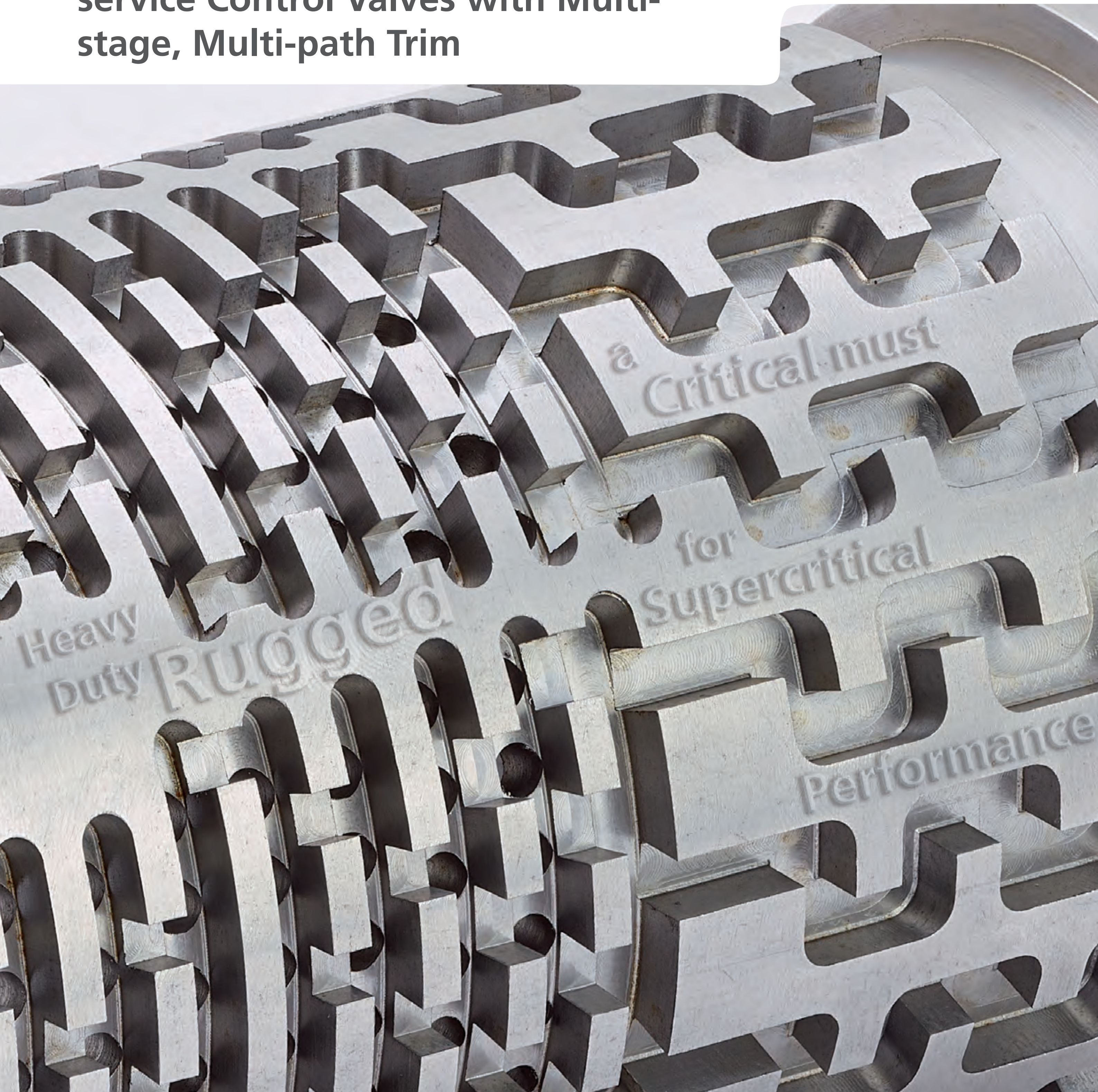
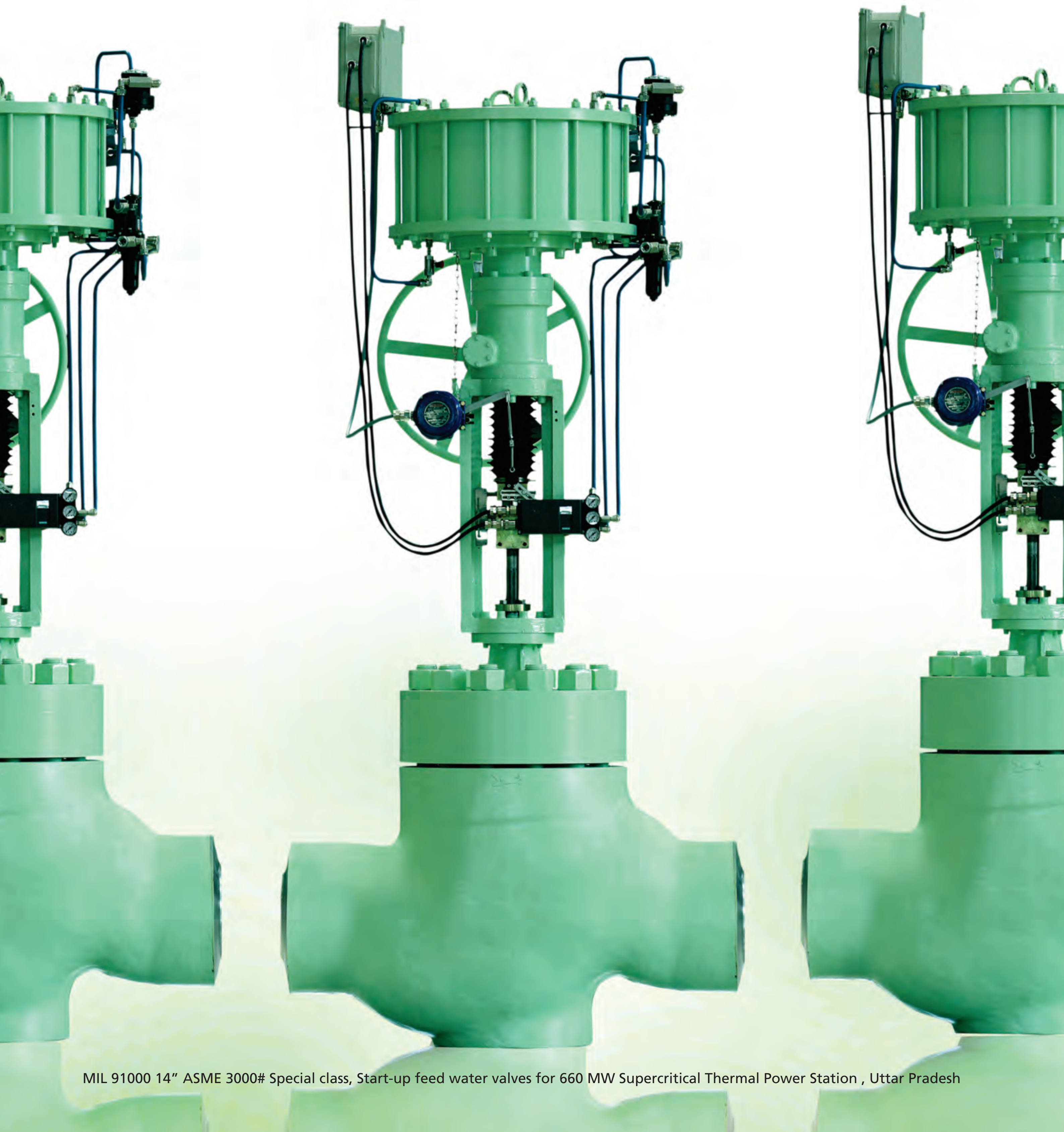
Our technology. Your success.
Pumps • Valves • Service

