified for critical applications where the control valve may be required to be closed, without a blocking valve, for long periods of time with high differential pressure across the seating surfaces. It requires special manufacturing, assembly and testing techniques. This class is generally associated with metal seat, unbalanced single-seat control valves or balanced single-seat designs with exceptional seat and seal tightness. Use test procedure Type B using water at the maximum operating differential.

18.3.6 CLASS VI. This class establishes the maximum permissible seat leakage generally associated with resilient seating control valves either unbalanced or balanced single-seat with "O" rings or similar gapless seals. Use test procedure Type C.

Leakage Class	Maximum Seat Leakage
Class I (See 18.3.1)	See Paragraph 18.3.1
Class II (See 18.3.2)	0.5% of rated valve capacity
Class III (See 18.3.3)	0.1% of rated valve capacity
Class IV (See 18.3.4)	0.01% of rated valve capacity
Class V (See 18.3.5)	5 x 10^{-4} ml per minute of water per inch of seat diameter per psi differential
	5 x 10^{-12} m^3 per second of water per mm of seat diameter per bar differential
	4.7 standard ml per minute of air per inch of orifice diameter
	11.1 x 10^{-6}standard m^3 per hour of air per mm of orifice diameter
Class VI (See 18.3.6)	Leakage per Paragraph 5.4.4 as expressed in ml per minute versus seat diameter

VALVE LEAKAGE RATES

Fig. 41

18.4 For tight shutoff applications, the leakage class should be at least Class V.

18.5 When better than Class V leakage is specified, composition (soft) seats may be considered as long as the valve seat materials can conform to the process design pressure and temperature, and the chemistry of the process. Composition seats are usually limited to process temperatures below 230 °C (450 °F) due to the fact that most elastomer materials begin to cold flow at this temperature. Steaming through a valve can damage or ruin a composition seat if the component pressure or temperature limitations are exceeded.

18.6 Double-ported valves and 3-way valves are limited to a Class II shutoff.

18.7 Single-seated unbalanced globe valves with metal-to-metal seating surfaces meet Class IV. Class V shutoff can be achieved by providing improved plug to seat ring concentricity or lapping seating surfaces and/or increasing actuator thrust. Resilient seats on single seated valves can provide Class VI shutoff.

19. HYDROSTATIC TESTING OF CONTROL VALVES

19.1 Control valves having bodies, bonnets, cover plates and bottom flanges made of carbon steel, low alloy and high alloy (stainless) steel, nickel-base alloy, cast Iron and ductile Iron shall be hydrostatically tested as per recognized standard ANSI/ISA 75.19.01.

19.2 Pressure measuring instruments used in testing shall be of the indicating or recording type.

19.3 It is recommended that gages and recording instruments have a range of approximately double of the test pressure.

20. PRESSURE TEST REQUIREMENTS FOR BUTTERFLY VALVES

20.1 All Butterfly Valves, completely assembled, shall be pressure tested by the manufacturer before dispatch, and in accordance with the recognized standard such as BS EN 593.

20.2 Testing shall be carried out before valves are painted or otherwise externally coated with materials that are capable of sealing against leakage. Internal linings and external non-pressure sealing anticorrosion treatments shall be permitted for the purposes of testing.

20.3 No valve undergoing pressure testing shall be subject to shock loading.

20.4 Valves and connections shall be purged of air prior to pressure testing.

20.5 The test fluid for all pressure tests shall be either water with the addition of a suitable inhibitor, or another liquid whose viscosity at ambient temperature is equal to or less than that of water.

Note:

Attention is drawn to the need to control the chloride content of test water in contact with austenitic stainless steel components.

20.6 Test pressures shall be determined by the following relationships:

a) Shell test: 1.5 × maximum permissible, working pressure at 20°C.

b) Disk strength test (applicable to valves 14 inches and larger): 1.5 × maximum permissible working pressure at 20°C.

c) Seat test: 1.1 × maximum permissible working pressure at 20°C.

20.7 Test procedures for shell, Disk and seat of Butterfly valves shall be in accordance with the recognized standard such as BS EN 593.

20.8 Test durations for Butterfly valves shall be conducted as per BS EN593 and BS EN12266-1.

21. SOLENOID VALVES TEST REQUIREMENT

21.1 Solenoid valves shall be tested by the manufacturers before dispatch according to UL1203 specification and approvals or other recognized testing organizations.

21.2 Test approvals by third party is only necessary for equipment used in hazardous areas, which should be certified in accordance to any approved bodies such as BASEEFA, UL, FM, PTB etc. In this regard IPS-E-EL-110 shall be followed.

21.3 Solenoid valves are used in hazardous areas shall meet the electrical area classification requirements.

22. MARKING

22.1 Nameplate

The nameplate should be 316 stainless steel and 70 × 50 mm and should be marked with the following information as minimum:

a) Tag No.

b) Body material

c) Trim material

d) Body/ port sizes

e) Actuator air to open/close

f) Actuator operating pressure/electrical ratings

g) Manufacturers name and model No. and serial No.

h) Pressure rating/class

i) Maximum differential pressure

j) A tag, indicating type of packing and lubricant

k) The arrow indicating direction of valve flow on the body.

l) Bench set pressure

m) Valve characteristics

n) CV

23. DOCUMENTATION/LITERATURE

23.1 At Quotation Stage

Suppliers are to provide the following documents in the numbers requested at the time of quotation:

a) Comprehensive descriptive literature.

b) List of recommended commissioning spare parts with prices.

c) Details of any special tools required with prices.

d) All calculation such as CV, noise, and etc.

23.2 At Ordering Stage

Suppliers are to provide the following in quantities and at times as detailed on the order:

a) List of recommended spare parts for two years continuous operation.

b) Illustrated comprehensive spare parts manual with part numbers suitable for warehouse stocking.

c) Illustrated installation and operating instructions.

d) Maintenance manuals.

If the end user requires more specific vendor documentation, the following other technical documents are available from the valve manufacturer, if specifically requested in the purchase requisition:

a) Valve signature curves;

b) Certified Material Test Reports (CMTRs);

c) Positive Material Identification (PMI) record;

d) Certificate of Conformance – NACE (either MR1075 or MR0103);

e) X-ray examination;

f) Magnetic particle or liquid penetrant testing.

Notes:

The above shall include identification of all proprietary items. All drawings and literature shall be in the English language and show all dimensions, capacities, etc., in metric (SI) units. The order number must be prominently shown on all documents.

Drawings are to be properly protected and packed.

24. GUARANTEE

24.1 The manufacturers shall guarantee equipment performance as specified for a warranty period of 18 months from delivery or 12 months after installation, whichever comes first. Manufacturers shall also guarantee all equipment furnished against defects in design, materials, and workmanship and will bear the entire cost of correcting such defects which would develop during the specified warranty period.

24.2 The manufacturers/suppliers shall guarantee the supply of min. 10 years spare parts for the quoted equipment.

APPENDICES

APPENDIX A

TYPICAL SPECIFICATION FORMS FOR PROCESS MEASUREMENT AND CONTROL INSTRUMENTS

1) Specification forms for control valves.

2) Specification forms for pressure control valves pilots and regulators.

3) Specification forms for self-actuated temperature regulators.

4) Specification forms for solenoid valves.

5) Specification forms for electro hydraulic valves.

SPECIFICATION FORM FOR CONTROL VALVES

	PROJECT UNIT P.O. ITEM CONTRACT MFR SERIAL	DATA SHEET OF SPEC TAG DWG SERVICE

No.								
1		Fluid				Crit Pres PC		
	SERVICE CONDITIONS		Units	Max Flow	Norm Flow	Min Flow	Shut-Off	
2		Flow Rate					__	
3		Inlet Pressure						
4		Outlet Pressure						
5		Inlet Temperature						
6		Spec Wt/ Spec Grav/Mol Wt					__	
7		Viscosity/Spec Heats Ratio					__	
8		Vapor Ptessure P_V					__	
9		*Required C_V					__	
10		*Travel	%				0	
11		Allowable/*Predicted SPL	dBA	/	/	/	__	
12								

No.	Section	Item	No.	Section	Item
13	LINE	Pipe Line Size In	53	ACTUATOR	*Type
14		& Schedule Out	54		*Mfr & Model
15		Pipe Line Insulation	55		*Size Eff Area
16	VALVE BODY / BONNET	*Type	56		On/Off Modulating
17		*Size ANSI Class	57		Spring Action Open/Close
18		Max Press/Temp	58		*Max Allowable Pressure
19		*Mfr & Model	59		*Min Required Pressure
20		*Body/Bonnet Matl	60		Available Air Supply Pressure:
21		*Line Material/ID	61		Max Min
22		End In	62		*Bench Range /
23		Connection Out	63		Act Orientation
24		Flg Face Finish	64		Handwheel Type
25		End Ext/Matl	65		Air Failure Valve Set at
26		*Flow Direction	66		
27		*Type of Bonnet	67		Input Signal
28		Lub & Iso Valve Lube			
29		*Packing Material	68	POSITIONER	Type
30		* Packing Type	69		Mfr & Model
31			70		*On Incr Signal Output Incr/Decr
32	TRIM	*Type	71		Gauges By-Pass
33		*Size Rated Travel	72		*Cam Characteristic
34		*Characteristic	73		
35		*Balanced/Unbalanced	74	SWITCHES	Type Quantity
36		*Rated C_V F_L X_T	75		*Mfr & Model
37		*Plug/Ball/Disk Material	76		Contacts/Rating
38		*Seat Material	77		Actuation Points
39		*Cage/Guide Material	78		
40		*Stem Material	79	AIR SET	*Mfr & Model
41			80		*Set Pressure
42			81		Filter Gauge
43	SPECIALS / ACCESSORIES	Class Group Div	82		
44			83	TESTS	*Hydro Pressure
45			84		ANSI/FCI Leakage Class
46			85		
47			86		
48					
49					
50					
51		* Information supplied by manufacturer unless already specified.			
52					

