HG / HA-Series Control Valves

Tortuous Flow Path X[iks]-Trim Application Globe & Angle Valves

Flow Dynamic Management Technology

Introduction

X[iks]-trim is BFS's top-of-the-line high performance special trim that offers a proven solution to those severe service applications where a true velocity control trim is the best or possibly the only answer.

By limiting the fluid velocity inside the valve, X[iks]-trim disk stack design precludes those problems typically associated with high velocity such as erosion, noise ,vibration and poor control. Every X[iks]-trim disk stack is custom engineered to meet the needs of the toughest liquid, steam and gas services in the power and process industries.

Contents

Model Numbering System

□□	□□	□□	□□	□□
Body series	**Trim Design**	**Trim Type**	**Body Rating**	**Actuator Type**
HG / Heavyduty Globe	G1 / Unbalanced	XT-X[iks]-trim	01-150 / 10K	DR-Diaphragm/Rever.
HA / Heavyduty Angle	G2 / Balanced	XS-Small X[iks]-trim	02-300 / 20K	DD-Diaphragm/Direct
	G3 / Aux. Pilot Plug	XP-Punch X[iks]-trim	03-600 / 40K	CS-Spring Cylinder
			04-900 / 62K	CD-Double Cylinder
			05-1500	EM-Electric Motor
			06-2500	HS-Hydraulic Cylinder
			07-4500	HC-Self Contained Hydraulic Actuator
				HO-Gas-Over-Oil Hydraulic Actuator

1. HG/HA-series,
X[iks]-Trim Valve Specification

- **Body Style**
  ; Heavy-duty Globe, Angle Pattern Body.
- **Body Size :** 1-1/2" to 36" / Over 36"(option)
- **Pressure Rating :**
  ; ANSI# 150,300,600,900,1500,2500,4500.
  ; KS(JIS) 10K, 20K,40K, 62K, DIN,API (Option)
- **End Connections :** FF, RF, RTJ, BW, SW, SCRD, Etc..
- **Bonnet :** Bolted type, Pressure Seal type.
  ; Standard type.
  ; Extension type.
  ; Bellows seal type.
  ; Long Extended type / Cryogenic Service.
- **Flow Direction**
  ; Flow to open / Compressible Gas & Steam
  ; Flow to Close / Liquid, Water
- **Trim Design** : Balanced
- **Trim Form**
  ; X[iks]-trim
  ; G3/APT / Auxiliary-Pilot-Plug Trim
- **Characteristics :** Linear, EQ-%, Modfied-%. Quick-open.
- **Rangeability :**
  ; 30:1, 50:1, 80:1, 100:1. / Option 800:1.
  ; As required by application.
- **Seat Leakage**
  ; Standard - FCI 70-2. Class IV
  ; Option - FCI 70-2. Class V. VI. / MSS-SP-61
- **Materials of Body & Bonnet**
  ; A216-WCB, LCC, A217-WC6, A217-WC9, A217-C12A, A105, A182-F11,F22, F91, F92, Inconel.
  ; A351-CF8,8M, CF3,3M, Monel, Duplex, Al-Bronze, Alloy Hastelloy, Titanium, Tantalum, Etc...
- **Materials of Trim**
  ; 316 SS, 410 SS, 416 SS, 420 SS, 420J2, 431 SS, 630 SS,
  ; 17-4PH, A182-F11/F22+Stellite overlay. Etc...
  ; Inconel, Other Special Materials
  ; Special Treatment / C.V.D Treatment.
- **Actuators**
  ; Spring Diaphragm
  ; Double Cylinder & Spring Cylinder
  ; Electric Motor
  ; Hydraulic Cylinder
  ; Self Contained Electro-Hydraulic Cylinder
  ; Gas-Over-Oil Hydraulic Cylinder
- **Hand-wheel / Option.**
  ; Worm Gear Box / Side mounted or Top Mounted
  ; Hydraulic Hand Jack.

2. Key Features

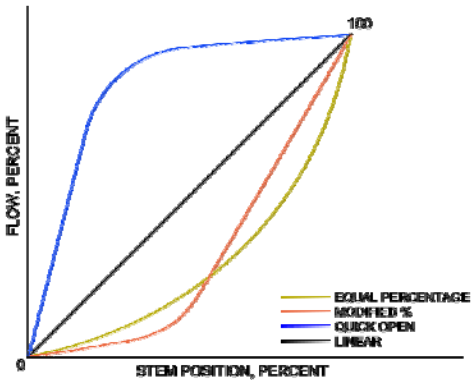
- Multi-turns(stage) X[iks]-Trim® disk stack technology
  ; Limits trim fluid exit velocity and kinetic energy
  ; Multi-stage pressure drop
- Multiple Cv Trims throughout disk stack
- Balance Seal
  ; High integrity spring energised teflon balance seal
  ; Inconel with graphite seal for high temp. application.
- Class V metal seat shut-off with 500 PLI loading force achieves tight shut-off
- Custom designs available for high temperature and other applications
- Disk stack labyrinth groove design eliminates flow passages and breaks up clearance flow preventing seat ring damage

Ensure High System Reliability and Efficiency

There are many components to system reliability and efficiency. These include:

• Maintain plant efficiency
• Maintain high plant throughput
• Ensure high valve and equipment reliability
• Increase plant availability.

All of these are consistent with each other. Excellent products and services ensure an excellent system that is reliable and efficient. Compromising with a lower cost inferior technical solution to save money will end up costing more money in the long run. How can you meet the above purposes? By specifying the critical control valves important to the project at an early stage. Critical control valves heavily impact the above aspects of the plant the Owners are measuring. The valve specifications ensuring that the above requirements are met, include the Control valve Specifications based on ISA.



Cv Curve Characteristic

3. HG,HA-Series

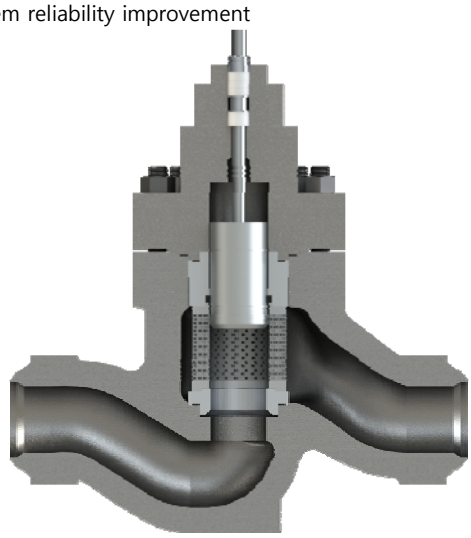
3-1. HG-Series / Globe Body

3-1-1. Feature of HG-Series

X[iks]-trim disk stack control element
Feedwater main flow control valves
Equal-Percentage or Modified-Percentage characteristic.
High Rangeability and Long Valve Stroke
Quick Change Trim
Globe valve configuration

2-1-2. Benefit of HG-Series

Combine Start-up and Main valve (Rangeability 100:1)
Precise Flow Control
Start-up time and maintenance cycle reduction
Plant efficiency improvement
Erosion and cavitation elimination
System reliability improvement



X[iks]-Trim Globe Valve / HGG2XT-Series

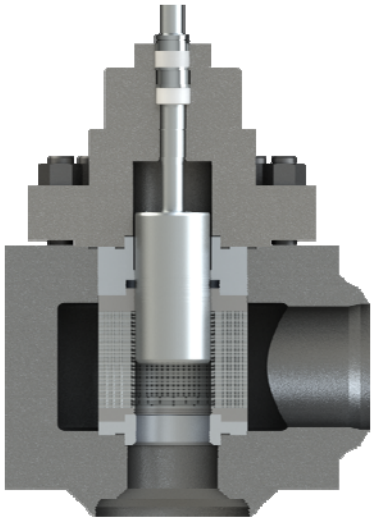
3-2. HA-Series / Angle Body

3-2-1. Feature of HA-Series

X[iks]-trim disk stack control element
Equal-Percentage or Modified-Percentage characteristic.
High Rangeability
Long Valve Stroke
Quick Change Trim
Angle valve configuration

3-2-2. Benefit of HA-Series

Eliminate costly and damaging leakage (ANSI Class V)
Feedpump recirculation and reliable pump protection
Start-up time & Maintenance cycle reduction.
Plant efficiency improvement
Erosion and cavitation elimination
Avoid plant shutdowns.
System reliability improvement