MIL 91000 Matrix Series - Severe service Control Valves with Multi-stage, Multi-path Trim





MIL 91000 14” ASME 3000# Special class, Start-up feed water valves for 660 MW Supercritical Thermal Power Station , Uttar Pradesh

Why Control valves go out of control ?

High pressure drops, associated high trim velocities and cavitation are synonymous with critical service process control applications. Control valves used in such extreme conditions are plagued by problems like shortened trim life, plug stem failure, vibration, erosion of internals and high noise levels.

Pressure drop in a control valve is a two stage process. First the static pressure drops to Vena Contracta * pressure (Pv_C) where it is accelerated to Vena Contracta velocity (Vv_C) and further it recovers downstream in it's path. During the first stage, if Pv_C falls below the vapour pressure of the liquid, the liquid boils forming vapour bubbles. As the liquid moves further downstream, its pressure recovers, converting almost all its Kinetic energy to Pressure energy. However, a phase transformation occurs turning the vapour back to liquid if the downstream pressure is higher than vapour pressure.

This phase transformation is typically characterised by implosion of the vapour bubbles. This phenomenon is commonly referred to as Cavitation. The cavitation in turn releases large amount of localized surface stress as high as 200,000 psi. This can lead to severe damage of internals and the body of a control valve.

Cavitation could be aggravated further when associated with the sort of extreme pressure drops typical of power plant applications like Boiler Feed Pump Minimum Re-circulation, Start-up Feed Water Control etc.