Rev	Date	Revision	Org	App

EXPLANATION OF TERMS AND DEFINITION OF CONTROL VALVES

Line	Explanation of Terms and Definitions	Examples
PROJECT	Specify project name for which control valve is intended	
UNIT	Specify unit within project	SI
P.O.	Specify purchase order number from purchaser to control valve manufacturer	P.O. 12345
ITEM	Specify item number of purchase order	3
CONTRACT	Specify contract number of project for purchaser's reference	56-V-32510
MFR SERIAL	This line may show the valve manufacturer's serial number(s) and is normally filled in at the time of shipment of the valve. Serial numbers often continue the manufacturer's shop order number	CI2650-3
DATA SHEET	Specify data sheet number. Normally assigned by purchaser	3 of 12
SPEC	Specify number of technical specification on which valve selection is based	FL-13265-A
TAG	Specify tag number, if any, used to designate location of valve	FV-103
DWG	Specify piping and instrumentation diagram number. Loop diagram number, engineering flow diagram number, etc.	17-453
SERVICE	Describe service of control valve and/or pipe line number	Feedwater control Reheat spray 2^{o}MA 1051 WA7

NOTE: The above lines are suggested only and may be modified to fit the individual company's needs. If the provided space is insufficient, add an additional sheet and refer to it.

EXPLANATION OF TERMS AND DEFINITION OF CONTROL VALVES

Line	Explanation of Terms and Definitions	Examples
TAG	Specify tag number, if any,used to designate location of valve	FV-103
1	Describe fluid flowing into valve and its State. Indicate corrosive or erosive service and the corrosive or erosive agents. Specify thermodynamic critical pressure of the fluid.	Superheated stream Saturated water Crude oil and natural gas 21800 kpa abs
2	Specify volumetric or mass flow rate at inlet or standard conditions. Maximum flow condition, if greater than normal flow condition, is the condition for which the valve is sized.	600 std. m^3/s 7500 scfm 300 kg/h
3	Specify inlet pressure (gauge or absolute).	2000 kPa abs.
4	Specify outlet pressure (gauge or absolute).	400 kPa gauge
5	Specify inlet temperature in ^{0}C or K. Must agree with state of fluid and its inlet pressure.	200° C 815 K
6	Specify specific weight (kg/rn^3), specific gravity, or molecular weight of fluid. Identify the appropriate term.	1.03 kg/m^3 44.01
7	Specify viscosity in appropriate units for liquids or specific heats ratio for gases.	**7** 20 centipoise 17.8 centistokes 1.27
8	Specify vapor (saturation) pressure at inlet temperature in absolute units. Only required for liquid flow.	4700 kpa abs.
9	Specify required C_V as calculated for each condition per ANSI/ISA 75.01. No additional safety (oversize) factor should be included at this point.	260
10	Specify travel of the valve in percent of rated travel calculated from required C_V rated C_V of the valve, trim selected, and characteristic (see lines 33, 34, and 36). 0% is full closed, 100% is full open.	78%
11	Specify laboratory-measured allowable and predicted sound pressure levels, both normally in dBA.	90/87 dBA

Line No.	Explanation of Terms and Definitions	Examples
1 2	Extra line for information not covered in lines 1 through 11.	Compressibility factor Z Ambient temperature Base Pressure and temperature
13 & 14	Specify size and schedule (or wall thickness if nonstandard) of pipe line into which valve is installed.	8" SCH 40 15" OD × 13 mm" wall DN200, PN100
1 5	Specify pipe line insulation. This information is required for predicted sound pressure level calculations.	50 mm thermal None
1 6	Specify type of valve body.	Globe (through, angle) Split body Double port, Butterfly Ball, pinch
17	Specify nominal size of valve body. Specify ANSI class in accordance with ASME B16.34.	4" 600 2500 SPECIAL
18	Specify maximum pressure and temperature of the valve.	13600 KPA,345$^{\upsilon}$c
19	Specify manufacturer and model number.	XYZ Controls Model 7 19-2
20 material.	Specify body and bonnet	Steel, ASTM A216, WCB
21	Specify body liner material, if any, and its inside diameter.	Polyurethane, 100mm”
22 & 23	Specify end connection. May be integral or welded onto body.	6" RTJ Class 1500 flange Buttweld end
24	Specify flange face finish per ASME B16.5 or special finish as required.	ASME B16.5 Special finish: 32 RMS
25	Specify end extensions, if any. Normally. refers to sections of pipe or reducers welded to the body by the valve manufacturer.	150mm long, SCH 80, A106, GR. B

EXPLANATION OF TERMS AND DEFINITION OF CONTROL VALVES

Line No.	Explanation of Terms and Definitions	Examples
26	Specify direction of the flow through the body. FTO flow-to-open, FTC flow-to-close valve. NOTE: Thedescriptor “FTO” and “FTC” refer to the direction of fluid forces on the closure member.If immaterial, leave blank. When FTO and FTC are not applicable, specify direction as appropriate.	FTO FTC
27	Specify type of bonnet.	Standard Cooling fin Extended
28	Specify whether a lubricator and isolation valve are required.Specify lubricant.	Yes Silicone
29	Specify packing material.	Graphite impreg. asbestos TPE Non-asbestos
30	Specify type of packing.	Braided Molded V-ring Laminated filament Pressure/Vacuum
31	Extra line for special body or bonnet not covered in lines 16 through 30.	Body drain Separable flanges Flangeless
32	Specify type of trim.	Single seat cage guided Multi-stage Multi-hole Top-and bottom-guided Double seat
33	Specify nominal size and travel of installed trim.	50 mm
34	Specify inherent flow characteristic of installed trim.	Linear Equal % Modified parabolic Quick-opening
35	Specify whether trim is balanced or unbalanced. Semi-balanced trim should be considered as balanced	Balanced Unbalanced
36	Specify rated C_V, F_L and X_T of installed trim. Refer to ANSI/ISA 75.01.	260 0.9 0.68
37	Specify closure member, i.e., plug, ball, or disk material as applicable.	17-4 PH, H-1150 316
38	Specify seat material.	420 hardened 316 hardfaced
39	Specify cage, bearing, or guide material.	410 hardened
40	Specify stem material.	17-4 PH, H-1150 316
41 &42	Extra lines for additional trim requirements not covered in lines 32 through 40.	Chrome-plate Pilot- operated
43	Specify hazardous location classification per the *National Electrical Code®,* ANSI /NFPA 70.	NEC® Class I, ANSI / NFPA Zones
44—52	Specify special requirements and/or accessories not covered else where.	Solenoid valves E/P transducer NACE MR-0175 Seismic Net weight=125 kg
53	Specify type of actuator. Diaphragm, pneu-	Diaphragm, pneu-matic Hydr. Piston double-acting Pneumatic rotary vane
54	Specify manufacturer and model number.	XYZ Control P-100-160
55	Specify nominal size and effective diaphragm! piston area.	8" 160 square inch 0.2 m^2
56	Specify whether actuator is for on/ off or modulating service.	Modulating On/ off
57	Specify whether spring! if any, acts to open or to close valve.	Open Close None
58	Specify maximum pressure for which the.actuator is designed.	600 kpa

EXPLANATION OF TERMS AND DEFINITION

Line No.	Explanation of Terms and Definitions	Examples
59	Specify minimum pressure required to fully stroke the installed valve under specified conditions.	440 kpa
60&61	Specify limits of available air or hydraulic supply pressure. If upper limit is greater than line 58, a reducing valve (air set) should be furnished. Lower limit or reducing valve setting must be higher than pressure shown on line 59.	600 kpa/470 kpa
62	Specify the pressures in the actuator when valve starts travel and at its rated travel position without fluid forces acting on the valve.	120/210 kpa
63	Specify orientation of actuator as “VERT.UP” or “VERT.DOWN” (vertical) or”HORIZ.”(horizontal). For rotary valves, also specify whether mounting is “RH" (right-hand) or “LH” (left-hand) as viewed from valve inlet,if appropriate. Specify additionalinformation as appropriate orprovide sketch.	VERT.UP HORIZ. RH LH
64	Specify type and orientation of handwheel (manual override), if any.	Top-mounted Side-mounted/ LH
65	Specify if air failure valve (actuator air lock-up valve) is required and at what supply pressure it shuts.	Yes 240 kpa
66	Extra line for additional actuator requirements not covered in lir	Hydraulic damper Stroking speed 25 mm/sec.
67	Specify input signal range for full travel.	3—IS psig 20—100 kPa 4-20 mA
68	Specify type of positioner.	None Single acting Double acting

