Education Institute for

Equipment & Process Design

PV-1006

Sizing and Design Principle

1.Operating Condition

Fluid: Natural Gas Fluid Phase: G Viscosity: 0.013 cP Compressibility: 0.93

Ratio of Specific Heats: 1.28 Mole Weight: 16.74

	UNIT	MIN	NOR	MAX
FLOW RATE	Nm3/h	54,000.000	178,361.000	198,000.000
PRESS.P1	bar(A)	52.900	52.900	52.900
PRESS.P2	bar(A)	51.000	51.000	51.000
SHUT OFF P	bar(A)			60.000
TEMP.	deg.C	40.000	40.000	40.000
DENSITY	mol	16.700	16.700	16.700

ISA Factors:

Fp : 1.0 Ff : 1.0 Fl : 0.9 Fr : 1.0 Fd : 1.0 Xt : 0.72

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2. Body/Bonnet

In Body/Bonnet Tab the following information should be determined:

1.Type

2. Size

3.Rating

4.Connection type

5.Body material

6.Pipe inlet and outlet

Type:

Since the valve is used for pressure controlling application a Globe valve is used.

Rating:

The rating of valves is the same as the rating of connecting pipes. Since the adjacent pipe class is 600, the valve class would be 600.

Connection type:

The three most common methods of installing control valves into pipelines are by means of screwed pipe threads, bolted gasketed flanges, and welded end connections.

Screwed end connections, popular in small control valves, offer more economy than flanged ends. The threads usually specified are tapered female NPT (National Pipe Thread) on the valve body. They form a metal-to-metal seal by wedging over the mating male threads on the pipeline ends.

This connection style, usually limited to valves NPS 2 (DN 50) or smaller, is not recommended for elevated temperature service. Valve maintenance might be complicated by screwed end connections if it is necessary to take the body out of the pipeline because the valve cannot be removed without breaking a flanged joint or union connection to permit unscrewing the valve body from the pipeline.

Flanged end valves are easily removed from the piping and are suitable for use through the range of working pressures for which most control valves are manufactured. Flanged end connections can be used in a temperature range from near absolute zero to approximately 815°C (1500°F). They are used on all valve sizes. The most common flanged end connections

Screwed End	Flanged End	Welded End
2" and smaller	Up to class 900	Suitable for class 1500 and 2500

include flat-face, raised-face, and ring-type joint.

Since the valve class is 600, flanged end is used for connection of the valve to adjacent piping,

Body material

1.A216 WCB/WCC or forged carbon steel, A105 is used in non-corrosive services from -28 to 427C.

2. If there are some severe conditions such as flashing, it is typical to use A217 WC9

3. For high temperature services like steam let-down station or HHPS it is a practice to use A217 WC6.

4. A351 CF8 is used mostly for combined flashing and corrosive services and for temperatures below -28C.

5. For oxygen services, it is highly recommended to use Monel.

Based on the next-page Table, A 216 WCB is selected for natural gas applications.

Valve Body Material Selection based on Fluids

Fluid	Material
NG	SA216 WCB
Purge Gas	SA216 WCB
Syngas	SA216 WCB/A351 CF8
Process Condensate	A351 CF8
LPS	SA216 WCB
MPS	SA216 WCB
HPS	SA216 WCB /SA217 WC6
HHPS	SA217 WC6
LPC	SA217 WC6/WC9
MPC	SA216 WCB
HPC	SA217 WC9
BFW	SA216 WCB/ SA217 WC6
WMW	A351 CF8
Nitrogen	SA216 WCB
Crude Methanol	SA216 WCB
Flashed Methanol	A351 CF8
Refined Methanol	SA216 WCB
Process Gas	SA216 WCB/ A351 CF8
Oxygen	Monel

3. Trim

For Trim Tab the following should be specified:

1.Cv calculation

2.Charachteristic

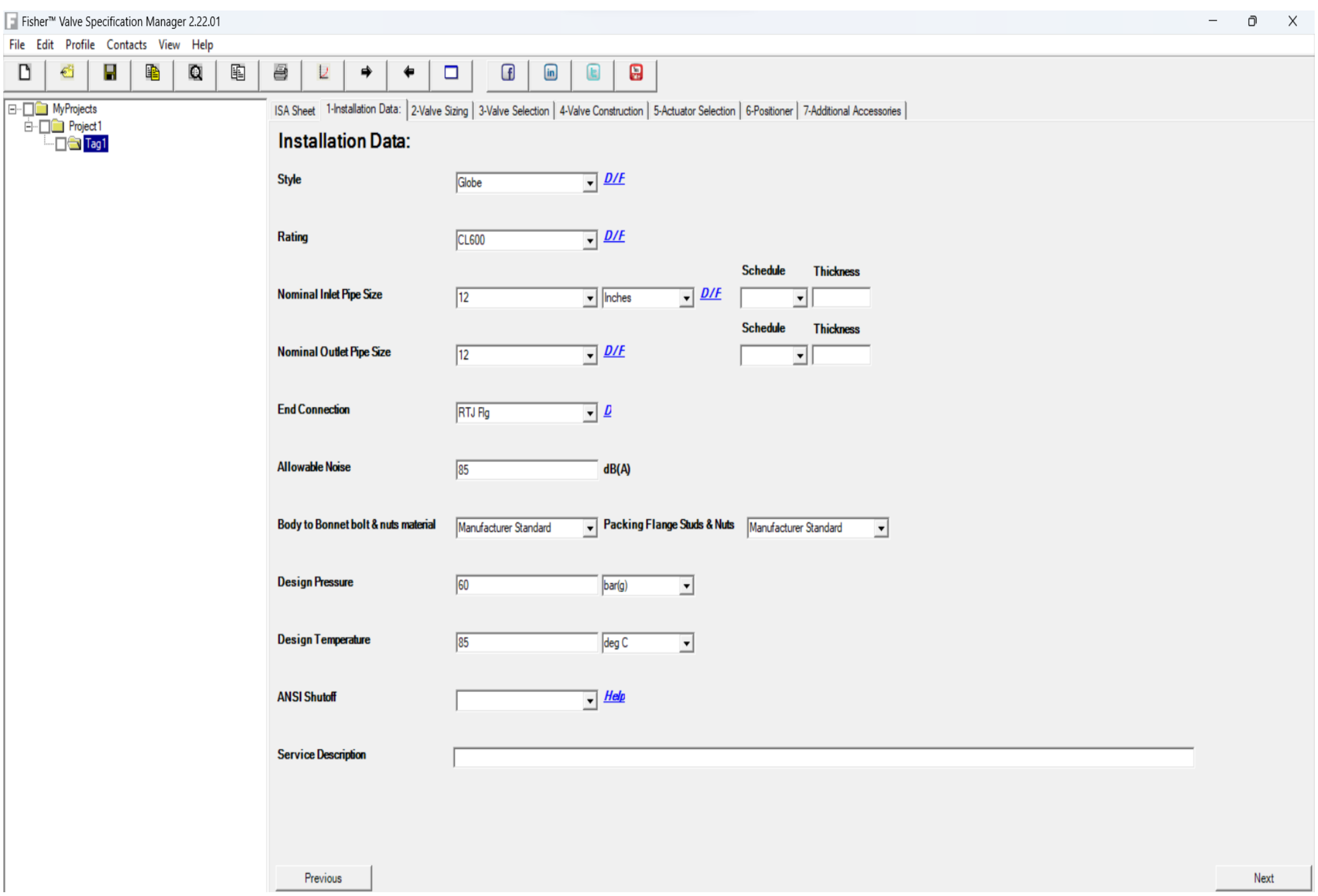
3.Type

4.Material

5.Leakage Class

Cv calculation

For Cv calculation Fisher FSM software is used.