The cavitation potential of a valve is a direct derivative of its pressure recovery characteristics. This is defined in terms of a dimension-less index called the Pressure Recovery Factor, (C_f or F_L#) the ratio of the total pressure drop across the valve to the pressure drop at Vena Contracta.

Conventional single stage valves with low C_f generate excessive trim velocities (and vice versa) since pressure recovery and velocity are complementary. This phenomenon can cause trim erosion. The option of using harder material in single stage valves, to resist trim erosion due to cavitation and high velocity has been tried. However, results have not been satisfactory. A more sophisticated option is to use multi-stage valves which distribute the pressure drops over a fixed number of stages †. But here also there are some deficiencies.

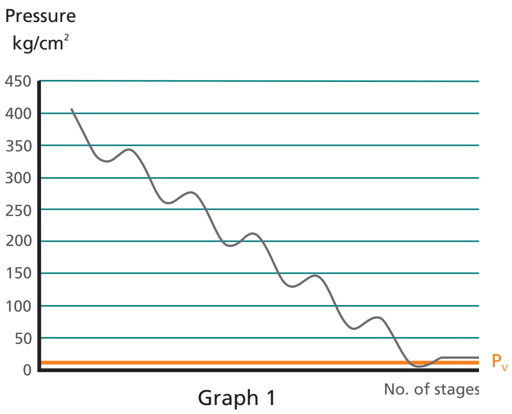
In extreme conditions it is not always possible to keep the final stage (Vena Contracta) pressure from dipping below vapour pressure (refer graph 1) as the stage wise pressure drops are equal and larger here. Rangeability of many of these valves were limited and these had linear as their inherent control characteristic.

* The point where pressure reaches it's lowest.

C_f or $F_L = \sqrt{\dfrac{P_1 - P_2}{P_1 - P_{VC}}}$

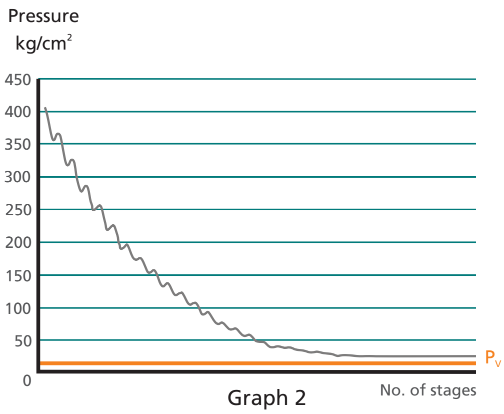
† Usually 8, owing to manufacturing constraints.

Conventional Multi- stage valves versus Matrix - Pressure recovery; a comparison



Graph 1

Pressure recovery in conventional multi-stage valves



Graph 2

Pressure recovery in Matrix series valves

KSB MIL's industry leadership is the result of its ongoing focus on innovation and proven track record on quality. The expertise attained from solving control valve performance problems of customers resulted in the setting of high levels of innovation & quality, influencing every step of the production process.

KSB MIL, with its strong engineering division and efficient Research and Development wing, has continued to develop and introduce advanced product technology. Matrix technology is considered one of the landmark innovations in the history of severe service control valve industry . In the year 2000, KSB MIL designed, developed and commissioned the first Matrix series control valve, as a premium solution for handling high pressure fluids.