Line No.	Explanation of Terms and Definitions	Examples
69 r.	Specify manufacturer and model	XYZ Control Co. Model AB
70	Specify whether an increasing signal increases or decreases output pressure to actuator.	Incr. Decr.
71	Specify whether air pressure gauges and positioner are required.	Yes No
72	Specify cam characteristic, if posi- Linear tioner has a cam. Normally linear.	Linear Square root
73	Extra line for positioner requirements.	Aluminum-free
74	Specify type and quantity of limit switches.	Mech.(lever arm) Proximity Pneumatic2
75	Specify manufacturer and model number.	ABC Electric Co. Model A20Z
76	Specify electrical rating and number of contacts and action.	10A, 600 VAC/ DPDT
77	Specify valve travel at which switches are to actuate.	Full open/ full closed
78	Extra line for additional limit switch requirements not covered in lines 74 through 77.	NEMA 4 IP65
79	Specify manufacturer and model number of air set (pressure regulator).	RBJ Co. Model R-70
80	Specify output pressure setting.	470 kpa 130 kpa
81	Specify whether filter and/or output pressure gauge is required.	Yes No
82	Extra line for additional air set requirements not covered in lines 79 through 81.	Mount separate form valve
83	Specify pressure of hydrostatic test. Normally per ANSI/ISA 75.19.01	2278 kpa
84	Specify leakage class per ANSI/ FCI 70.2.	Class IV
85 & 86	Extra lines for additional test requirements not covered in lines 83 and 84.	Hydro for 30 minutes Helium leak test Stroking time test Dead band test

PRESSURE CONTROL VALVES-PILOTS AND REGULATORS

	PRESSURE CONTROL VALVES PILOTS and REGULATORS				SHEET 1 OF 1		
					DATA SHEET. NO.		REV.
	NO	BY	DATE	REVISION			
					JOB NO.		DATE
PROJECT TITLE :					REQ.	P.O.	
					BY	CHK'D	APPR.
REF. STD. : IPS - G - IN - 160 (0)							

GENERAL	1.	Tag No.									
	2.	Service									
	3.	Line No./Vessel No.									
	4.	Line Size/Sched.No.									
	5.	Function									
BODY	6.	Type of Body									
	7.	Body Size	Port Size								
	8.	Guiding	No.of Ports								
	9.	End Conn. & Rating									
	10.	Body Material									
	11.	Packing Material									
	12.	Lubricator	Iso.Valve								
	13.	Seal Type									
	14.	Trim Form									
	15.	Trim Material									
	16.	Seat Material									
	17.	Required Seat Tightness									
	18.	Max Allow Sound Level dBA									
ACTUATOR/ PILOT	19.	Type of Actuator									
	20.	Pilot									
	21.	Supply to Pilot									
	22.	Self Cont.	Ext.Conn.								
	23.	Diaphragm Material									
	24.	Diaphragm Rating									
	25.	Spring Range									
	26.	Set Point									
	27.										
ACCESS.	28.	Filt.Reg.	Supply Gage								
	29.	Line Strainer									
	30.	Housing Vent									
	31.	Internal Relief									
	32.										
	33.										

(to be continued)

PRESSURE CONTROL VALVES-PILOTS AND REGULATORS (continued)

SERVICE	34.	FLOW UNITS		LIQUID		STEAM		GAS			
	35.	Fluid									
	36.	Quant.Max.	C_V								
	37.	Quant.Oper.	C_V								
	38.	Valve C_V	Valve F_L								
	39.	Norm.Inlet Press.	ΔP								
	40.	Max.Inlet Press.									
	41.	Max.Shut Off	ΔP								
	42.	Temp.Max.	Operating								
	43.	Oper.sp.gr.	Mol.Wt.								
	44.	Oper Visc.	%Flash								
	45.	%Superheat	%Solids								
	46.	Vapor Press.	Crit.Press.								
	47.	Predicted Sound Level dBA									
	48.	Manufacturer									
	49.	Model No.									

Notes:

1-4. Identification and service or location. It is assumed that each tag number is for a single valve.

5. Pressure reducing, back pressure control, or differential pressure regulator.

6. Globe, angle, or Manufacturer's Standard (MFR. STD.).

7. Body connection size and inner valve size.

8. Guiding may be top, top and bottom, skirt, or MFR. STD. Select single or double port, if applicable.

9. Specify screwed (NPT), flanged, or weld end; and flange rating, such as 150 lb ANSI.

10-11. Specify materials.

12. Write in "yes" or use check mark if required.

13. Quick open, equal percent, linear, etc. State Characteristic:

L = Linear
LV = Linear V Port
EP = Equal Percentage
EPT = Equal Percentage Turned
EPB = Equal Percentage Balanced
Q = Quick Opening

Or use your own code and identify in notes.

14. Refers to seal between body and top works, such as diaphragm, stuffing box, etc.

15. Refers to seat, plug, stem; in general, all internal wetted parts.

16. Use only to specify soft seat, otherwise material will be same as trim specified in line 15.

17. Use if required.

18. Max allowable sound level dBA 1m from pipe and 1m downstream of the valve outlet.

19. Actuator may be spring type or springless pressure balanced.

20. The pilot is an integral or external auxiliary device which amplifies the force available through an operating medium, usually air.

21. Give pressure available and specify medium.

22. Refers to valve pressure sensing system. Specify whether controlled pressure is sensed internally or by means of an external line requiring an additional piping connection.

23-24. Specify diaphragm material and pressure or temperature limits, if applicable.

25. Range over which pressure setting can be made

26. Specification of set pressure does not apply to factory setting. This must be called for specifically, if required.

27. Specify filter regulator, with or without gage, if required for air supply to pilot. Write "yes" or use check mark.

28. Specify if strainer is to be furnished with valve. Write "yes" to check off; or give style or model number.

30-31. Options available in gas regulators. On line 30 specify "bug-proof" if required.

34. State liquid, steam, gas units liter/min, kg/hr, m^3/hr,etc.

35. Name of fluid and state whether vapor or liquid if not apparent.

36. State maximum quantity required by process and corresponding Cv.

37. State operating quantity required by process and corresponding Cv.

38. The manufacturer shall fill in the valve Cv and FL (Liquid Pressure) Recovery Factor without reducers or other accessories.

39. Operating inlet pressure and pressure differential with units (kpa.abs., kpa, mm H_2O or Hg). Note at this point that one might consider how minimum conditions will fit the sizing.

40. Maximum inlet pressure if different from normal.

41. State the maximum pressure drop in shut-off position to determine proper actuator size. This is actual difference in inlet and outlet pressure stated in kpa, mm of H_2 0 or Hg, etc.

42. State ^{0}C.

43. State operating specific gravity and molecular weight.

44. State operating viscosity and its units. State flash at valve outlet, i.e., of max flow that will be flashed to vapor because of the valve pressure drop.

45. In the case of vapors, state superheat and in the cases of liquids, state the solids, if present.

46. Note vapor pressure of fluid as well as the critical pressure.

47. Give manufacturers predicted sound level dBA.

48. Complete when available.

SELF ACTUATED TEMPERATURE REGULATORS

	SELF-ACTUATED TEMPERATURE REGULATOR				SHEET 1 OF 1		
					DATA SHEET. NO.		REV.
	NO	BY	DATE	REVISION			
					JOB NO.		DATE
PROJECT TITLE :							
					REQ.	P.O.	
					BY	CHK'D	APPR.
REF. STD. : IPS - M - IN - 120 (0)							

GENERAL	1.	Tag No.								
	2.	Service								
	3.	Line No./Vessel No.								
	4.	Line Size/Sched.No.								
	5.	Function								
VALVE	6.	Body Size	Time Size							
	7.	Number of Ports								
	8.	End Conn. and Rating								
	9.	Body Material								
	10.	Trim Material								
	11.	Plug Form								
	12.	Seat Material								
	13.	Action On Temp. Rise								
	14.									
THERMAL SYSTEM	15.	Fill:SAMA Class								
	16.	Bulb Type								
	17.	Bulb Material								
	18.	Extension Length								
	19.	Insertion Length								
	20.	Bulb Connection								
	21.	Capillary Material								
	22.	Armor								
	23.	Capillary Length								
	24.	Well Material								
	25.	Well Connection								
	26.	"U" Dimension	"T" Dim.							
	27.	Adjustable Range								
ACCESS.	28.									
	29.	Integral Thermometer								
	30.									
	31.									
	32.									
	33.									

(to be continued)

SELF ACTUATED TEMPERATURE REGULATORS (continued)

SERVICE	34.	FLOW UNITS		LIQUID		STEAM		GAS			
	35.	Fluid									
	36.	Quant.Max.	C_V								
	37.	Quant.Oper.	C_V								
	38.	Valve C_V	Valve F_L								
	39.	Norm.Inlet Press.	ΔP								
	40.	Max.Inlet Press.									
	41.	Max. Shut Off	ΔP								
	42.	Temp.Max.	Operating								
	43.	Oper.sp.gr.	Mol.Wt.								
	44.	Oper Visc.	%Flash								
	45.	%Superheat	%Solids								
	46.	Vapor Press.	Crit.Press.								
	47.	Predicted Sound Level dBA									
	48.	Manufacturer									
	49.	Model No.									

Notes:

SELF ACTUATED TEMPERATURE REGULATORS

Instructions for data sheet 1 of 1

1. Identification of item by tag number.

2. Process area or function

3. Stream description and/or pipe size or vessel number with which valve is used.

5. Function heating or cooling.

6. Specify nominal size of body and trim in inches.

7. 1 - single port (SP); 2 - double port (DP); 3 -three way.