X[iks]-trim Angle Valve / HAG2XT-Series

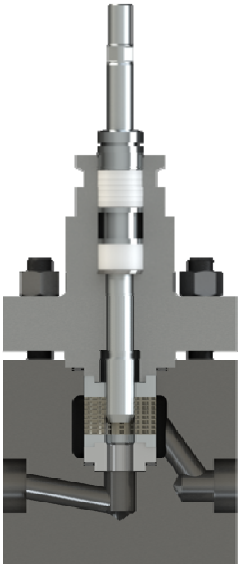
3-3. Unbalanced Small X[iks]-trim

3-2-1. Feature of Unbalanced Small X[iks]-trim

X[iks]-trim disk stack control element
Equal-Percentage or Modified-Percentage characteristic.
Repeatable leakage class V shutoff
Quick Change Trim
Angle and Globe valve configuration
Forged steel application

3-2-2. Benefit of Unbalanced small X[iks]-trim

Attemperator spray-water control valves
Fuel cost savings
Precise low end temperature control
Feed-pump output increase & reliable pump protection
Easy maintenance and Maintenance cycle reduction.
Plant efficiency improvement
Erosion and cavitation elimination



Small X[iks]-Trim Valve / HGG1XT-Series

4. X[iks]-Trim®

4-1. Labyrinth Flow Path Disk Stack Type Trim

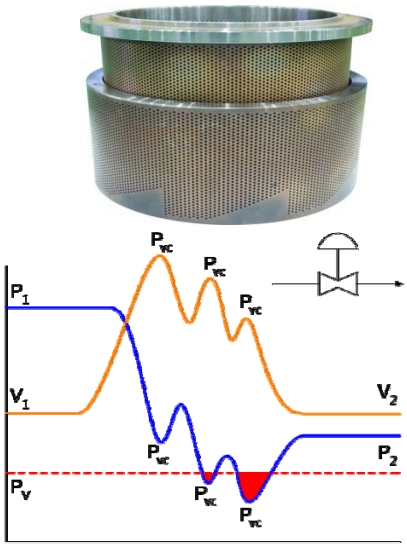
The X[iks]-trim disk stack incorporates a unique advanced design that is super at limiting flowing velocities to low levels resulting in valves providing service that is quiet, non cavitations and non erosive.

X[iks]-trim disk stack low velocity is achieved through the use of a trim cage made by bonding together a series of individual disks. Each disk has a pattern of carefully controlled orifices and channels with a multitude of sharp turns etched into its surface. As the trim plug travels within the cage the fluid is throttled and forced to travel an extremely torturous path with each turn effecting a stage of pressure drop.

The combined effect of numerous narrow flow channels, each with many sharp turns and a continually expanding flow path, removes kinetic energy from the fluid while gradually lowering its pressure. In doing so, abrupt velocity increases that are the source of noise are avoided. The additional benefit for liquid flow is the elimination of cavitations and damage it can do to a valve, its trim and the downstream piping

By its very design, X[iks]-trim disk stack allows for many more stages of drop than conventional tortuous path times, which resolves existing problems for both compressible and incompressible fluid flow applications.

Globe and Angle valves are available with disk stacks with passages that are uncovered as a closely fitted plug travels to open positions. Each disk has a pattern of turns machined in one side, forcing the flow through a tortuous path.



Drilled Multi-Hole Multi-Stage Trim / MHMS

4-2. Cavitation

Cavitation, a common cause of structural damage in control valves, is the rapid formation and collapse of vapor pockets. This violent phenomena can produce surface stresses greater than 200,000psi (1,400Mpa), consuming even the highest hardness trim materials. Trying to compensate for cavitation with the addition of hard surface treatments is a temporary fix that only incrementally increases the life of the trim. The key to increasing trim life is to eliminate the root cause of cavitation, excessive trim velocities. BFS adheres to the ISA guidelines for trim exit velocity

Service conditions	Velocity at Trim Exit
Continuous service single phase fluid	30m/sec
Cavitating & Multi-phase fluid	23m/sec.
Vibration-sensitive systems	12m/sec

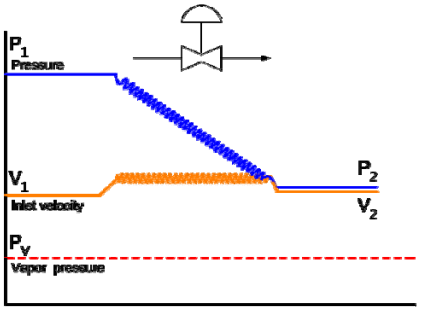
Recommendation for fluid velocity to control cavitation

Based on information presented in the publication "Control Valves-Practical Guides for Measurement and Control", edited by Guy Broden. Jr. and Paul G Friedman. 1998 edition. published by ISA and other sources.

4-2-1. Impact of Cavitation

The trim damage that is the result of cavitation can adversely affect the performance of the plant. Many applications require that the control valve have fine control or tight seat leakage performance. When a trim is damaged by cavitation these attributes can be negatively impacted resulting in:

- Noise and vibration
- Trim damage
- Poor control
- Increased seat leakage
- High maintenance costs and downtime.



Labyrinth Disk Stack Trim / X[iks]-Trim Solution

4-2-2. Cavitation Index

Various cavitation indices have been used to correlate performance data to improve designs of hydraulic process equipment. A cavitation index, called Sigma (δ), has been developed and applied to quantify cavitation in control valves;

$$\delta = \frac{(P1 - Pv)}{(P1 - P2)}$$

Where

P1 = Upstream pressure (psia), measured two pipe diameters upstream from the valve.

P2 = Downstream pressure (psia), measured six pipe diameters downstream from the valve

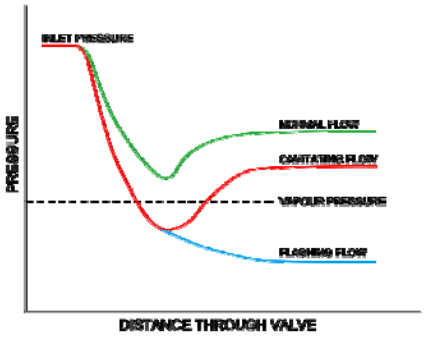
Pv = Vapor pressure of the liquid at flowing temperature.

Sigma is seen as the ratio of the potential for resisting cavity formation to the potential for causing cavity formation. When Sigma is 1.0 or less, flashing is occurring. Through laboratory and field testing results, acceptable operating Sigmas for eliminating cavitation (and its associated choking, noise, and damage) have been established. For example:

Tests indicate that a full-area, single-seated globe valve at 100 percent open with 27℃(vapor pressure of 0.5 psia), 200 psia water and with flow-over-the plug chokes at a downstream pressure of 56 psia. The choked cavitation index is then:

$$\mathbf{S}_{\text{choked}} = \frac{(200 - 0.5)}{(200 - 56)} = 1.39$$

These tests also indicate that cavitation damage ($\mathbf{S}_{\text{damage}}$) for this particular style of valve in continuous operation begins at about $\mathbf{S}_{\text{damage}} = 1.73$. The point at which incipient cavitation ($\mathbf{S}_{\text{incipient}}$) occurs can also be deduced from tests; it is found at a somewhat higher value than $\mathbf{S}_{\text{damage}}$ (i.e. lower pressure drop)



If this same valve operates wide open at an upstream pressure (P1) of 500psia and downstream pressure (P2) of 200 psia, and the water temperature increased to 82℃ (vapor pressure = 7.5 psia), the operating Sigma is:

$$\delta_{\text{operating}} = \frac{(500 - 7.5)}{(500 - 200)} = 1.64$$

Because this Sigma value is greater than δ_{choked}, the valve is not choked at these conditions. However, the Sigma is less than δ_{damage}; therefore, the valve may experience cavitation damage unless special anti-cavitation trim or harder materials are used.

Some of the other factors that affect the intensity of cavitation are the magnitude of the actual service pressure compared with test pressures, the flow path geometry and the fluid purity. By researching these factors, methods of scaling the index for such variables have been established. This geometry and pressure scaling is not accounted for in the use of liquid pressure recovery factory (F_L) and liquid cavitation factor (Fi) in previous valve sizing equations.