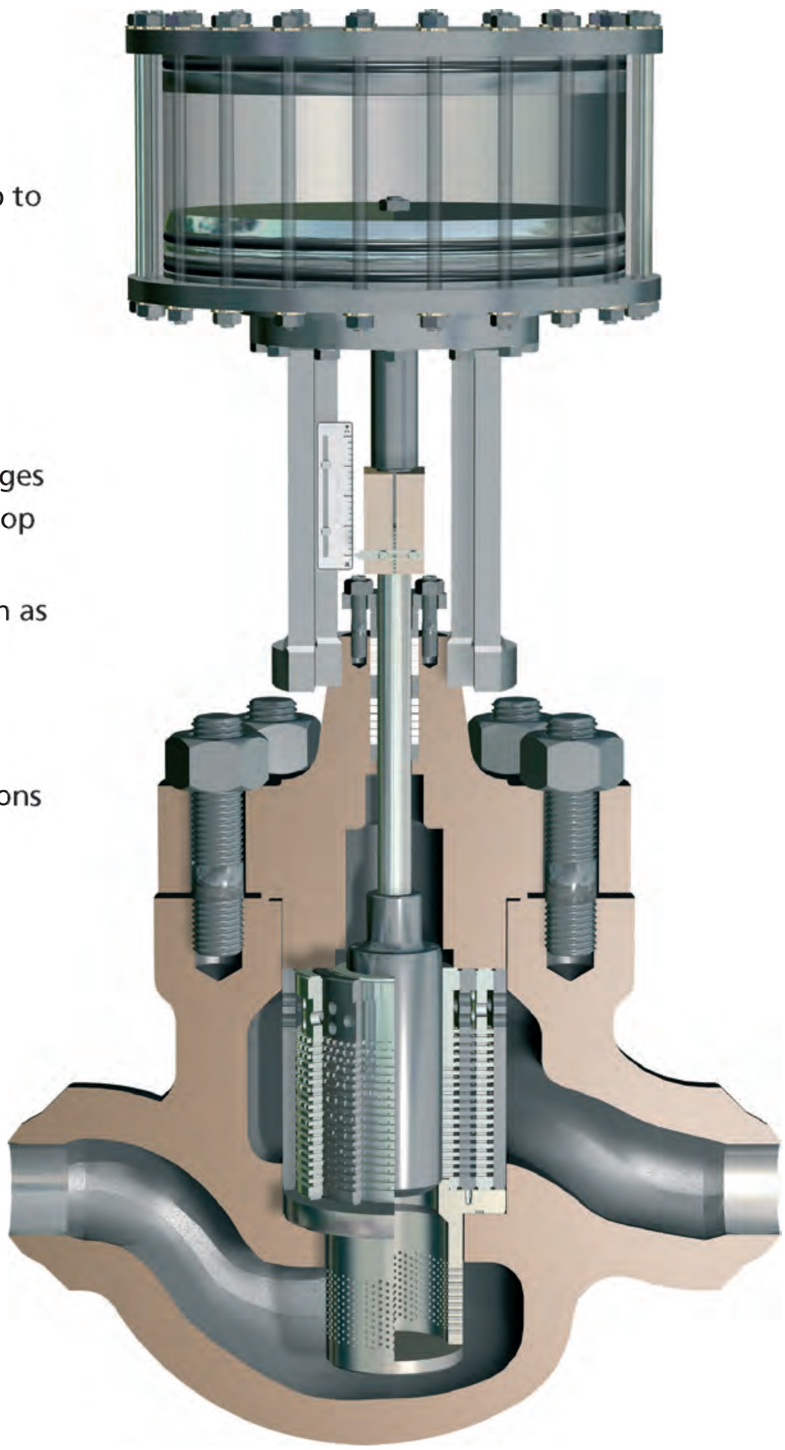
KSB MIL's unique combination of engineering experience and global resources is utilized to provide compatible solutions that enhance continued valve performance and maintenance savings. Thus Matrix technology stands a step ahead in the industry.

Favoured worldwide

KSB MIL's innovations in engineering, design and manufacturing have consistently been outstanding. KSB MIL's invention of the Matrix is a major technology breakthrough. Matrix valves now constitute an integral part at the heart of our clients' processes. Coupled with innovation, KSB MIL's know-how and experience in control valve manufacturing for a range of industries make it a sought after supplier worldwide.

Features

- Multi-stage, multi-path trim design
- Varying and expanding flow passage
- Discrete pressure and velocity reduction stages
- Tortuous, high impedance, energy absorbing 3 dimensional flow path
- Near zero pressure recovery and Pressure Recovery Factor (C_f or F_L) up to 0.999
- Large stroke valves for precise controllability
- Flow to open design for inherent dynamic stability
- No cavitation damage to leading edges of the plug due to lesser pressure drop in last stages
- Field proven and rugged design with as many as 50 pressure / velocity reduction stages
- Low noise levels
- Custom built for specific site conditions
- High rangeability, 100:1



The finest Control Valves for Critical applications

Matrix series from KSB MIL are engineered to effectively focus on common control valve glitches and here are the highlights.

Smart design: Matrix achieves very low pressure recovery (C_f as high as 0.999) by forcing the fluid through a multi-path, multi-stage and progressively declining resistance three dimensional flow path. This effectively kills the fluid energy and also brings down velocity by arresting the turbulence. The three dimensional flow path, similar in structure to a Matrix (refer fig. 1), formed in the perfectly aligned cages ensures that the fluid follows in a zigzag pattern, thereby absorbing excess energy created high pressure drops.

The fluid pressure gradually recedes from the first stage to the final one with a more or less, asymptotic approach.

Ingenious flow path: The valve trim consists of a unique welded cage assembly which offers a tortuous flow path. This kills pressure / velocity by forcing the fluid through an array of ruts and throttling stages that have been allocated over successive stages of the valve trim. The last stages are devoted exclusively for contouring the trim exit velocities with discrete velocity stages.