8. Specify screwed or flange rating and facing.

9. Specify material of body such as bronze, carbon steel, cast iron, etc.

10. Specify material of trim such as bronze, 316 stainless steel, etc.

11. State Characteristic:

L = Linear B = Blending

LV = Linear V PortD = Diverting

EP = Equal Percentage

EPT = Equal Percentage Turned

EPB = Equal Percentage Balanced

Q = Quick Opening

Or use your own code and identify in notes.

12. Specify seat material such as 316 stainless steel, Buna N, etc.

13. Specify open or close.

15. Filled thermal system instruments are classified as follows:

Class IA: Liquid filled, uniform scale, fully compensated.

Class IB: Liquid filled, uniform scale, case compensated only.

Class IIA: Vapor pressure, increasing scale, with measured temp. above case and tubing temp.

Class IIB: Vapor pressure, increasing scale, with measured temp. below case and tubing temp.

Class IIC: Vapor pressure, increasing scale, with measured temp. above and below case and tubing temp.

Class IID: Vapor pressure, increasing scale, above, at, and below case and tubing temp.

Class IIIA: Gas filled, uniform scale, fully compensated.

Class IIIB: Gas filled, uniform scale, case compensated only.

Class VA: Mercury filled, uniform scale, fully compensated.

Class VB: Mercury filled, uniform scale, case compensated only.

16. State whether plain, averaging, sanitary bulb.

17. Give material and type of bulb and extension; such as 316 SS.

18. Write in length of extension, followed by "ben" for bendable, "adj" for adjustable or"rgd" for rigid.

number.

19. The bulb insertion length should be given if no well data are shown.

20. Specify size of jam nut or union connector; or part

21. Specify material of capillary tubing.

22. Specify material of armor (Bronze, 316 SS, etc.) or write "None."

23. Specify length in meter.

24. Specify well material such as bronze, 304 stainless steel, 316 stainless steel, monel, etc.

25. Specify process connection size and type, such as ¾ in. NPT, 11/2 in. 150 lb RF, etc.

26. Specify "U" dimension from face of flange or bottom of thread to tip of well. Specify "T" (lagging extension) dimension in mm.

27. Note adjustable range available from the manufacturer.

29. Specify range, or write in "None."

34. State liquid, steam, gas units liter/min, kg/hr, m^3/hr, etc.

35. Name of fluid and state whether vapor or liquid if not apparent.

36. State maximum quantity required by process and corresponding Cv.

37. State operating quantity required by process and corresponding Cv.

38. The manufacturer shall fill in the valve Cv and FL (Liquid Pressure) Recovery Factor without reducers or other accessories.

39. Operating inlet pressure and pressure differential with units (kpa.abs, kpa, mm H_2O or Hg). Note at this point that one might consider how minimum conditions will fit the sizing.

40. Maximum inlet pressure if different from normal.

41. State the maximum pressure drop in shut-off position to determine proper actuator size. This is actual difference in inlet and outlet pressure stated in kpa, mm of H_2 0 or Hg, etc.

42. State ^{0}C.

43. State operating specific gravity and molecular weight.

44. State operating viscosity and its unit. State flash at valve outlet, i.e., of max flow that will be flashed to vapor because of the valve pressure drop.

45. In the case of vapors, state superheat and in the cases of liquids, state the solids, if present.

46. Note vapor pressure of fluid as well as the critical pressure.

47. Give manufacturers predicted sound level dBA.

48. Complete when available

SOLENOID VALVES

	SOLENOID VALVES				SHEET 1 OF 1		
					DATA SHEET. NO.		REV.
	NO	BY	DATE	REVISION			
					JOB NO.		DATE
PROJECT TITLE :							
					REQ.	P.O.	
					BY	CHK'D	APPR.
REF. STD. : IPS - G - IN - 160 (0)							

	1	Tag Number				
	2	Service				
	3	Line No./ Vessel No.				
	4	Quantity				
VALVE BODY	5	Type				
	6	Size - Body/Port				
	7	Rating & Type Conn.				
	8	Material - Body				
	9	Material - Seat				
	10	Material - Diaphragm				
	11	Operation Direct/Pilot				
	12	Packless or Type Packed				
	13	Manual Re-Set				
	14	Manual Operator				
	15					
	16					
WHEN DE-ENERGIZED	17	2-Way Valve Opens/Close				
	18	3-Way				
	19	Vent Port Opens/Close				
	20	Press Port Opens/Close				
	21	4-Way				
	22	Press to Cyl.l/Cyl 2				
	23	Exh. from Cyl l/Cyl 2				
	24					
	25					
SOLENOID	26	Enclosure				
	27	Voltage/Hz				
	28	Style of Coil				
	29	Single or Double Coil				
	30					
	31					

(to be continued)

SOLENOID VALVES (continued)

SERVICE CONDITIONS	32	Fluid								
	33	Qty. Maximum								
	34	Oper. Diff. Min/Max								
	35	Allow. Diff. Min/Max								
	36	Temp. Norm/Max.								
	37	Oper.sp. gr.								
	38	Oper. Viscosity								
	39	Required C_V								
	40	Valve C_V								
	41									
	42									
	43									
	44									
	45	Manufacturer								
	46	Model Number								
Notes:										

SOLENOID VALVES

1. Identification by tag number.

2. Process service.

3. Identification of line and vessel.

4. Number of identical valves.

5. Indicate whether 2-way, 3-way, or 4-way.

6. Specify body and port size in inches.

7. Maximum pressure rating and type of connections such as screwed or FLANGE rating.

8. Specify material such as bronze, aluminum or stainless steel.

9. Specify seat such as bronze or stainless steel, synthetic rubber, teflon, etc.

10. If diaphragm is used, specify material such as synthetic rubber, teflon.

11. Designate whether direct operated, self-pilot type or with pilot requiring auxiliary operating medium.

12. Specify packless or type of packing.

13. State whether no voltage release or electrically tripped.

14. Specify if required.

15,16. Blanks for special requirements i.e., manifold valves etc.

17-23. State whether open or closed in appropriate places.

24,25. Blanks for special requirements.

26. Specify enclosure as general purpose, water tight, explosion proof.

27. State electrical characteristics voltage, ac or dc, and ac hertz.

28. Style of coil to be standard, molded, high temperature.

29. State whether single or dual coil. If dual coil, explain operation in space for notes.

30,31. Blanks for special requirements.

32. Name fluid and state whether liquid or gas if not apparent.

33. State maximum required capacity in units of flow such as liter/min, kg/hr, m^3/hr.

34. State actual minimum and maximum differential encountered under operating conditions.

35. Vendor to state minimum operating differential required to operate valve and maximum allowable differential.

36-38. State normal operating temperature and maximum possible temperature operating, specific gravity or molecular weight and operating viscosity.

39. State calculated Cv requirement.

40. Vendor to state valve Cv.

SPECIFICATION FORM FOR ELECTRO HYDRAULIC TYPE CONTROL VALVES

	PROJECT UNIT P.O. ITEM CONTRACT MFR SERIAL	DATA SHEET OF SPEC TAG DWG SERVICE

No.				Units	Normal Flow	Max. Flow	Min. Flow	
1	SERVICE CONDITIONS	Fluid						
				Units	Normal Flow	Max. Flow	Min. Flow	
2		Flow Rate						
3		Inlet Pressure						
4		Outlet Pressure						
5		Vapor pressure						
6		Intel Temperature						
7		Density @ Operating Temp.						
8		Liquid Critical Pressure						
9		Spec Gravity						
10		Viscosity						
11		Calculated Cv						
12		Required Cv						
13		Travel		%				
14		Predicted Noise	Max. Allowed Noise	dBA				

No.			
15	LINE	Pipe Line Size	In
16		& Schedule	Out
17		Pipe Line Insulation --	
18	VALVE BODY / BONNET	Type	
19		Size	
20		Max Press / Temp	
21		Mfr.& Model	
22		Body / Bonnet Matl	
23		Liner Material / ID	
24		End In	
25		Connection Out	
26		Flg Face Finish	
27		End Ext / Matl	
28		Flow Direction	
29		Lub & Iso Valve	
30		Packing Material	
31		Packing Type	
32		Type Of Bonnet	
33	TRIM	Type	
34		Size	
35		Characteristic	
36		Balanced / Unbalanced	
37		Action Push Down to	
38		Plug / Ball / Disk Material	
39		Seat Material	
40		GUID TYPE :	
41		Cage / Guide Material	
42		Leakage Class :	
43		Stem Material	

No.			
44	ACTUATOR	Type	
45		Mfr.& Model	
46		Size	
47		Control Signal:	
48		Power Failure:	
49		Electrical Rating: V / HZ / KW	
50		Function:	Direct Reverse
51		Supply Press:	Max
52			Min
53		Bench Set Range Barg	
54		Act Orientation:	
55		Handwheel Type:	
56		Hand pump	
57	SWITCHES	Type	Quantity
58		Mfr.& Model	
59		Contacts / Rating	
60		Actuation Points	
61			
62			
63			
64			
65	TES T	Hydro Pressure	
66		ANSI / FCI Leakage Class	
67	SPECIAL ACCESSORIES		

APPENDIX B

DEFINITIONS OF PARTS COMMON TO MANY TYPES OF VALVES

B.1 CONTROL VALVE

A power actuated device that modifies the fluid flow rate in a process control system. It consists of a valve connected to an actuator mechanism (including all related accessories) that is capable of changing the position of a closure member in the valve in response to a signal from the controlling system.