Globe Valves experience minimal cavitation damage when operating at low pressure (Sigma between 2 and 1.7). Generally, in these cases, no cavitation control trim is necessary. However, at between Sigma 1.7 and 1.15, some cavitation control is usually required. When the Sigma index for a valve is less than 1.15, the potential for severe cavitation damage exists and a staged pressure drop severe service trim must be included in the valve's sizing.

4-3. Choked Flow

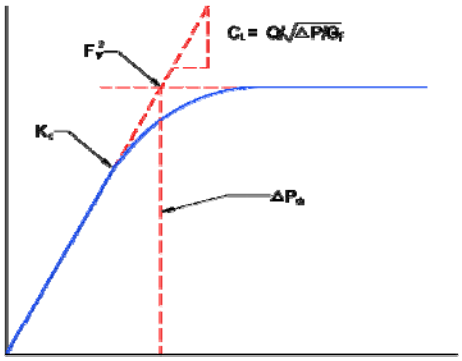
Also known as critical flow. This condition exists when at a fixed upstream pressure the flow cannot be further increased by lowering the downstream pressure. This condition can occur in gas, steam or liquid services. Fluids flow through valve because of a difference in pressure between the inlet(P1) and outlet (P2) of the valve. This pressure difference (ΔP) or pressure drop is essential to moving the fluid. Flow is proportional to the square root of the pressure drop, which means that the higher the pressure drop is the more fluid can be moved through the valve. If the inlet pressure to a valve remains constant, then the differential pressure can only be increased by lowering the outlet pressure. For gases and steam, which are compressible fluids, the maximum velocity of the fluid

through the valve is limited by the velocity of the propagation of a pressure wave which travels at the speed of sound in the fluid. If the pressure drop is sufficiently high, the velocity in the flow steam at the vena contracta will reach the velocity of sound. Further decrease in the outlet pressure will not be felt upstream because the pressure wave can only travel at sonic velocity and the signal will never translate upstream. Choked flow can also occur in the liquids but only if the fluid is a flashing or cavitation condition. The vapor bubbles block or choke the flow and prevent the valve from passing more by lowering the outlet pressure to increase the pressure drop. A good Rule of Thumb on Gasses and Steam service is that if the pressure drop across the valve equals or exceeds one half the absolute inlet pressure, then there is a good chance for a choked flow condition.

Example

P1 = 100psig
P2 = 25psig
ΔP = 75psig
P1(ABS) = 100+14.7 or 114.7
½ of 114.7 = 57.35
Actual pressure drop = 75

Choked flow is probable. The style of valve (that is whether it is a high recovery or a low recovery style) will also have an effect on the point at which a choked flow condition will occur.



Choked Flow Curve

4-4. Noise and Vibration

Noise and vibration are pervasive in applications involving throttling or venting of compressible gases. Frequently, these problems can be avoided with the selection of a valve that can properly control the kinetic energy of the fluid during the pressure letdown process. BFS encourages the process industries to adhere to ISA guidelines for valve trim exit kinetic energy in order to ensure noise and vibration problem are avoided.

Service Condition	Kinetic Energy	Velocity Head
Intermittent Duty	150 psi	1030 kPa
Continuous Duty	70 psi	480 kPa

Recommendation for kinetic energy / Velocity Head at trim exit.

Based on information presented in the publication "Control Valves-Practical Guides for Measurement and Control", edited by Guy Broden. Jr. and Paul G Friedman. 1998 edition. published by ISA and other sources.

5. X[iks]-trim for Severe Service Applications

5-1. Fluid Applications

5-1-1. Gas Applications

With gases, the X[iks]-trim design features a unique flow path that permits radial expansion of the fluid. The trim is effective on large pressure reductions in gases, because an additional flow path expansion is provided to handle the increasing volume as the pressure is decreased. This is accomplished by making disk stack and each passage with flow path stages(turns). The increased flow area maintains acceptable gas velocity at every point across the disks.

5-1-2. Liquid Applications

With X[iks]-Trim, a series of small, multiple pressure drops prevent cavitation from occurring at any point inside the valve. The amount of pressure drop that can be taken without cavitation occurring is proportional to the difference between the local static pressure and vapor pressure. The expanding X[iks]-Trim design is used with liquids to eliminate most of the pressure drop as the flow first enters the trim. Because the fluid flows under the plug, the smaller turns in any passage are encountered first, resulting in a higher pressure drop. As the fluid progresses through the stack, the expanding disk pattern allows the pressure to be reduced in a series of successively smaller pressure drop without excursions below the vapor pressure- avoiding the formation of cavitation altogether.

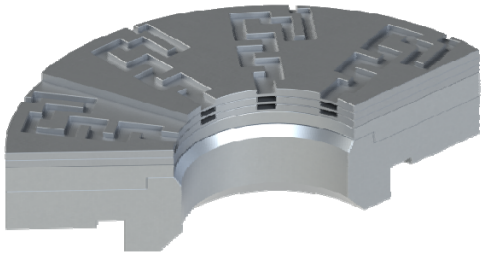
5-1-3. Velocity Control

One of the fundamental design considerations with BFS control valves with X[iks]-trim is the establishment of acceptable velocities at every point as the flow passes through the valve. For liquid applications, maintaining valve outlet velocities below 30feet per second is desirable -although higher velocities may be acceptable depending upon the application and process fluid.

For gaseous control valve applications, keeping the maximum outlet gas velocity below 0.33 Mach is desirable, although higher velocities may be acceptable based on the application.
Velocity must be assessed for the most difficult flowing conditions at the following critical points (as shown in below picture)

5-1-4. Pressure Reduction Through Sudden Expansion and Contraction

An important mechanism acting to reduce the pressure in X[iks]-trim is the sudden expansion and contraction phenomenon that takes place as the flow passes over the labyrinth disk of X[iks]-Trim. The X[iks]-trim valves ability to gradually reduce pressure is important for the reduction of noise in the process line.



X[iks]-Trim Disk Stack Sectional View

5-1.5. Easy Maintenance

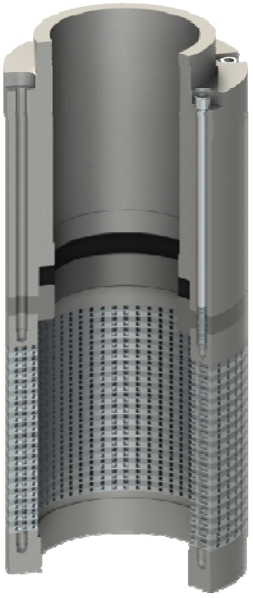
All BFS control valve trims are designed for easy maintenance and X[iks]-Trim is not an exception. Clearance between the stack and plug is designed for an optimum combination of stability and smooth operation. The clamped-in seat, top-entry trim design permits quick disassembly. The X[iks]-Trim can be easily removed for inspection or cleaning. The X[iks]-Trim design is ideal for fluids with entrained particles. Fine and medium-sized particles easily pass through the disks including any horizontal boundaries within the stack.

5-2. Power Plant

5-2-1. Coal Fired, HRSG, Bio-mass, Cogeneration.

Coal Fired : Drum Boiler (Include Sub-Critical Pressure Class)
Once Thru Boiler (Super Critical Pressure Class)

Drum boilers vary in size, from small boilers used to generate steam industrial heating up to the large public utility boilers which produce enough steam to generate up to 900 MW of power,

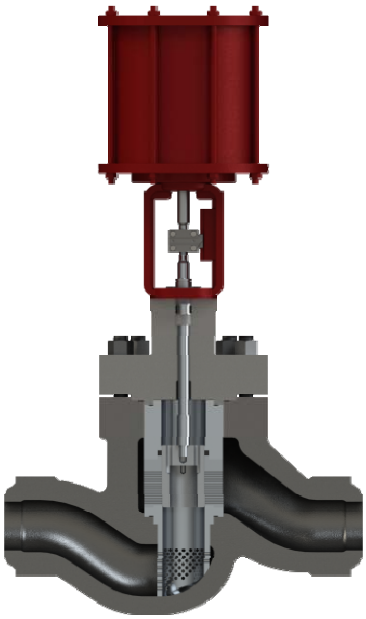


1-pices trim for horizontal install Angle Pattern Valves (Seat-ring+Cage+Balance Cylinder+ Balance Seal)