The number of ruts in each stage is fixed according to the pressure drop and thereby, the velocity control. The number of ruts in successive stage increases as the fluid progresses downstream, thereby providing an expanding flow passage, reducing the pressure to a point where cavitation would not occur (refer graph 2 in page 2) and trim exit velocities are within safe limits.

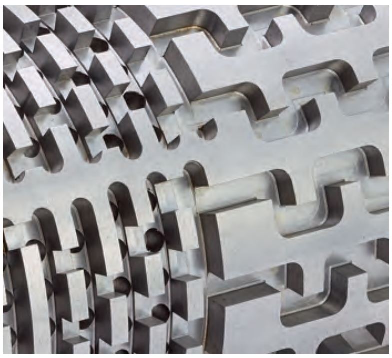
Advantageous flow direction: Matrix series valves, both axial flow and radial flow, are characterised by flow stream under the plug (flow tending to open) construction. This unique feature conclusively eliminates dynamic instability, a major irritant that afflicts conventional flow to close valves and helps to eliminate the wire drawing and cavitation damage to the plug, which is prevalent with the flow to close construction. This ingenious design avoids the last stage pressure drop (where chances of cavitation exists) against the plug thereby eliminating cavitation damage to the seating surface (refer fig.2 & fig.3).

Unique cage stack: Consisting of concentric cages machined with hairline accuracy and welded together, it forms a rugged heart which can withstand the severest conditions. Fabricated out of tough martensitic stainless steel after heat treatment and case hardening, the assembly is a perfect example of KSB MIL's engineering prowess.

The fluid flow channels are designed to offer maximum resistance to the highly erosive flow conditions. Each valve is precisely tailor made on specific flow parameters.

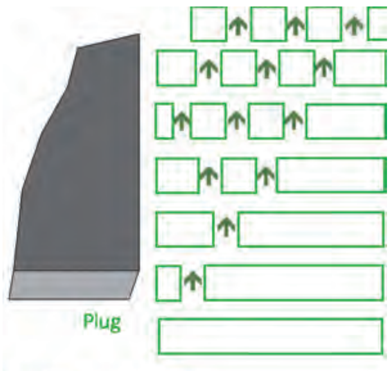
Ruggedness of design: Matrix series valves are designed with up to 50 pressure/velocity reduction stages and this ensures longevity even in very severe applications. Ingenious design results in a simpler manufacturing process. This makes Matrix series valves the most reasonably priced in their league.

Outstanding engineering. Unbeatable economies - Matrix. In a class all its own.

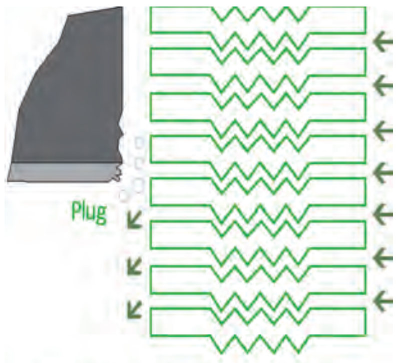


Flow path with directional changes as in Matrix

Fig . 1



Axial Flow as in Matrix
(No cavitation damage to Seating / Sealing Surfaces)
Fig . 2

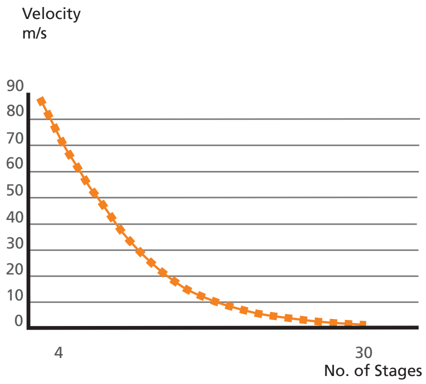


Radial Flow in flow to close
(Cavitation Damage can occur at the leading edges of the plug)
Fig . 3

Typical Velocity Profiles

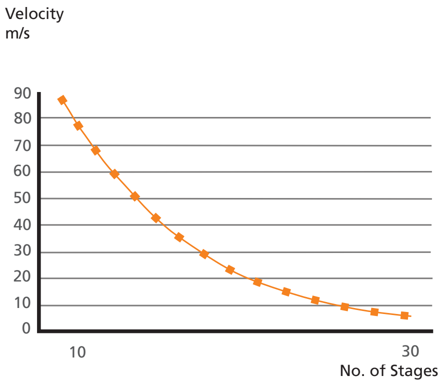
Since the pressure drop is effected through a number of stages, the velocity is discretely controlled at every stage by judicious pressure drop allocation to each stage, depending on the application and the total pressure drop. The expanding flow passage facilitates a continuously reducing velocity towards the outlet of the trim. This results in a very low outlet velocity.