B.2 GENERAL TERMS

B.2.1 Capacity

The rate of flow through a valve usually stated in terms of CV or KV.

B.2.2 Pressure Working Class

A convenient round number used to designate allowable pressure/temperature ratings for valves and pipe fittings using arbitrary class numbers from tables developed by ASME and ISO for a variety of materials.

B.2.3 Control Valve Gain

The change in the flow rate as a function of the change in valve travel. It is the slope of the installed flow characteristic curve.

B.2.4 Cold Working Pressure

The maximum pressure rating of a valve or fitting coincident with ambient temperature, generally in the range from -29º C to +38º C (-20º F to +100º F).

B.2.5 Air Set

a regulator that is used to control the supply pressure to the valve actuator and its auxiliaries.

B.2.6 Bench Set

The shop calibration of the actuator spring range of a control valve, to account for the in-service process forces.

B.2.7 Failure Mode

The position to which the valve closure member moves when the actuating energy source fails.

B.2.7.1 Fail-closed

A condition wherein the valve closure member moves to a closed position when the actuating energy source fails.

B.2.7.2 Fail-in-place

A condition wherein the valve closure member stays in its last position when the actuating energy source fails.

B.2.7.3 Fail-open

A condition wherein the valve closure member moves to an open position when the actuating energy source fails.

B.2.7.4 Fail-safe

A characteristic of a particular valve and its actuator that upon loss of actuating energy supply will cause a valve closure member to be fully closed, fully open, or remain in the last position, whichever position is defined as necessary to protect the process. Fail-safe action may involve the use of auxiliary controls connected to the actuator.

B.2.8 Flow Characteristic

An indefinite term. (See below "inherent flow" and "installed flow.")

B.2.8.1 Equal percentage characteristic

An inherent flow characteristic that, for equal increments of rated travel, will ideally give equal percentage changes of the flow coefficient (Cv or Kv).

B.2.8.2 Quick opening characteristic

An inherent flow characteristic in which a maximum flow coefficient is achieved with minimal closure member travel

B.2.8.3 Linear characteristic

An inherent flow characteristic that can be represented by a straight line on a rectangular plot of flow coefficient (Cv or Kv) versus rated travel. Therefore, equal increments of travel provide equal increments of flow coefficient (Cv or Kv).

B.2.8.4 Modified parabolic characteristic

An inherent flow characteristic that provides equal percent characteristic at low closure member travel and approximately a linear characteristic for upper portions of closure member travel.

B.2.9 Inherent Flow Characteristic

The relationship between the flow rate and the closure member travel as it is moved from the closed position to rated travel with constant pressure drop across the valve.

B.2.10 Installed Flow Characteristic

The relationship between the flow rate and the closure member travel as it is moved from the closed position to rated travel as the pressure drop across the valve is influenced by the varying process conditions.

B.2.10.1 Linear characteristic

An inherent flow characteristic that can be represented by a straight line on a rectangular plot of flow coefficient (Cv or Kv) versus rated travel. Therefore, equal increments of travel provide equal increments of flow coefficient (Cv or Kv).

B.2.10.2 Modified parabolic characteristic

An inherent flow characteristic that provides equal percent characteristic at low closure member travel and approximately a linear characteristic for upper portions of closure member travel.

B.2.10.3 Quick opening characteristic

An inherent flow characteristic in which a maximum flow coefficient is achieved with minimal closure member travel.

B.2.10.4 Leakage class

Classifications established by ANSI/FCI 70-2 to categorize seat leakage allowances for different needs of seat tightness.

B.2.11 Rangeability

The ratio of the largest flow coefficient (Cv or Kv) to the smallest controllable flow coefficient (Cv or Kv) within which the deviation from the specified flow characteristic does not exceed the stated limits.

B.2.12 Repeatability

The closeness of agreement among a number of consecutive measurements of the output for the same value of input under the same operating conditions, approaching from the same direction, for full range traverses. It does not include hysteresis.

B.2.13 Hysteresis

The maximum difference in output value for any single input value during a calibration cycle, excluding errors due to dead band. This difference is sometimes called hysteretic error. See ANSI/ISA-51.1-1979 (R1993), Process Instrumentation Terminology.

B.2.14 hysteresis Plus Dead Band

The maximum difference for the same input between the upscale and downscale output values during a full range traverse in each direction. This is the summation of hysteresis and dead band.

B.2.15 In-line Valve

A valve having a closure member that moves to seat axially in the direction of the flow path. In-line valves are normally operated by a fluid energy source but may be operated mechanically.

B.2.16 Lift

A nonstandard term. See "travel."

B.2.17 Travel

The movement of the closure member from the closed position to an intermediate or rated full open position.

B.2.18 Cycling Life

A number of cycles over which a device will operate without changing its performance beyond tolerance.

B.2.19 Direct Acting Valve

A valve that travels to the closed position when the signal increases.

B.2.20 Drift

An undesired change in the output/input relationship over a period of time.

B.2.21 Flanged

Valve end connections incorporating flanges that mate with corresponding flanges on the piping.

B.2.21.1 Split clamp

Valve end connections of various proprietary designs using split clamps to apply gasket or mating surface loading.

B.2.21.2 Threaded

Valve end connections incorporating threads, either male or female.

B.2.21.3 Welded

Valve end connections that have been prepared for welding to the line pipe or other fittings. May be buttweld (BWE), or socket weld (SWE).

B.2.22 Environment

Ambient conditions (including temperature, pressure, humidity, radioactivity, and corrosiveness of the atmosphere) surrounding the valve and actuator. Also, the mechanical and seismic vibration transmitted through the piping or heat radiated toward the actuator from the valve body.

B.2.23 Lubricator Isolating Valve

A manually operated valve used to isolate the packing lubricator assembly from the packing box.

B.2.24 Modulation

The action of a control valve to regulate fluid flow by varying the position of the closure member.

B.2.25 Throttling

See "modulation."

B.2.26 Turndown

See "rangeability."

B.2.27 Multiple Orifice

A style of valve trim where the flow passes through a multiple of orifices in parallel or in series.

B.2.28 Nominal Size

A numerical designation of size that is common to all components in a piping system other than components designated by outside diameters or by thread size. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions. ISO uses initials DN as an abbreviation for the term with the letters DN followed by a numerical value designating size. All equipment of the same nominal size and nominal pressure rating shall have the same mating dimensions appropriate to the type of end connections.

B.2.29 Nominal Pressure

A numerical designation relating to pressure that is a convenient round number for reference purposes.

The International Organization for Standardization (ISO) uses the term "nominal pressure" the same way that ANSI uses the term "class" in identifying piping component pressure rating. ISO uses the initials PN as an abbreviation for the term with the letters PN followed by a numerical value designating pressure rating. All equipment of the same nominal diameter and nominal pressure rating shall have the same mating dimensions appropriate to the type of end connections.

B.3 PROCESS TERMS

B.3.1 Vena Contracta

The portion of a flow stream where fluid velocity is at its maximum and fluid static pressure and the cross-sectionalarea are at their minimum. In a control valve, the vena contracta normally occurs justdownstream of the actual physical restriction.

B.3.2 Cavitation

A two-stage phenomenon of liquid flow. The first stage is the formation of vapor bubbles within the liquid system due to static pressure of fluid falling below the fluid vapor pressure; the second stage is the collapse or implosion of these cavities back into an all-liquid state as the fluid decelerates and static pressure is recovered.

B.3.3 Flashing

Occurs when the pressure of a fluid falls below its vapor pressure, changing from a liquid to a vapor. During this process small vapor cavities form that grind away at the outlet of the control valve and its trim components. Flashing damage is marked by shiny, smooth gouges in material.

B.3.4 Choked Flow

A condition wherein the flow rate through a restriction does not increase when the downstream pressure is decreased at a fixed inlet pressure.

B.3.5 Cracked Flow

A nonstandard term. See "clearance flow."

B.3.6 Clearance Flow

That flow below the minimum controllable flow with the closure member not seated.

B.4. BODY

B.4.1 Valve Body

The part of the valve which is the main pressure boundary. The body also provides the pipe connecting ends, the fluid flow passageway, and may support the seating surfaces and the valve closure member.

B.4.2 Valve Body Types

Different valve types utilize different body types:

B.4.2.1 Encapsulated body

All surfaces of the body are covered by a continuous surface layer of a different material, usually an elastomeric or polymeric material.

B.4.2.2 Globe body

A valve body distinguished by a globular shaped cavity around the port region, wherein the closure member motion is linear and normal to the plane of the port. (See Fig. B.4 a))

B.4.2.3 Lugged body

A thin annular section body with lug protrusions on the outside diameter of the body, whose end surfaces mount between the pipeline flanges or may be attached to the end of a pipeline without any additional flange or retaining parts, using either through-bolting and/or tapped holes.