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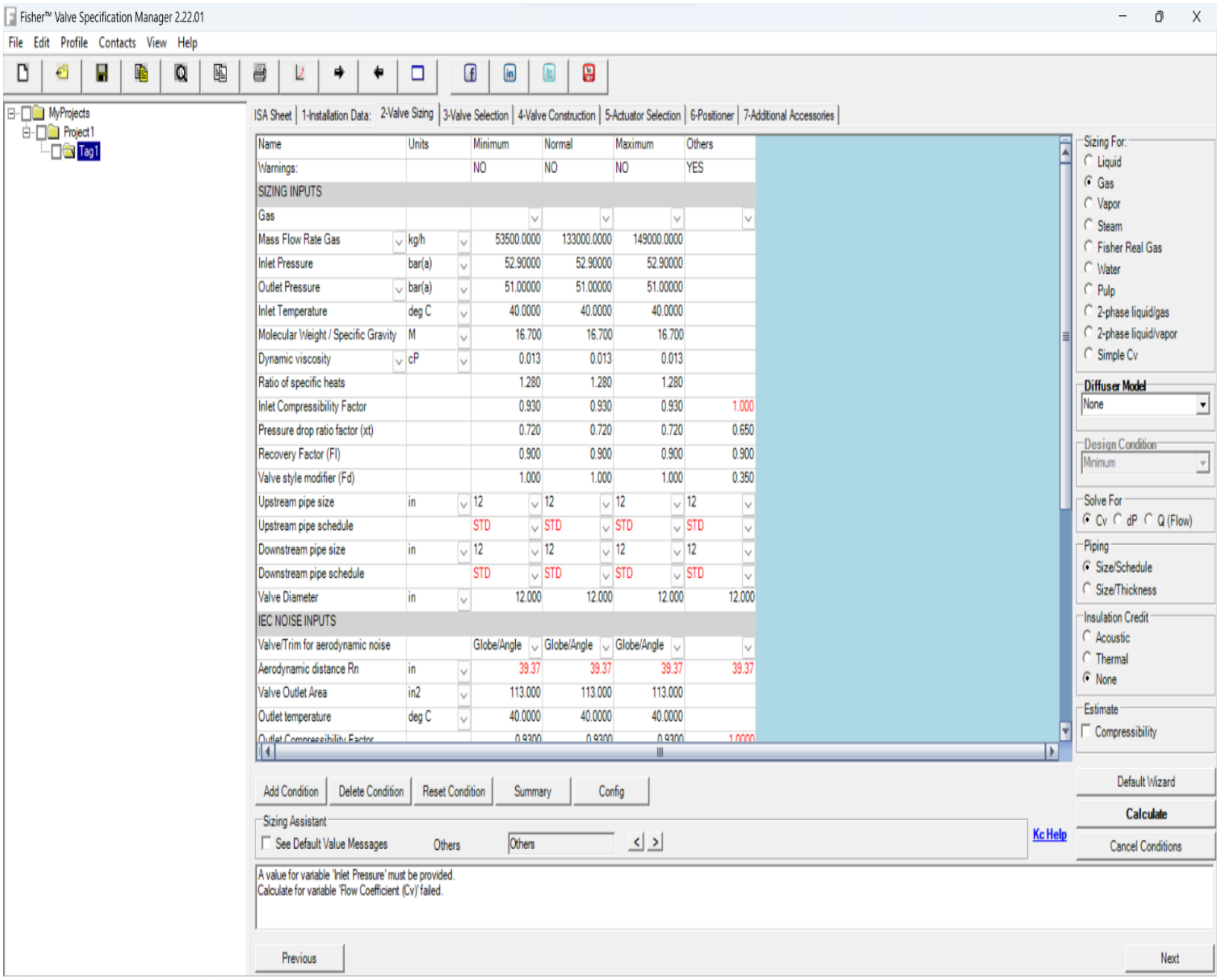