Stage wise velocity profiles of a Matrix series valve dropping 400 Kg/cm^2 pressure (230 TPH flow) in 30 stages.



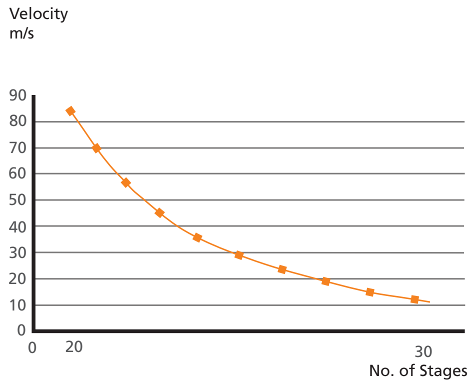
Graph 3

Velocity profile at 10% opening



Graph 4

Velocity profile at 40% opening



Graph 5

Velocity profile at 100% opening

Technical Information

Model decodification

Actuator type	Body series	Seal type	Body type	Trim type
37. Direct spring diaphragm 38. Reverse spring diaphragm 67. Direct piston cylinder 68. Reverse piston cylinder 90. Electrical actuator	91. Multi- stage, multi-path, anti-cavitation & low control valve	0. Undefined 1. Unbalanced 2. Pressure energised polymeric seal ring (static) 5. Metallic seal ring 6. Polymeric seal ring 9. Graphite seal ring	0. Undefined 1. Inline 2. Angle	1. Axial (Incompressible flow) 2. Radial (Incompressible flow) 3. Radial (Compressible flow)

General data

Body

Type	Globe or Angle
End connections	Flanged or Butt weld or Socket weld
Standard flow direction	Flow to open Flow to close* (Optional)

* Consult KSB MIL

Bonnet

Type	Stud bolted with moderate extension
Temperature*	-29 °C to 566 °C (< 315 °C for soft seal balanced design)

Trim

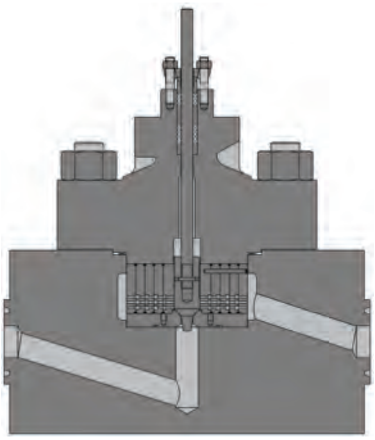
Cage stack	Multi-stage and multi-path, radial or axial flow with flow stream under the plug
Plug	Heavily guided all along its length. Unbalanced without seal ring or balanced with seal ring
Seat	Metal seated, quick change type
Optional	Diffuser seat ring

Gland packing

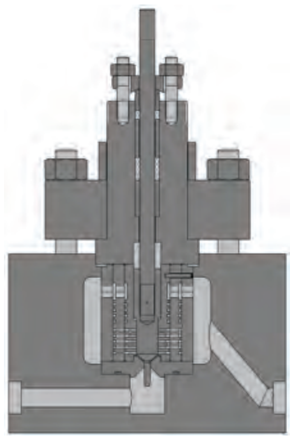
Type	Adjustable double sealed packing box with PTFE (≤180°C) or Graphite (>180°C) moulded split rings
Optional	Eco-lock gland sealing system

* Special designs available for applications outside the given temperature range, consult KSB MIL

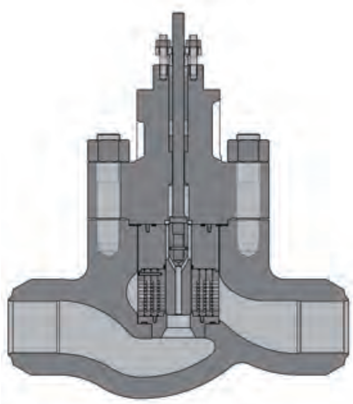
Overview of Design Options



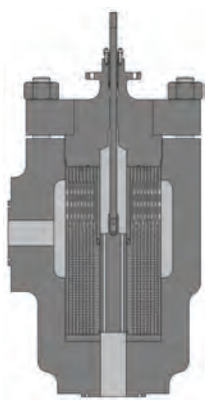
Radial flow - Unbalanced (MIL 91112)