B.4.2.4 Pinch body

A body containing a flexible elastomeric tubular member that can be mechanically squeezed. (See Figure B.6)

B.4.2.5 Split body

A valve body design in which the seat and gaskets are secured between two segments of a valve body. (See Figure B.4 b))

B.4.2.6 Wafer body

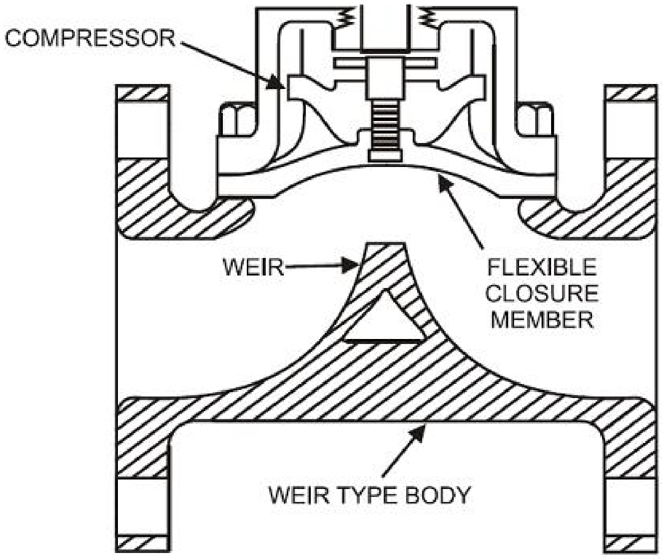
A thin annular section butterfly body whose end surfaces are located and clamped between the piping flanges by bolts extending from flange to flange.

B.4.2.7 Weir-type body

A body having a raised contour contacted by a diaphragm to shut off fluid flow. Also referred to as a Saunders patent diaphragm valve. (See Fig. B.1)

B.4.2.8 Diaphragm valve

See "weir-type body."



DIAPHRAGM VALVE

Fig. B.1

B.4.3 Body Cavity

The internal chamber of the valve body.

B.5 ACTUATOR

A pneumatic, hydraulic, or electrically powered device that supplies force and motion to position a valve's closure member at or between the open or closed position.

B.5.1 Bellows Actuator

A fluid powered device in which the fluid acts upon a flexible convoluted component, the bellows.

B.5.2 Diaphragm Actuator

A fluid powered device in which the fluid acts upon a flexible component, the diaphragm. (See Fig. B.2)

B.5.3 Double-acting Actuator

A device in which power is supplied in either direction.

B.5.4 Electrohydraulic Actuator

A device that converts electrical energy to hydraulic pressure and into motion.

B.5.5 Electromechanical Actuator

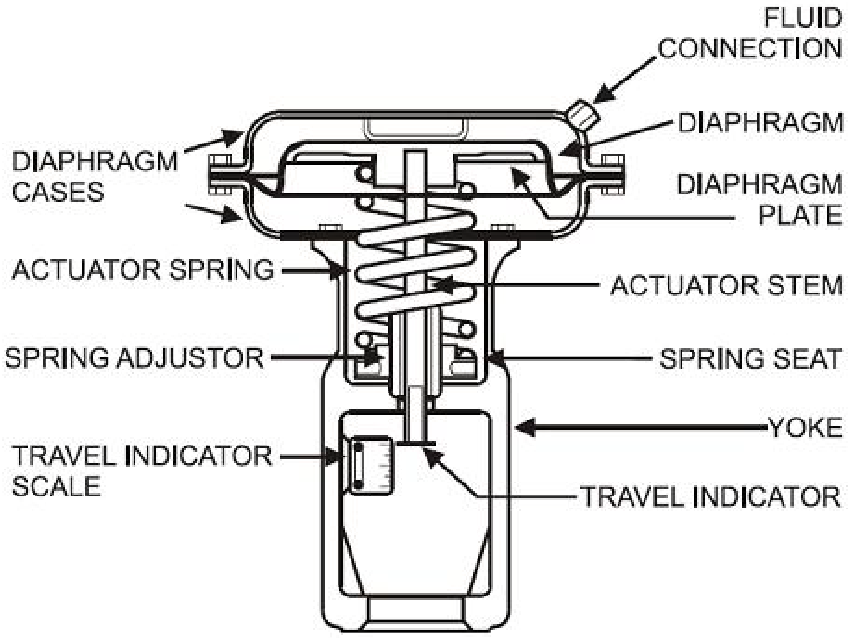
A device that converts electrical energy into motion.

B.5.6 Hydraulic Actuator

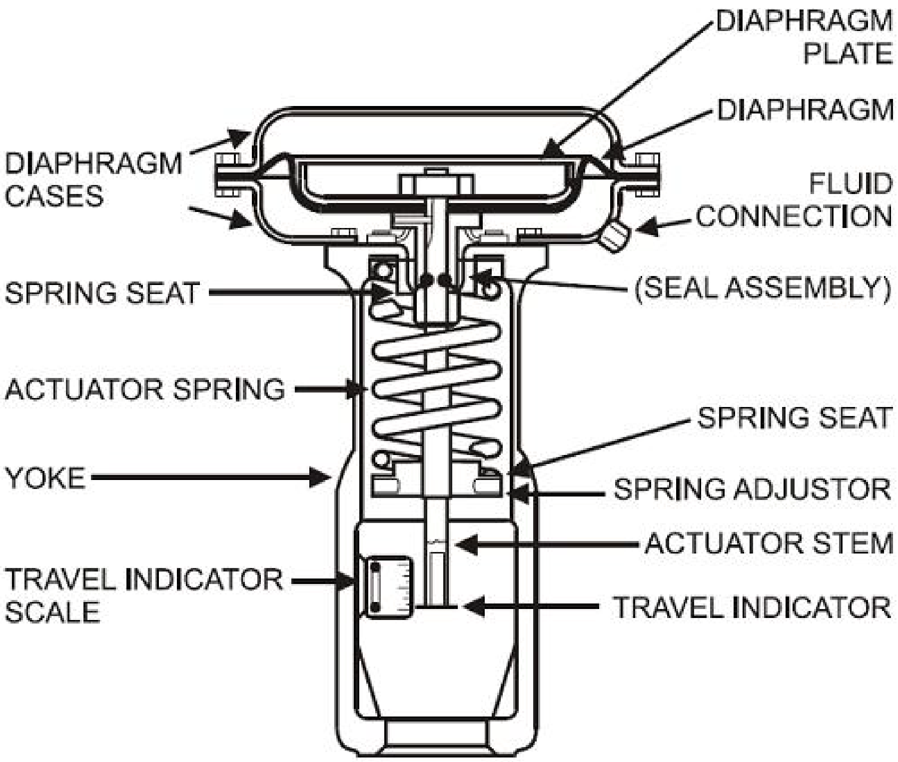
A fluid device that converts the energy of an incompressible fluid into motion.

B.5.7 Piston Actuator

A fluid powered device in which the fluid acts upon a movable piston to provide motion to the actuator stem. (See Fig. B.3)



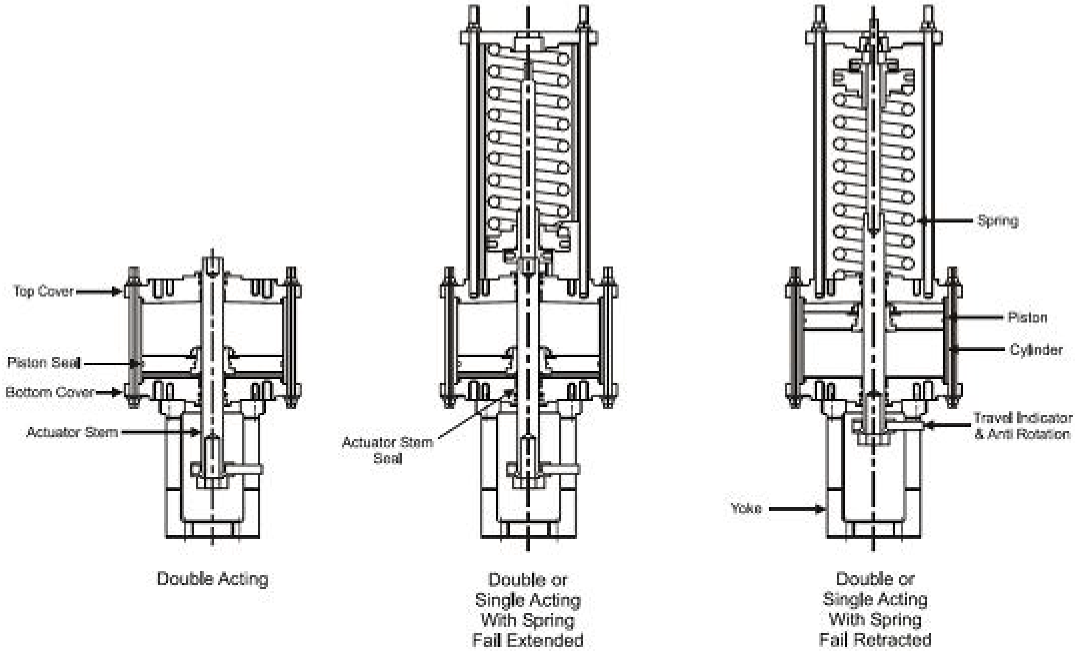
a) Fluid-To-Extend Stem



b) Fluid-To-Retract Stem

SINGLE ACTING DIAPHRAGM ACTUATOR

Fig. B.2



PISTON ACTUATORS

Fig. B.3

B.5.8 Pneumatic Actuator

A device that converts the energy of a compressible fluid, usually air, into motion.