- We supply the X[iks]-trim feed-water regulators for small boilers. The cogenerating units are between 50 MW to 200MW in size. In these units, we supply feed-pump recirculation valves, and auxiliary steam valves. Vents are another application.
- Combined cycle plants often require turbine bypass valves of 50-100% capacity.
- Large utility drum boilers have more severe service applications which require X[iks]-Trim® valve technology. These boilers also require turbine bypass valves.
- Drum level control of conventional fossil fired plants (combined and start-up)
- Start-up feed-water regulator valve on large sub-critical and supercritical boilers
- Boiler circulation valves, used on supercritical once-through boilers to maintain minimum flow through the boilers

- Feedwater pump recirculation control valve
- Feedwater start-up (minimum flow) control valve
- Feedwater main flow control valves
- Condensate booster pump recirculation
- Deaerator level control valve
- HP/LP attemperator spray control valve
- HP/LP coolant injection control valve
- HP/LP turbine bypass valves
- Turbine extraction/exhaust desuperheater.
- Process desuperheater
- Auxiliary PRDS system
- Auxiliary steam shoot blower control valve

- Atmospheric steam dump valve
- Steam generator blow down valve
- HP heater drain control valve
- Other severe service control valves



Globe X[iks]-Trim Heater Drain Valve with Flow Distributer Integral with the Seat Ring

5-2-2. Nuclear Power Plant

In nuclear facilities, the highest level of equipment reliability is required to insure plant and public safety. X[iks]-trim valves provide this dependability with design for class 1, 2 and 3 applications that range from hand-operated 3/8" to 20" pressure rating ANSI class 1500.

These applications involve various flow media, temperature and pressure drop.

- Main steam atmospheric dump & condenser dump.
- Main steam atm. dump & turbine bypass condenser
- Pilot operated valve, Pressurizer relief valve.
- Steam generator blow down.
- Main feedwater with minimum flow control valves.
- Feedwater pump recirculation control valve.
- Condenser dump
- Heater drain
- Boric Acid flow control, Condensate clean-up circulation.
- Condensate feed pump recirculation.

5-3. Oil & Gas, LNG, Petrochemical...

BFS develop and provide severe service valve in oil & Gas plants including LNG plant..

The challenges of higher wellhead pressures, with aggressive fluids and entrained solids, have been met with the combination of advanced materials(C.V.D treatment) and X[iks]-trim velocity control technology.

Quick stroking requirements for the compressor recycle have reached less than one second using low cost and highly reliable pneumatic actuation.

Repeatable tight shutoff is ensured with proven balance seal with velocity control trim parts.

X[iks]-Trim Valve Technology has advanced along with the Oil & Gas industry. Hydraulic actuation has been used but is not favored due to high maintenance, and reliability cost.

BFS can assist in selection of Severe Service valve applications, to ensure low ownership costs. BFS can lower installation cost due to smaller pipe sizes, and reduce parallel valve installation due to high valve rangeability. For example, in compressor recycle, a start-up ball valve may be in parallel to the recycle valve. However, BFS can add this application requirement into the compressor recycle application, saving the client installation costs.

To summarize, Severe Service applications are critical for low noise, protection of major requirement components, minimizing loss of product or feedstock, increase compressor efficiency, and ensuring high plant reliability and efficiency. BFS engineers can review systems and apply proven solutions to lower installation cost.

5-3-1. Oil Production

Production

- Production Choke
- 1st. Stage separator level control
- 2nd. stage separator level control
- Separator pressure control
- Gas to flare

Injection

- Compressor recycle
- Gas injection
- Steam injection
- Water injection pressure control
- Water injection pump recirculation
- Overboard dump

Oil Export

- MOL. pump recirculation
- Pressure control
- Flow control

Balance of Plant

- Fire water pump recirculation
- Fire water pump discharge.

5-3-2. Gas Production

Production

- Production choke
- 1st. Stage separator level control
- 2nd. stage separator level control
- Separator pressure control
- Gas to flare
- Emergency depressurizing

Injection

- Methanol injection

Gas Export

- Compressor suction throttle control
- Gas export pressure control
- Compressor recycle

Balance of plant

- Fire water pump recirculation
- Fire water pump discharge

5-3-3. Gas oil Separation Plants

- 1st. Stage separator level control
- 2nd. stage separator level control
- Separator pressure control
- Gas to flare
- Emergency depressurizing

Punched X[iks]-Trim Sectional View

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5-3-4. Severe Service Application for oil & Gas

- Compressor recycle & Anti-surge valve
- Blow down discharge to vent flare
- Reactor depressurization
- Turbo expander bypass
- Gas injection lift control
- Gas storage pressure letdown
- Gas flow regulation
- Pipeline anti-surge
- Heavy-oil letdown
- Ethylene letdown
- Steam vent atmosphere
- Wellhead/production choke valves
- Sweep Angle Valves
- Methanol injection
- Metering stations (active monitor)
- Emergency depressurizing / Gas to flare.
- Amine letdown
- Process gas to vent / flare
- Air vent to atmosphere.

6. C.V.D Treatment / Hard Facing

Chemical Vapor Deposition.

Using the CVD process to improve the wear life of metal components. This is not for simple coating on the material surface, but for a surface penetration.

So, the CVD treated material has no flaking which usually takes place in the coated material such as in Titanium Carbide and Tungsten Carbide Coating etc.

What is "CVD"

CVD is thermo-chemical surface treatment in which metal atoms are diffused into the surface of a workpiece to form CVD layer with the base material.

CVD has been proven to have more than several times the wear life of metal parts with tungsten and titanium carbide coating, carburized, nitride, nitro-carburized, or hard chrome plated in numerous applications.

Features

Excellent wear resistance from surface hardness of 1700 – 2300HV achieved on steel and nickel, cobalt based alloys, tungsten carbide, titanium carbide. Proven to have more than several times the wear life of many components. Hardness is retained at high service temperature 650℃.

CVD increases acid corrosion resistance to Hydrochloric, Sulfuric and Phosphuric acids in particular.

Properties of CVD Layers

The hardness of layers on steel ranges between 1700 and 2300HV (77 – 88 HRC). Hardness of layers varies with base material, Layers also retain hardness up to subcritical temperature 650℃.

Layers depths range from 20 to 150-micron M depending on base material and application with the layer depth being matched to the intended application.

(Stellite #6 Facing HRC45° / CVD Treatment HRC84°)

Resistance to Acids

CVD can increase the resistance of low alloy steel to acids such as sulfuric, Phosphoric and Hydrochloric. CVD austenitic stainless steel has excellent resistance to Hydrochloric acid.

7. Special Application

7-1. Anti-Surge Valves

7-1-1. Compressor Recycle Valve Configuration

Normally gas flow through a X[iks]-trim recycle valve is under the plug. Gas flow passes through the plug seat-ring area under full compressor discharge pressure before entering the energy-dissipating disk stack. This configuration takes into account the expanding gas volume as it passes from the inside diameter of the disks to the large outside diameters. For this same reason compressor recycle valves are usually provided with larger outlet than inlet nozzles. These inlet and outlet nozzles are sized to hold velocity heads below 30 psi.

- **Quick Response** : X[iks]-trim valve with a fast acting pneumatic double acting piston actuator that will stroke in less than 1 sec.
- **Thight shut-off** : X[iks]-trim valve for compressor recycle / Anti-surge service designed with an ANSI Class VI soft seat, Class V metal seat to assure repeatable tight valve closure at shut-off. (MSS-SP-61)
- **Noise Control** : The disk stack surrounds the plug throughout its travel from closed to wide open. Thus the velocity head throughout valve is controlled regardless of plug position. Velocity head **(ρv2/2gc)** through this disk stack is limited to 70 psi (480Kpa) to minimize noise. The design can hold noise level to 85 dBA or below at 1meter to comply with the current noise abatement regulations.

Typical Anti-Surge Valve Section View

7-1-2. Compressor Recycle Actuation

In an upset situation, recycle valve must rapidly stroke from full closed to full open to adequately protect the compressor from severe damage. In many cases this means a valve stroke travel of up to 24-inch less than two seconds.

7-2. Liquid filed Natural Gas

Vent-to-Flare

As an LNG train comes on-line, it is essential to achieve a stable and controllable gas flow prior to passing the gas into the separators, strippers, compressors, and other critical process equipment. The gas flow is passed through a vent-to-flare valve until the unit reaches the desired level of capacity.