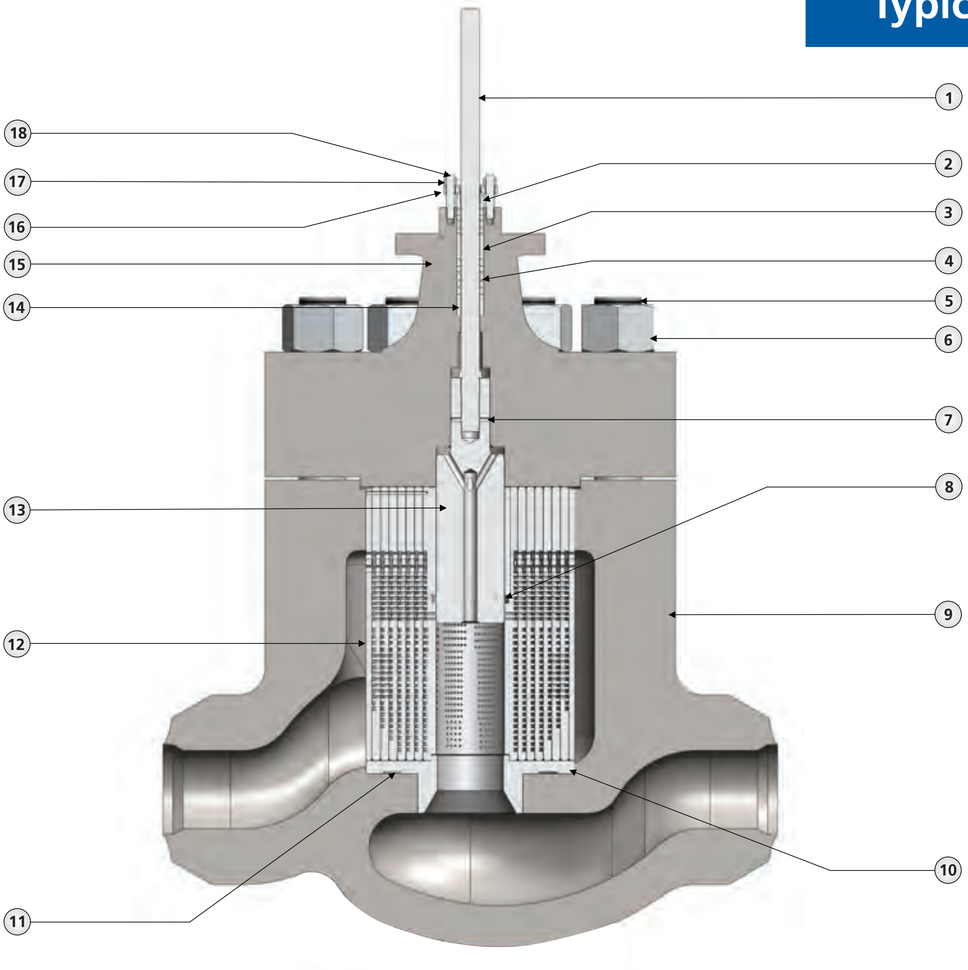
Axial flow - Unbalanced (MIL 91111)



Radial flow - Pressure balanced (MIL 91212)



Axial flow - Balanced angle valve (MIL 91221)



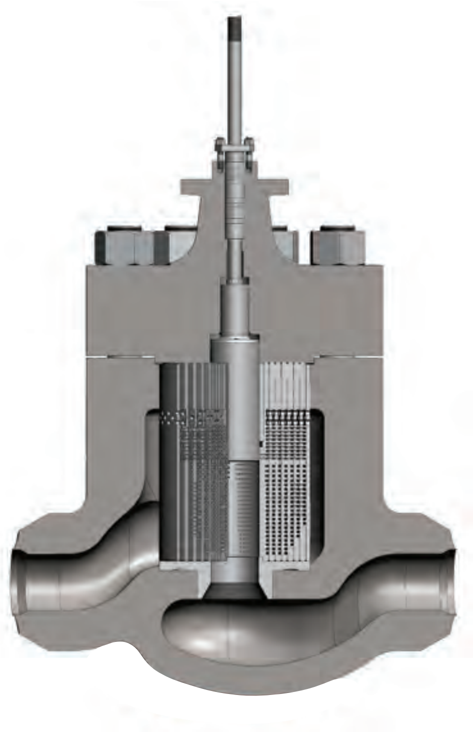
Matrix series. MIL 91000: Axial flow - pressure balanced

No	Part name	Standard material of construction *
1	Plug stem	17.4 PH SST H-1075
2	Packing follower	304 SST
3	Packing spacer	304 SST
4	Packing	PTFE $\leq$ 180°C / Graphite > 180°C
5	Body stud	ASTM A 193 Gr. B7
6	Body nut	ASTM A 194 Gr. 2H
7	Plug pin	316 SST
8	Spring energized seal ring	Ekonol + PTFE
9	Body	Carbon steel : ASTM A 216 Gr. WCC / ASTM A 105 Alloy steel : ASTM A 217 Gr. WC6 / WC9 / C12A / ASTM A 182 Gr. F11 / F22 / F91 Stainless steel : ASTM A 351 Gr. CF8/ CF8M/ ASTM A 182 Gr. F316
10	Seat ring	316 SST + Stellite
11	Seat ring gasket	316L SST + Graphite
12	Cage stack S/A	Inconel 718, CA6NM nitrided
13	Plug	440C SST Heat treated, Inconel 718, CA6NM nitrided
14	Guide bush	440C SST
15	Bonnet	Same as body material
16	Packing flange	ASTM A 105
17	Packing nut	ASTM A 194 Gr. 8
18	Packing stud	ASTM A 193 Gr. B8