Name	Units	Minimum	Normal	Maximum	Others
Warnings:		NO	NO	NO	YES
SIZING INPUTS					
Gas					
Mass Flow Rate Gas	kg/h	53500.0000	133000.0000	149000.0000	
Inlet Pressure	bar(a)	52.90000	52.90000	52.90000	
Outlet Pressure	bar(a)	51.00000	51.00000	51.00000	
Inlet Temperature	deg C	40.0000	40.0000	40.0000	
Molecular Weight / Specific Gravity	M	16.700	16.700	16.700	
Dynamic viscosity	cP	0.013	0.013	0.013	
Ratio of specific heats		1.280	1.280	1.280	
Inlet Compressibility Factor		0.930	0.930	0.930	1.000
Pressure drop ratio factor (xt)		0.720	0.720	0.720	0.650
Recovery Factor (Fl)		0.900	0.900	0.900	0.900
Valve style modifier (Fd)		1.000	1.000	1.000	0.350
Upstream pipe size	in	12	12	12	12
Upstream pipe schedule		STD	STD	STD	STD
Downstream pipe size	in	12	12	12	12
Downstream pipe schedule		STD	STD	STD	STD
Valve Diameter	in	12.000	12.000	12.000	12.000
IEC NOISE INPUTS					
Valve/Trim for aerodynamic noise		Globe/Angle	Globe/Angle	Globe/Angle	
Aerodynamic distance Rn	in	39.37	39.37	39.37	39.37
Valve Outlet Area	in2	113.000	113.000	113.000	
Outlet temperature	deg C	40.0000	40.0000	40.0000	
Outlet Compressibility Factor		0.9300	0.9300	0.9300	1.0000

Flow Coefficient (Cv)		239.826	596.202	667.925
Volumetric Flow Rate Gas	Nm3/h	71749.68068	178368.36506	199826.21349
Pressure differential	bar	1.90000	1.90000	1.90000
Valve dP/P1 pressure ratio		0.036	0.036	0.036
Pipe and fitting flow correction factor		1.00	1.00	1.00
Combined recovery factor		0.90	0.90	0.90
Adjusted pressure drop ratio factor		0.72	0.72	0.72
Inlet Density	kg/m3	36.49	36.49	36.49
Kinematic viscosity	cSt	0.35624	0.35624	0.35624
Expansion factor		0.98	0.98	0.98
Reynolds Number		171092030.96	270636125.66	286732997.99
Choked flow pressure drop	bar	34.82331	34.82331	34.82331
Upstream Inside Diameter	in	12.000	12.000	12.000
Downstream Inside Diameter	in	12.000	12.000	12.000
IEC NOISE OUTPUTS				
Whisper III Trim Level				
Trim LpA at 1m	dB(A)	70	71	71
Outlet LpA at 1m	dB(A)	< 50	< 50	< 50
Valve LpA at 1m	dB(A)	70	71	71
Valve LpA at Rn	dB(A)	70	71	71
VELOCITY OUTPUTS				
Mach Number Upstream	Mach	0.012	0.031	0.035
Mach Number Valve Outlet	Mach	0.013	0.032	0.036
Mach Number Downstream	Mach	0.013	0.032	0.036
Fluid Velocity Upstream	m/s	5.5812	13.8749	15.5440

The installed Cv is normally selected 20-40% larger than the calculated Cv for the maximum operational flow conditions for valves with linear characteristic, and 30-60% larger for valves with equal percentage characteristic. An over-sizing factor of 1.3 based on the maximum operational flow is used for both types when selecting the required valve Cv.

Valves in venting service shall not be oversized, but specified for the maximum flow condition.

The actual installed Cv for a linear trim must not differ from the required by more than -10% and +10%.

The actual installed Cv for a Eq% trim must not differ from the required by more than -0% and +30%.

Control valves should preferably be designed to operate within the limits of 10% to 90% of their stroke.

The Cv for normal flow divided by the Cv for the minimum required flow should generally be less than 30-40. If control requires higher rangeability, two valves in parallel can be used.

Butterfly valves for on/off service shall be sized for 90° opening, whilst valves for continuous control shall be sized for a maximum opening angle of 60°. Characterised disc butterfly valves are an exception; these may be sized for a maximum opening angle of 90°C.

Maximum permissible velocity for non flashing liquids at valve outlet is 5-6 m/sec. and for gases it is Mach 0.35 at the outlet of the downstream pipe reducer. No extra noise is generated if velocity is Mach 0.3 or less. Maximum sound pressure level shall be 85 dBA measured one meter

Based on above calculation the Cv for normal operation 596 and for max flow 668 is reported.