The BFS HA-series is available with MH1S, MH2S, MHMS trim, as well as X[iks]-trim for higher pressure drop applications. These valves are available with a number of different instrument packages to meet various specifications, including a fast stroke of 1 second or less, or precise control with resolution to 1/10,000th of an inch.

- Reliable venting of gas in less than 1 second.
- Seat Leakage Class V. & MSS-SP-61 Tight shut-off

7-3. Power Generation

7-3-1. Vent to Atmosphere

Similar to the Vent-to-Flare application, the vent-to atmosphere valve must contend with the problems of high pressure, high noise and gas expansion.

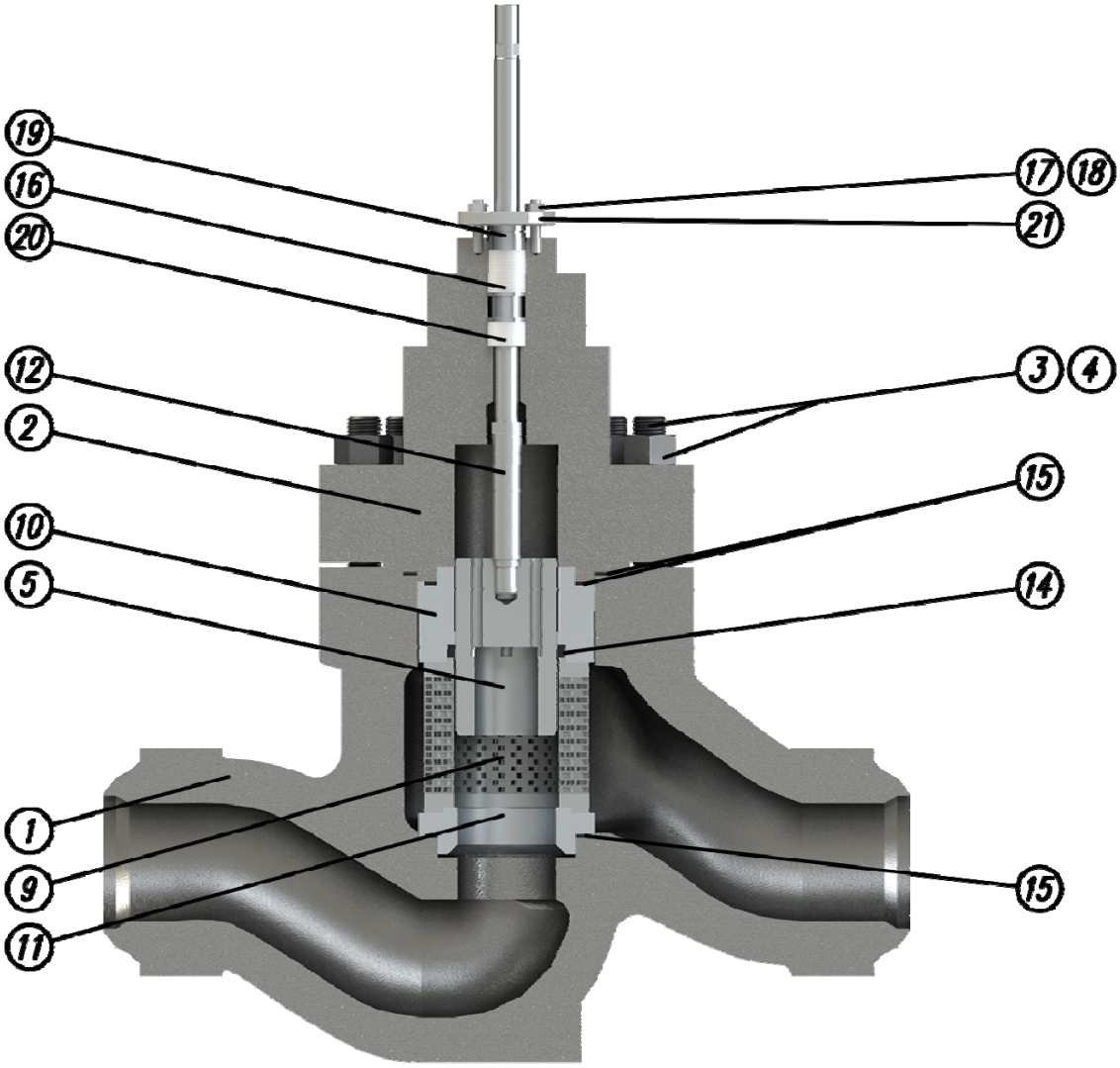
7-3-2. Soot-Blower & Auxiliary Steam

Depending on the power plant design, soot blower and auxiliary steam process applications can exhibit a wide range of pressure drops. Because of the wide range of pressure drop ratios, no one valve or trim design is best suited to serve all possible variations of soot blower and auxiliary steam process applications.

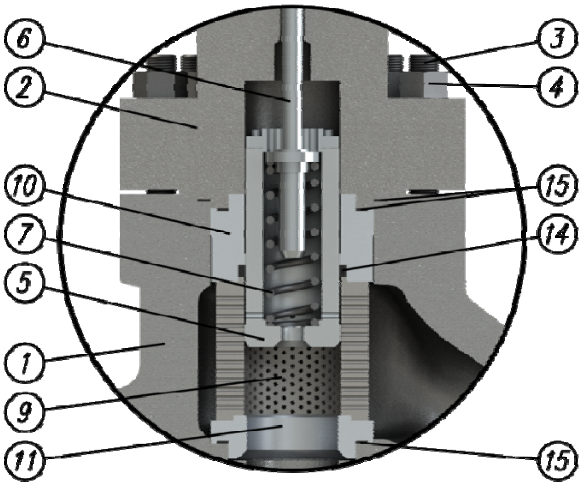
7-3-3. Boiler Feedwater Start-up & Regulator Valves

Conventional power plants are often designed with feedwater systems using two separate control valves. The first control valve is used for start-up, as the conditions yield a low amount of flow with severe pressure drop. This start-up condition exhibits high cavitation risk and requires a very rugged valve solution. Typically a second control valve is used to regulate the feedwater conditions as the plant operates at full capacity. This main feedwater regulator valve does not experience cavitation.