B.5.9 Single-acting Actuator

A device in which the power supply acts in only one direction, e.g., a spring diaphragm actuator or a spring return piston actuator. (See Fig. B.2)

B.5.10 Vane Actuator

A fluid powered device in which the fluid acts upon a pivoted member, the vane, to provide rotary motion.

B.5.11 Actuator Stem or Actuator Shaft

The part that connects the actuator to the valve stem or shaft and transmits motion (force) from the actuator to the valve. Rotary motion valves have shafts while linear motion valves generally have stems.

B.5.12 actuator effective area:

The net area of piston, bellows, vane, or diaphragm acted on by fluid pressure to generate actuator output force.

B.6 POSITIONER

A position controller that is mechanically connected to a moving part of a final control element or its actuator, and automatically adjusts its output to the actuator in order to maintain a desired position of the closure member in proportion to the input signal.

B.6.1 Double Acting

A positioner with two outputs, suited to a double-acting actuator.

B.6.2 Single Acting

A positioner with one output, suited to a spring-opposed actuator.

B.7 BONNET

That portion of the valve pressure retaining boundary which may guide the stem and contains the packing box and stem seal. It may also provide the principal opening to the body cavity for assembly of internal parts or be an integral part of the valve body. It may also provide for the attachment of the actuator to the valve body. Typical bonnets arebolted, threaded, welded, pressure-sealed, or integral with the body.

B.7.1 Bonnet Types

Typical bonnets are bolted, threaded, welded, pressure-sealed to or integral with the body. Other types sometimes used are defined below.

B.7.2 Extension Bonnet

A bonnet with a packing box that is extended above the bonnet joint of the valve body so as to maintain the temperature of the packing above or below the temperature of the process fluid. The length of the extension bonnet is dependent upon the difference between the fluid temperature and the packing design temperature limit as well as upon the valve body design.

B.7.3 Bonnet Bolting

A means of fastening the bonnet to the body. It may consist of studs with nuts for a flanged bonnet joint, studs threaded into the bonnet neck of the body, or bolts through the bonnet flange.

B.7.4 Bonnet Gasket

A deformable seal between the mating surfaces of the body and bonnet. It may be deformed by bonnet bolting loading or energized by fluid pressure within the valve.

B.7.5 Bonnet, Seal Welded

A bonnet welded to a body to provide a zero leakage joint.

B.8 CLOSURE MEMBER

A movable part of the valve which is positioned in the flow path to modify the rate of flow through the valve. There are different closure member configurations:

B.8.1 Characterized

Closure member with contoured surface, such as the "vee plug," to provide desired flow characteristics.

B.8.2 Cylindrical

A cylindrical closure member with a flow passage through it (or a partial cylinder).

B.8.3 Eccentric Rotary Plug

Closure member face of a rotary motion valve that is not concentric with the shaft centerline and moves into seat when closing.

B.8.4 Eccentric Spherical Disk

The disk is a spherical segment in a rotary motion valve that is not concentric with the disk shaft and moves into the seat when closing.

B.8.5 Linear

A closure member that moves in a line perpendicular to the seating plane.

B.8.6 Rotary

A closure member that is rotated into or away from a seat to modulate flow.

B.8.7 Tapered:

Closure member is tapered and may be lifted from seating surface before rotating to close or open.

B.9 BALL

A kind of spherically shaped closure member is utilized in ball valves. Types of balls are:

B.9.1.1 Full ball

A closure member that has a complete spherical surface with a flow passage through it.

B.9.1.2 Segmented ball

A closure member that is a segment of a spherical surface that may have one edge contoured to yield a desired flow characteristic.

B.10 PORT

(1) The flow control orifice of a control valve, and (2) the opening of a valve's inlet or outlet passageways.

B.11 YOKE

The structure that rigidly connects the actuator power unit to the valve.

B.12 FLOW CONTROL ORIFICE

The part of the flow passageway that, with the closure member, modifies the rate of flow through the valve. The orifice may be provided with a seating surface, to be contacted by or closely fitted to the closure member, to provide tight shutoff or limited leakage.

B.12.1 Seat Ring

A part that is assembled in the valve body and may provide part of the flow control orifice. The seat ring may have special material properties and may provide the contact surface for the closure member.

B.12.2 Cage

A part in a globe valve surrounding the closure member to provide alignment and facilitate assembly of other parts of the valve trim. The cage may also provide flow characterization and/or a seating surface for globe valves and flow characterization for some plug valves.

B.12.3 Integral Seat

A flow control orifice and seat that is an integral part of the body or cagematerial or may be constructed from material added to the body or cage. Aug. 2003 IPS-E-IN-160(1) 69

B.13. Stem

The stem rod, shaft or spindle which connects the valve actuator with the closure member.

B.13.1 Stem Seals

The part or parts needed to effect a pressure-tight seal around the stem while allowing movement of the stem.

B.13.2 Packing

A sealing system consisting of deformable material of one or more mating and deformable elements contained in a packing box which may have an adjustable compression means to obtain or maintain an effective pressure seal.

B.13.3 Packing box

B.13.4 Integral Stem/Shaft

A design in which the stem/shaft is an integral part of the closure member. The chamber, in the bonnet, surrounding the stem and containing packing and other stem sealing and guiding parts.

B.13.5 Packing Flange

A device that transfers the deforming mechanical load to the packing follower. A packing flange is fastened by studs.

B.13.6 Packing Follower

A part that transfers the deforming mechanical load to the packing from the packing flange or nut.

B.13.7 Packing Gland

A nonstandard term. See "packing follower."

B.13.8 Packing Lubricator Assembly

A device for injection of lubricant/sealer into a lubricator packing box.

B.13.9 Packing Nut

A packing nut is threaded into the packing box transmitting the deforming mechanical load to the packing.

B.14. BUSHING

A fixed member which supports and/or guides the closure member, valve stem and/or actuator stem. The bushing supports the nonaxial loads on these parts and is subject to relative motion of the parts.

B.15. VALVE TRIM

The internal components of a valve that modulate the flow of the controlled fluid.

B.15.1 Anti-cavitation Trim

A combination of plug and seat ring or plug and cage that by its geometry permits non-cavitating operation or reduces the tendency to cavitate, thereby minimizing damage to the valve parts, and the downstream piping.

B.15.2 Anti-noise Trim

A combination of plug and seat ring or plug and cage that by its geometry reduces the noise generated by fluid flowing through the valve.

B.15.3 Balanced Trim

An arrangement of ports and plug or combination of plug, cage, seals, and ports that tends to equalize the pressure above and below the valve plug to minimize the net static and dynamic fluid flow forces acting along the axis of the stem of a globe valve.

B.15.4 Soft Seated Trim

Valve trim with an elastomeric, plastic or other readily deformable material used either in the valve plug or seat ring to provide tight shutoff with minimal actuator forces. See ANSI B16.104 for leakage classifications.

B.15.5 Erosion Resistant Trim

Valve trim which has been faced with very hard material or manufactured from very hard material to resist the erosive effects of the controlled fluid flow.

B.15.6 Reduced Trim

Control valve trim that has a flow area smaller than the full flow area for that valve.

B.16 BOTTOM FLANGE

A part which closes a valve body opening opposite the bonnet opening. It may include a guide bushing and/or serve to allow reversal of the valve action. In three-way valves it may provide the lower flow connection and its seat.

B.17 GUIDING MEANS

B.17.1 Stem Guide

A guide bushing closely fitted to the valve stem and aligned with the seat, (Fig. B.4 (b)).

B.17.2 Post Guide

Guide bushing or bushings fitted to posts or extensions larger than the valve stem and aligned with the seat.

B.17.3 Cage Guide

A valve plug fitted to the inside diameter of the cage to align the plug in globe valves with the seat, (Fig. B.4 (a)).

B.17.4 Globe Valve Plug Guides

The means by which the plug is aligned with the seat and held stable through out its travel. The guide is held rigidly in the body or bonnet.

B.17.5 Port Guide

A valve plug with wings or a skirt fitted to the seat ring bore.

B.18 CONTROL SIGNAL OVERRIDE DEVICE:

A device that overrides the control signal to the valve actuator, e.g., solenoid valves, lock-up valves, bypass valves, etc.

B.19 VALVE ACCESSORIES

B.19.1 Booster Relay

A volume or pressure amplifying pneumatic relay that is used to reduce the time lag in pneumatic circuits by reproducing pneumatic signals with high volume and/or high pressure output.

B.19.2 Hand Jack

A manual hydraulic or mechanical override device, using a lever, to stroke a valve or to limit its travel.

B.19.3 Handwheel

A mechanical manual override device, using a rotary wheel, to stroke a valve or to limit its travel.

B.19.4 Booster Relay

A volume or pressure amplifying pneumatic relay that is used to reduce the time lag in pneumatic circuitsby reproducing pneumatic signals with high volume and/or high pressure output.

B.19.5 Dashpot

A less preferred term. See "snubber."