Also, the required Cv according to above criteria is 596 * 1.3 = 713

The calculated Noise level is 71 dB at 1 meter which is less than max 85 set by the criteria.

The calculated Mach number is 0.03-0.04 which is much lower than 0.35 set by the criteria.

Valve Characteristic

The valve characteristic shall normally be Equal Percentage.

Valves with linear characteristic are used when the differential pressure is 'constant', such as in pressure-reducing, level control and venting services, and when two valves are used in a '3-way valve' function. Gas compressor recycle valves and 3-way valves for flow-splitting shall also be linear.

This usually results in using:

a) Equal percentage characteristic on flow and temperature services.

b) Linear characteristic on level services.

c) Linear characteristic usually for pressure control application, however it

requires consideration about energy loss as stated here above.

Linear characteristics shall be applied when specifically so required by the process and/or

control application as follows:

-Compressor anti-surge control,

-Split range control,

-Control valves that are only operated via manual control,

-Minimum flow protection for pumps.

Quick opening characteristic shall only be used when the quick opening
feature is considered to be necessary for process control reasons.

Quick-Opening Linear Equal-Percentage

Even though based on above rules a linear characteristic should be selected for pressure applications, an equal-percentage is selected due to start-up conditions in which at first stages of start-up low opening of the valve is required while at normal condition high opening is demanded. Equal percentage characteristic fulfills such demand and therefore is selected.

Trim type

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.

1) Globe Valves. Single-seated is the standard valve type in sizes below 8" in non-severe service where the pressure drop and shut-off pressure can be handled. Cage-guided globe valves shall be used for more rough service. Balanced trims can be considered for bigger sizes.

Globe valves with shut-off function shall generally be non-balanced.

Based on above explanation since the valve is going to be used in high pressure services and the size of the valve is more than 8-inch, balanced trim is selected.

Trim material

As standard, the material shall be AISI 316, unless otherwise specified.

Erosion-resistant trim with hardened or hard-faced surfaces are required when the pressure drop across the valve exceeds 10 bar, the temperature is above 315°C, the pressure drop across the valve exceeds 5 bar in steam service, or when there is a risk of flashing/incipient cavitation.

Cobalt-based alloys must not be used for hard-facing in boiler feed water and amine service.

Anti-cavitation trim is selected for high-pressure drop applications to prevent the onset of cavitation.

Anti-noise trim is selected for reducing the noise generated by the fluid.

Trim material for butterfly and gate valves may be the same as the body material.

Since the pressure drop does not exceed above criteria, the temperature is less than 315 and there is no risk of flashing or cavitation AISI 316 is selected for this application.

Leakage Class

Control valves are designed to throttle, but they are also often expected to provide some type of shut-off capability.

A control valve's ability to shut off has to do with many factors: Balanced or unbalanced plug, seat material, actuator thrust, pressure drop, and the type of fluid can all play a part in how wella particular control valve shuts off.

7.7 Seat Leakage Classifications

The classifications per ANSI/FCI 70-2 are:

Class II: 0.5% of rated capacity
Class III: 0.1% of rated capacity
Class IV: 0.01% of rated capacity
Class V: 0.03 ml water/min. per 100 mm port diameter per bar differential
Class VI: See table in ANSI/FCI 70-2

Vent valves that are normally closed shall be very tight to minimise leak losses; class V is the minimum. Block valves in double block-and-bleed arrangement shall be class V-VI (VI in oxygen service). Pump minimum flow valves must be tight, class V to avoid leakage and seat damage

Class IV is also known as a "Metal-to-Metal" seat classification. It is the kind of leakage rate you can expect from a valve with a metal plug and metal seat

Class VI is known as a "Soft Seat" classification. Soft Seat Valves are those where either the plug or seat or both are made from some kind of composition material such as Nitrile or Polyurethane.

Since it is with metal-to-metal seats Class IV is selected.

7.10 Actuators

As positioners are normally required, control valves shall be equipped with pneumatic actuators with a spring range from 0.4 – 2 bar g, in order to obtain small and fast actuators.

If feasible, higher ranges may be used for bigger valves, but the maximum range pressure should not exceed the minimum instrument air supply pressure minus 10%.