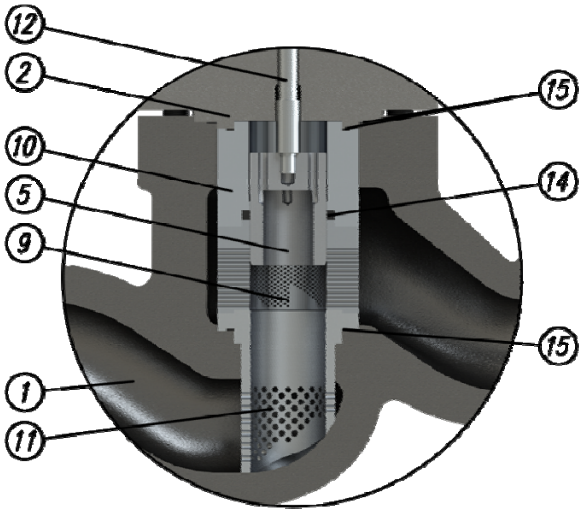
Body Assembly Construction / HG-Series



HGG2XT-Series / Globe Pattern Body X[iks]-Trim Application



Aux. Pilot Plug X[iks]-Trim View./ HGG3XT-Series



Heater Drain Application Internal Diffuser

Standard Material Application of HG/HA-series

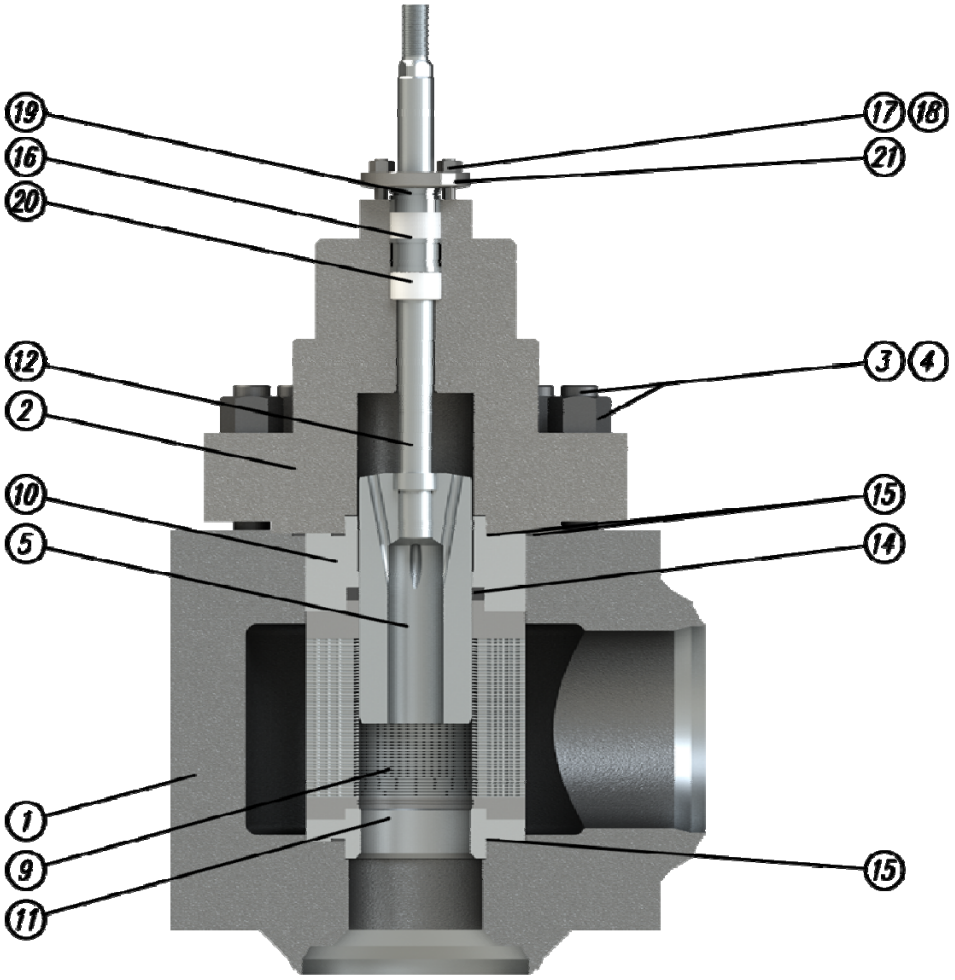
Fluid Temperature / ℃		-196	-45	-29	0	+270	+425	+450	+480	+566	+610	+710
Ref. No	**Parts Name**	**Application Materials**										
1	Body				A216-WCB / A105							
					A217-WC6,WC9, C12a / A182-F11, F22, F91, F92					F91	F92	
		A351-CF8, A351-CF8M, A351-CF3, A351-CF3M, 304 SS,316 SS, 304L SS, 316L SS.										
2	Bonnet				A216-WCB / A105							
					A217-WC6,WC9, C12a / A182-F11, F22, F91, F92					F91	F92	
		A351-CF8, A351-CF8M, A351-CF3, A351-CF3M, 304 SS,316 SS, 304L SS, 316L SS.										
3	Body Studs			SNB7							SNB16	
				Alloy Steel ASTM A193 Gr. B7								
		304 SS										
4	Body Stud Nuts			S45 C							ASTM A194 Gr. 4	
				Alloy Steel ASTM A194 Gr. 2H								
		304 SS										
5	Plug	316 SS or 316 SS + Stellited.										
					410 SS					Alloy Steel + Stellited / Inconel		
6	Pilot Plug	400 Series Stainless Steel / 17-4PH (630SS)								Inconel		
		316 SS or 316 SS + Stellited.										
7	Pilot Spring				17-4PH/630 SS					Inconel		
				17-4PH/630 SS								
8	Retaining Ring	Inconel 718										
9	Cage / Guide	316 SS or 316 SS + Stellited										
					410 SS					Alloy Steel + Stellited / Inconel		
10	Seat Ring	316 SS or 316 SS + Stellited										
					410 SS					Alloy Steel + Stellited / Inconel		
11	Plug Stem	316 SS										
		17-4PH/630SS										
		310 SS, Inconel, A286 Super Alloy. ASTM A638 Gr. 660										
12	Guide Bushing			440C SS / ASTM A276 TY 440C								
		Standard with Stainless Steel Body Materials / Stellited.										
13	Balance Seal	RTFE+316SS										
					Graphite+Inconel							
					Carbon-Ring / Metal-Ring							
14	Body Gasket	316 SS Teflon Filler / Spiral Wound										
		316 SS with Flexible Graphite Filler / Spiral Wound										
15	Packing	Braided Teflone or V-Teflone.										
				Molded Graphite, Flexible Graphite								
16	Packing Studs	304 SS										
17	Packing Studs Nuts	304 SS										
18	Packing Follower	304 SS										
19	Packing Spacer	316 SS										
20	Packing Flange	A351-CF8 or 304 SS										

* Body Materials Application : A216-WCB, A217-WC6, A217-WC9, A217-C12a, A105, A182-F11, A182-F22, A182-F91, A182-F92, A351-CF8, A351-CF8M, A351-CF3, A351-CF3M, Monel, Hastelloy-C/B, Duplex, Titanium, Inconel, Al-Bronze, Aluminium, Others.

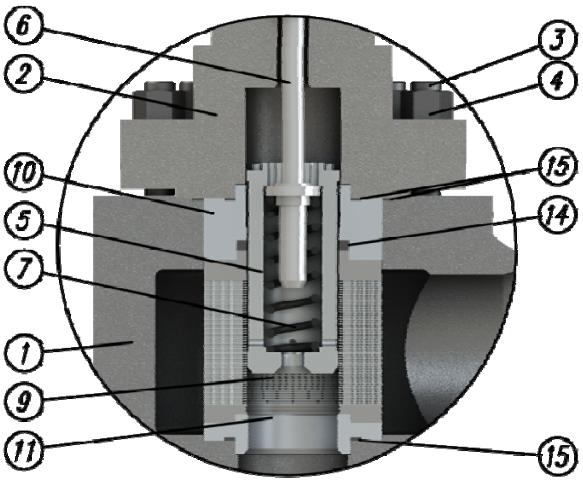
* Trim Materials Application : 304 SS, 316 SS, 316 SS+Stellited, 410 SS, 416 SS, 420 SS, 630 SS (17-4PH)

, A182-F11/22/F91 + Stellited, Inconel, Hastelloy, Titanium, Duplex, Monel, Others.

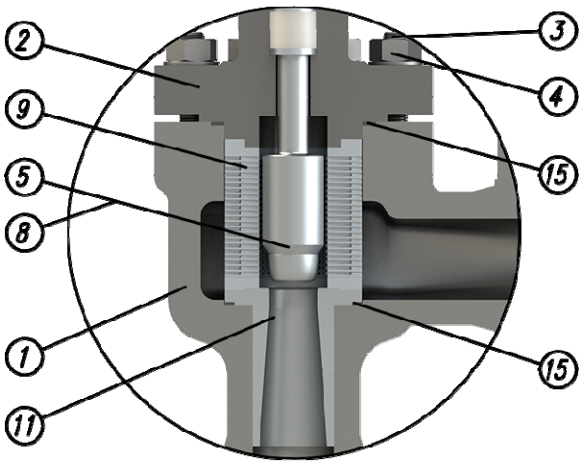
Body Assembly Construction / HG-Series



HAG2XT-Series / Angle Pattern Body X[iks]-Trim Application



Aux. Pilot Plug X[iks]-Trim View./ HAG3XT-Series

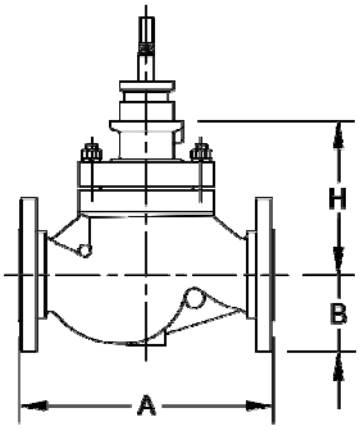


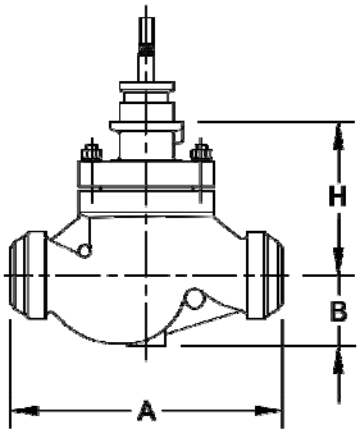
Venturi Seat-Ring Liners/ HAG1XT-Series

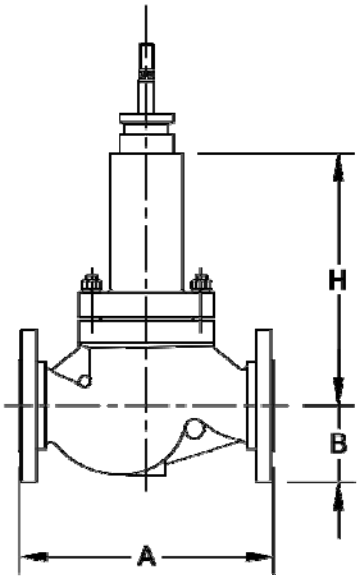
Body Dimension
HG-series
X[iks]-Trim Globe Body Valves