B.19.6 Snubber

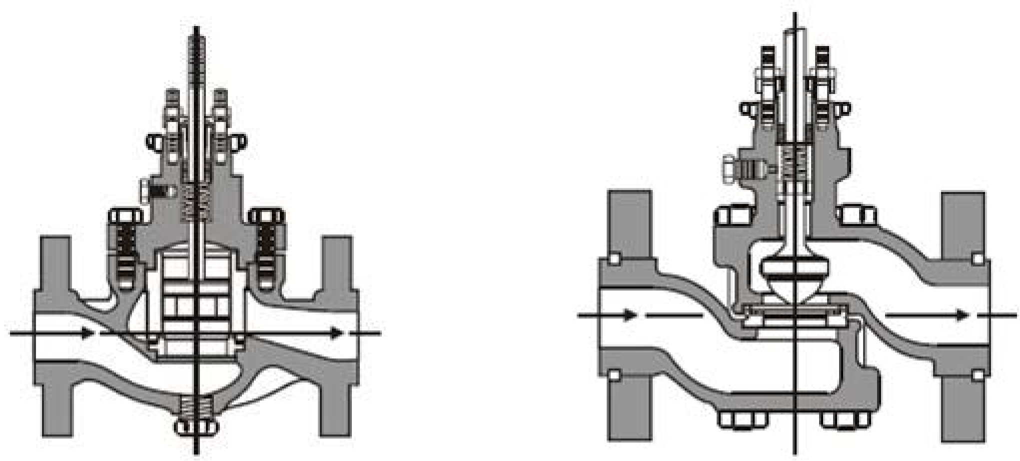
A device that is used to damp the motion of the valve stem.

B.20 LINEAR MOTION CONTROL VALVE TYPES

Types of valves with a closure member that moves with a linear motion to modify the rate of flow through the valve.

B.20.1 Globe Valve

A valve with a linear motion closure member, one or more ports and a body distinguished by a globular shaped cavity around the port region. Typical globe valve types are illustrated below. Flow arrows shown indicate a commonly used flow direction.



a) GLOBE BODY, CAGE GUIDED b) SPLIT BODY, STEM GUIDED

GUIDED VALVE BODIES

Fig. B.4

B.20.2 Diaphragm Valve

A valve with a flexible linear motion closure member that is forced into the internal flow passageway of the body by the actuator. Some main parts of this valve type are follow:

B.20.2.1 Valve diaphragm

A flexible member which is moved into the fluid flow passageway of the body to modify the rate of flow through the valve.

B.20.2.2 Compressor

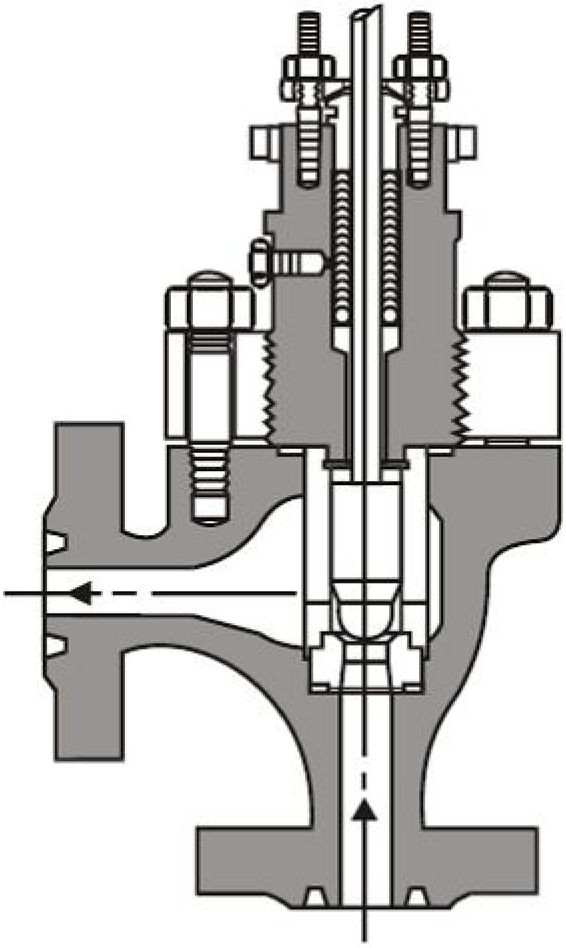
A device which the valve stem forces against the backside of the diaphragm to cause the diaphragm to move toward and seal against the internal flow passageway of the valve body.

B.20.2.3 Finger plate

A plate used to restrict the upward motion of the diaphragm and prevent diaphragm extrusion into thebonnet cavity in the full open position.

B.20.3 Angle Valve

A valve design in which one port is colinear with the valve stem or actuator, and the other port is at a right angle to the valve stem. (See Fig. B.5)

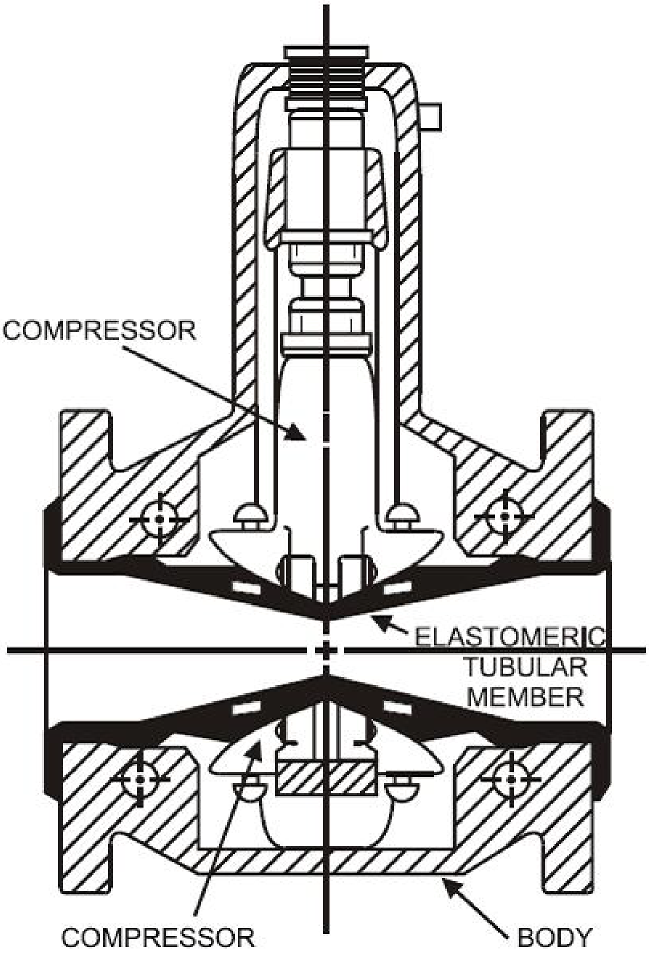


ANGLE VALVE

Fig. B.5

B.20.4 Pinch or Clamp Valve:

A valve consisting of a flexible elastomeric tubular member where flow control and shutoff is accomplished by mechanically squeezing the flexible member. (See Fig. B.6)



PINCH VALVE

Fig. B.6

B.21 ROTARY MOTION CONTROL VALVE TYPES

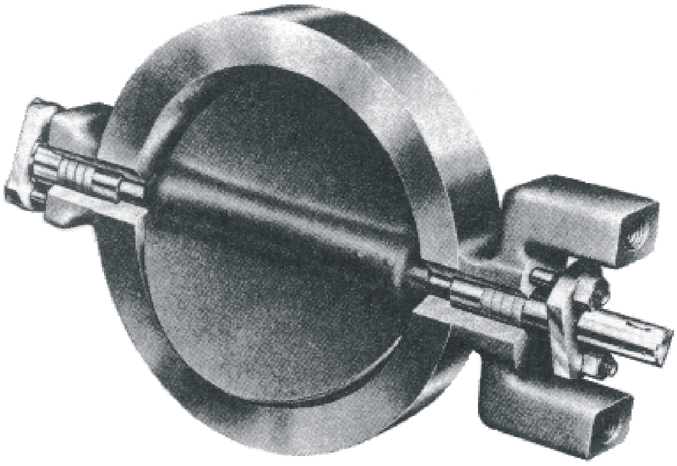
Types of valves with a closure member that moves with a rotary motion to modify the rate of flow through the valve.

B.21.1 Ball Valve

A valve which modifies flow rates with rotary motion of the closure member, which is either a sphere with an internal passage or a segment of a spherical surface, (Ref. 5.6.2).

B.21.2 Butterfly Valve

A valve with a circular body and a rotary motion disk closure member, pivotally supported by its stem. (See Fig. B.7)



BUTTERFLY VALVE

Fig. B.7

B.21.2.1 Body types

B.21.2.1.1 Wafer body

A body whose end surfaces mate with the pipeline flanges. It is located and clamped between the piping flanges by long bolts extending from flange to flange. A wafer body is also called a flangeless body.

B.21.2.1.2 Split body

A body divided in half by a plane containing the longitudinal flow path axis.

B.21.2.1.3 Lined body

A body having a lining which makes an interference fit with the disk in the closed position thus establishing a seal.

B.21.2.1.4 Unlined body

A body without a lining.

B.21.2.2 Typical disk orientations

a) Canted Disk

b) Angle Seated

B.21.2.3 Typical disk shapes

a) Knife

b) Fluted

B.21.2.4 Seal on disk

A seal ring located in a groove in the disk circumference. The body is unlined in this case.

B.21.2.5 Stem bearings

Butterfly stem bearings are referred to as either the outboard or the inboard type, depending on their location, outside or inside of the stem seals.