If not otherwise specified, actuators shall be sized to obtain a stroke time in seconds that does not exceed the valve size in inches. However, higher speeds will be required for anti-surge valves and slower speeds for preventing water hammer. Ball and plug valves used as shutdown valves shall have actuators designed with a safety factor of 2.5 with respect to start friction, as the friction increases if the valves have remained in one position for a long time.

As a rule, actuators shall be diaphragm- or piston-type with springs to provide the necessary failure action.

Double-acting piston actuators with volume tank and lock-up valves that ensure correct failure position are acceptable where high thrust is required. The volume tank shall be of stainless steel and be sized to stroke the valve twice.

for actuator and positioners Tab the following should be specified:

1.Type

2.Modulating or ON/OFF

3.Failiure position

4.dP for sizing

5.Positioner

Actuator Type:

Based on above criteria, Diaphragm with spring return with spring range of 0.4-2 bar is selected.

Modulating type is selected.

AIR TO CONTROL VALVE OPEN

Failure position

Control valves shall be such that on air failure the valve takes automatically a safe position

either open, or close, or locked in position, depending upon the process requirements.

Based on process requirement air failure holds last position (FLC)

7.13 Positioners and Tubing

Positioners shall be FF/P for Fieldbus communication with full diagnostic possibilities. Positioners shall be vibration-resistant. Output shall match bench-setting of the valve. Positioners shall have output gauges in stainless steel and filter regulators with pressure gauges. Valves in split range shall also have FF AI input; the split is done in the control system.

The positioners shall have sufficient air capacity to stroke the valves as described in clause 8.10.

Air tubes and fittings shall be in stainless steel. Size shall be adequate for the stroking time required. Tubing shall be thin-walled with an OD of not less than 6 mm. Larger valves require tubing with a larger diameter.

For this valve the type of positioner for this valve is FF/P.

Air Tubes and fitting are in SUS

Additional

7.8 Packing

The packing design for linear motion valves shall include a packing flange.

PTFE shall be used as standard packing material for bonnet temperatures below 230°C and graphite for higher temperatures. Higher temperatures can be accepted for PTFE if the bonnet is extended. Packing design and material shall be selected carefully for minimum stem friction and live-loading packing boxes shall be considered for PTFE packing.

Vacuum service and special services like oxygen, require special packing materials and should be given special consideration.

Since the temperature is less than 230 C then PTFE or equivalent is selected as packing for the Valve.

Depending upon design of the valve, an extension bonnet may be required to keep the temperature at the stuffing box to an acceptable value for the applied packing. An extension bonnet may also be required, when the operating differential pressure across the valve may cause freezing of the stuffing box/packing and/or ice formation on the trim. This may be the case, for instance, on compressor recycle (anti-surge) valves. For valves in vacuum service, the bonnet shall have an extended stuffing box, a lantern ring and a number of packing rings. Special attention shall be paid to the type of stem packing/sealing facilities as well as stem surface finish. Packing lubricators with steel isolating control valve shall be provided if required.

The bonnets shall be bolted according to ASME B31.3 and material shall be the same as the body material. Requirements for an extended bonnet depend on the fluid temperature and the chosen packing material.

Fluid type	Bonnet style		
	Plain	Extension	Finned
Gas	0	100	135
Superheated vapour	0	100	135
Saturated vapour	0	0	0
Liquid	0	140	185

Based on natural gas temperature which is 40C, a standard bonnet is selected.

7.9 Flow Tendencies

For valves in shut-off service, flow tendency shall comply with the action required to put the plant in a safe condition in the case of power failure. In some cases it is the back-flow scenario that shall be considered.

Generally, it is the flow-to-open tendency that is the most stable type of operation for modulating control valves. This is therefore the preferred flow direction for globe valves. For angle valves, the direction should be flow-tends-to-close. The direction of flow shall be clearly marked on the valve body.

There is a practice by some vendors which as follows:

over-plug flow for liquid services

under-plug flow for gas and vapor services

For the valve with natural gas as fluid a under-plug flow with flow-to-open tendency is selected.