unit/mm

Valve Size	ANSI Class	A			B	H	
		RF Flange	RTJ Flange	Welding		Standard	Extension
40A(1.5")	150	222	235	251	63	145	245
	300	235	248	251	78	145	245
	600	251	251	251	78	145	245
	900	333	333	330	80	187	287
	1500	333	333	330	80	187	287
	2500	381	384	359	103	250	350
50A(2")	150	254	267	286	75	156	256
	300	267	283	286	83	156	256
	600	286	289	286	83	156	256
	900	375	378	375	108	248	348
	1500	375	378	375	108	248	348
	2500	400	403	400	118	279	379
65A(2.5")	150	276	289	311	90	195	295
	300	292	308	311	95	195	295
	600	311	314	311	95	195	295
	900	410	413	375	123	248	348
	1500	410	413	375	123	248	348
	2500	441	447	400	133	279	379
80A(3")	150	298	311	337	95	204	304
	300	318	334	337	105	204	304
	600	337	340	337	105	210	310
	900	441	444	460	120	280	380
	1500	460	463	460	133	280	380
	2500	660	666	498	153	345	445
100A(4")	150	352	365	394	115	235	335
	300	368	384	394	128	235	335
	600	394	397	394	138	243	343
	900	511	514	530	145	339	439
	1500	530	533	530	155	339	439
	2500	737	747	575	178	399	499
150A(6")	150	451	464	508	140	320	420
	300	473	489	508	160	320	420
	600	508	511	508	178	328	429
	900	714	717	768	190	425	570
	1500	768	774	768	198	425	570
	2500	864	877	819	243	500	620
200A(8")	150	543	556	610	173	383	510
	300	568	584	610	190	383	510
	600	610	613	610	210	388	515
	900	914	917	832	235	425	675
	1500	972	982	832	243	425	675
	2500	1022	1038	1029	275	620	740
250A(10")	150	673	686	752	221	392	515
	300	708	724	752	223	392	515
	600	752	755	752	255	425	540
	900	991	994	991	273	600	845
	1500	1067	1073	991	293	600	845
	2500	1372	1385	1270	338	747	867
300A(12")	150	737	750	819	268	448	648
	300	775	791	819	268	448	648
	600	819	822	819	280	485	685
	900	1130	1133	1130	305	680	880
	1500	1219	1229	1130	338	680	880
	2500	1575	1597	1422	380	875	1075
350A(14")	150	889	902	1029	367	518	718
	300	927	943	1029	367	518	718
	600	972	975	1029	367	555	755
	900	1257	1260	1257	320	765	995
	1500	1257	1273	1257	375	765	995
400A(16")	150	1016	1029	1108	377	560	817
	300	1057	1073	1108	377	560	817
	600	1108	1111	1108	377	595	852
	900	1422	1432	1422	353	855	1105
	1500	1422	1441	1422	413	855	1105







1. Flanged End Face-to-Face dimensions are per ISA-75.08.01-2002 and 78.08.06-2002

2. Buttweld End to End dimensions are per ISA-75.08.05-2002

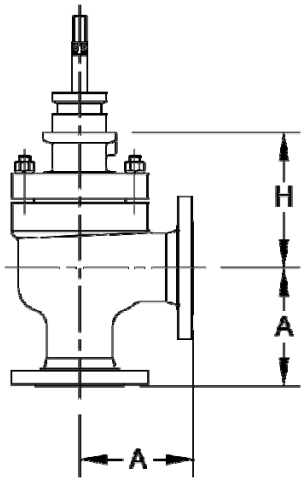
3. Other valves size and Pressure rating grade valves : Please contact BFS Sales Rep.

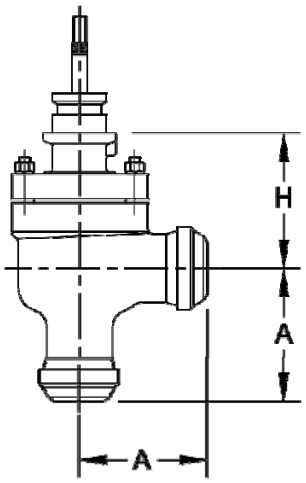
4. All dimensions are for reference only. Please consult the factory for certified dimensions.

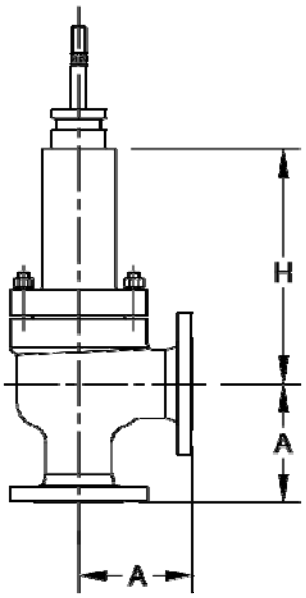
Body Dimension
HA-series
X[iks]-Trim Angle Body Valves

unit/mm

Valve Size	ANSI Class	A			a	H	
		RF Flange	RTJ Flange	Welding		Standard	Extension
25A(1")	150	92	99	105	*	124	224
	300	99	105	105	*	124	224
	600	105	105	105	*	124	224
	900	146	146	140	*	190	290
	1500	146	146	140	*	190	290
	2500	159	159	159	*	230	330
40A(1.5")	150	111	118	126	*	145	245
	300	118	124	126	*	145	245
	600	126	126	126	*	145	245
	900	167	167	165	*	187	287
	1500	167	167	165	*	187	287
	2500	191	192	180	*	250	350
50A(2")	150	127	134	143	*	156	256
	300	134	142	143	*	156	256
	600	143	145	143	*	156	256
	900	188	189	188	*	248	348
	1500	188	189	188	*	248	348
	2500	200	202	200	*	279	379
65A(2.5")	150	138	145	156	*	195	295
	300	146	154	156	*	195	295
	600	156	157	156	*	195	295
	900	205	207	188	*	248	348
	1500	205	207	188	*	248	348
	2500	221	224	200	*	279	379
80A(3")	150	149	156	169	*	204	304
	300	159	167	169	*	204	304
	600	169	170	169	*	210	310
	900	221	222	230	*	280	380
	1500	230	232	230	*	280	380
	2500	330	333	249	*	345	445
100A(4")	150	176	183	197	*	235	335
	300	184	192	197	*	235	335
	600	197	199	197	*	243	343
	900	256	257	265	*	339	439
	1500	265	267	265	*	339	439
	2500	369	374	288	*	399	499
150A(6")	150	226	232	254	*	320	420
	300	237	245	254	*	320	420
	600	254	256	254	*	328	429
	900	357	359	384	*	425	570
	1500	384	387	384	*	425	570
	2500	432	439	410	*	500	620
200A(8")	150	272	278	305	*	383	510
	300	284	292	305	*	383	510
	600	305	307	305	*	388	551
	900	457	459	416	*	425	675
	1500	486	491	416	*	425	675
	2500	511	519	515	*	620	740
250A(10")	150	337	343	376	*	392	515
	300	354	362	376	*	392	515
	600	376	378	376	*	425	540
	900	496	497	496	*	600	845
	1500	534	537	496	*	600	845
	2500	686	693	635	*	747	867







1. a * Same as to A dimensions.

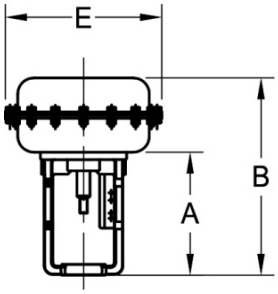
2. Standard Process Connection of Welded type : under 2" SW. Over 2" BW application

3. Flanged End Face-to-Face dimensions are per ISA-75.08.01-2002 and 78.08.06-2002

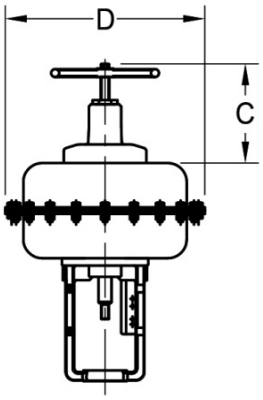
4. Other valves size and Pressure rating grade valves : Please contact BFS Sales Rep. / Over 6" and 4500Lbs.

5. All dimensions are for reference only. Please consult the factory for certified dimensions.

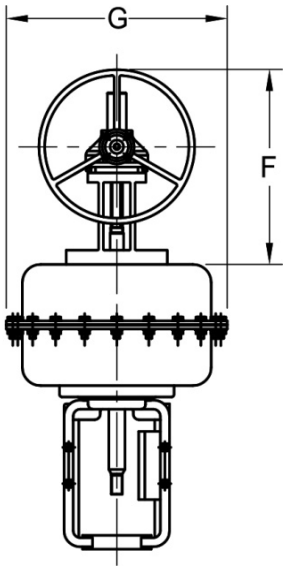
Actuator Dimensions
Pneumatic Spring Diaphragm Actuators



Standard



Top Handwheel



Top-Side Gear-Box Handwheel

Actuator Size	Actuator Dimensions (mm)							Weight (kg)	
	A	B	C	D	E	F	G	Standard	Handwheel
S1 / 250	210	340	200	230	250	-	-	14	17
S2 / 290	230	370	200	230	290	-	-	21	28
S3 / 370	230	410	200	230	370	-	-	40	49
S4 / 480	360	630	-	-	480	470	400	97	113
S5 / 550	360	680	-	-	550	470	400	125	149

** Side Mounted Handwheel.*

side mounted handwheels are available for the DD/DR-Series actuator. Contact BFS for detail and dimensions

** Manually operated actuators*

BFS offers handwheel operated actuators for applications where an mounted valve is not required or where compressed air service is unavailable

DD/DR-Series actuators are suitable for both on-off modulating service.

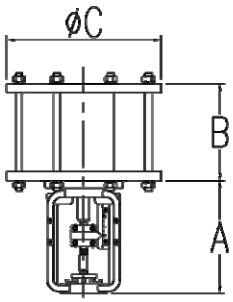
The DD/DR-Series is a pneumatic, spring-opposed diaphragm actuator operating from plant air. Excellent longterm accuracy and reliability is achieved through the use of multiple springs in the actuator.

The rugged one-piece yoke, the pressed steel diaphragm case and the special nylon reinforced diafragm provide dependable, high thrust performance. Additionally, the precisely formed diafragm eliminates friction and reduces variations in the effective area during operation which, in turn, results in exceptional linearity.

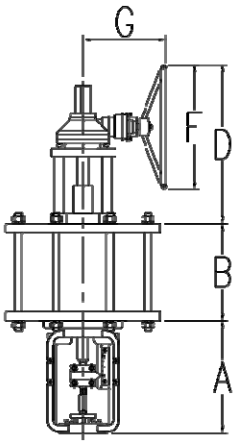
An optional top or side-mounted manual overrivde is available on both direct and reverse acting actuators.
Six different sizes of the DD/DR-Series actuators with the various accessories can virtually satisfy all application requirement.

DIMENSIONS

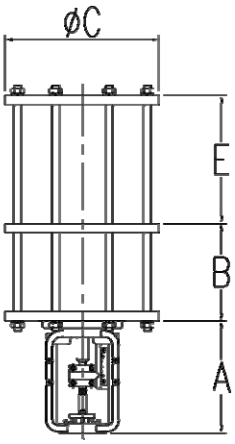
CD/CT-series / Double Acting Spring Less Type



CD-series



CD with Handwheel



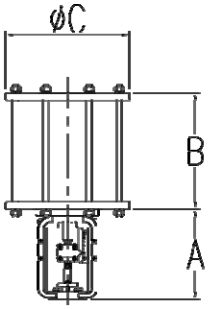
CT-series

unit/mm

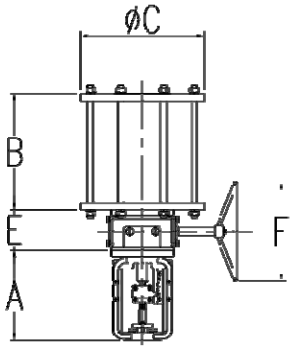
Actuator size	A	B	C	D	E	F	G
CD20/200	230	280	280	500	375	400	215
CD25/250	360	280	340	500	375	400	215
CD30/300	360	280	390	500	375	400	215
CD35/350	490	330	440	600	500	400	215
CD40/400	490	330	490	600	500	400	215
CD50/500	600	380	600	600	500	400	215

** The marked "B" dimension is standard specification. Therefore based on client requirement. The actuator is to be manufactured differehtly as optional specification*

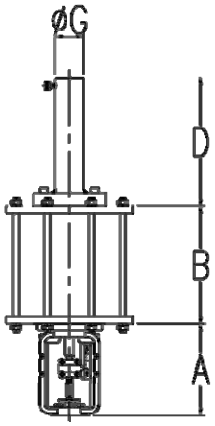
CS-series / Single Acting Spring Return Type



CS-series



CS with Handwheel



CS with Hydraulic Hand-jack

unit/mm

Actuator size	A	B	C	D	E	F	G
CS20/200	230	680	280	-	150	400	-
CS25/250	360	680	340	-	150	400	-
CS30/300	360	680	390	-	150	400	-
CS35/350	490	730	440	-	150	400	-
CS40/400	490	730	490	300	150	400	100
CS50/500	600	780	600	300	150	400	100

** The marked "B" dimension is standard specification. Therefore based on client requirement. The actuator is to be manufactured differehtly as optional specification*

Metric Conversion Tables

LENGTH		
Multiply	**By**	**To Obtain**
millimeters	0.039	inches
centimeters	0.394	inches
inches	2.54	centimeters
feet	30.48	centimeters
feet	0.304	meters

AREA		
sq. centimeters	0.155	sq. inches
sq. centimeters	0.001076	sq. feet
sq. inches	0.452	sq. centimeter
sq. inches	0.00694	sq. feet
sq. feet	929	sq. centimeter

FLOW RATES		
gallons US Minute	3.785	liters/min
gallons US Minute	0.133	cubic feet/hour
gallons US Minute	0.227	cubic meter/hour
cubic feed minute	7.481	GPM
cubic feed hour	0.1247	GPM
cubic feed hour	0.01667	cubicfeet/min
cubic meter hour	4.403	GPM
cubic meter hour	35.31	cubic feet / hour

VELOCITY		
feed per second	0.3048	meter/second
feed per second	1.097	km/hour
feed per second	0.6818	miles/hr

Temperature Conversion
F (Fahrenheit) = C (9/5)=32
C (Celsius) = (F-32)5/9

VOLUME AND CAPACITY		
Multiply	**By**	**To Obtain**
cubic feet	28.32	liters
cubic feet	7.4805	gallons
liters	61.02	cubic inches
liters	0.03531	cubic feet
liters	0.264	gallons
gallons	3785.0	cubic centimeter
gallons	231.0	cubic inches
gallons	0.1337	cubic feet

WEIGHT		
pounds	0.453	kilogram
kilgram	2.205	pounds

PRESSURE AND HEAD		
pound / sq. inches	0.06895	bar
pound / sq. inches	0.06804	atmosphere
pound / sq. inches	0.0703	kg/cm2
pound / sq. inches	2.307	ft of H2O (4℃)
pound / sq. inches	0.703	m of H2O (4℃)
pound / sq. inches	5.171	centimeter of hg (4℃)
pound / sq. inches	2.0	inch of hg (4℃)
atmosphere	14.7	psi
atmosphere	1.013	bar
atmosphere	1.033	kg/cm2
atmosphere	101.3	kPa
bar	14.5	psi
kilogram/sq cntimeter	14.22	psi
kilo Pascal	0.145	psi

Best Flow Solution

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