*Material indicated above are for reference only. KSB MIL reserves the right to supply alternate material / forms due to constant product upgradation. Other specific material are available on request.

Boiler Feed Pump Min. Recirculation Valve

MIL 91000, 8", 3000# ASME for 660 MW Supercritical Thermal Power Station, Madhya Pradesh



Boiler feed pump is one of the most vital part in a power plant. It always requires a minimum flow to avoid overheating and cavitation. To safeguard the pump when the boiler feed flow requirement is less than the minimum flow of the feed pump, the recirculation system returns a portion of the high pressure flow back through the min. recirculation control valve. When the pump starts, the valve would be fully open and closes as the system flow increases. This is deemed as among the most critical applications in thermal power plants, where the control valve must handle high pressure drop and severe cavitation, without erosion, vibration and high noise levels. The valve would be either on-off or modulating based on the design philosophy.

Design considerations

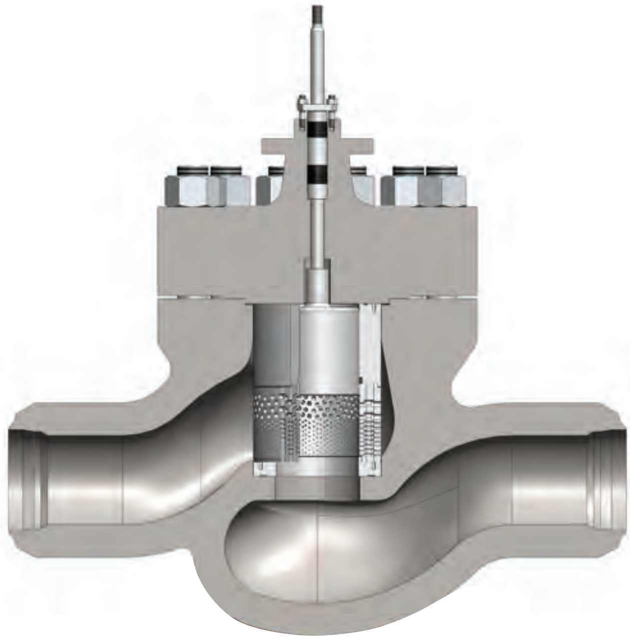
- Capable of handling very high pressure drop and severe cavitation, without erosion, vibration and high noise levels (30 to 40 pressure/velocity reduction stages)
- Tight shut-off requirement as leakage causes energy loss and wire drawing
- Valve will be kept closed for long periods when the load picks up
- Minimum flow specification based on the pump design
- Modulation or on-off based on the design philosophy

Typical parameters

Parameters	660 MW Supercritical	500 MW Subcritical
Design pressure	440 - 480 bar	315 bar
Design temperature	150°C - 200°C	150°C - 200°C
Max. inlet pressure	350 - 420 bar	300 bar
Pressure drop	340 - 410 bar	290 bar
Valve size / Rating	8"/10"/ 3000# (special)	8"/ 2500#
Material-Body/Trims	A182.Gr. F22	A217Gr. WC6
Rated Cv	30 - 45	35

Valve for lower capacity plant

Start-up Feed Control Valve



MIL 91000, 14", 3000# ASME for 660 MW Supercritical Thermal Power station, Bihar

In drum type boilers (for subcritical plants), during startup and low loads, the pressure differential between boiler feed pump and the boiler is high as the drum pressure has not been built up. Due to the high differential pressure and the low outlet pressure, the start-up feed water valve needs to have cavitation prevention features. Once the load picks up, the flow increases and differential pressure comes down. This calls for a high Cv and rangeability requirements. The outlet of start-up feed water control valve and full load feed water valve are connected and hence tight shut-off is not required for the control valve. Due to this reason, most of the start-up feed water applications require only Class IV leakage which uses simple seal ring design. The role of start-up feed control valve is crucial to maintain the flow in once-through boiler (for supercritical plants) within the required limits during start-up before firing commences. This minimum flow is typically around 30% - 35% MCR flow and is necessary to provide adequate cooling to the furnace wall tubes. Hence proper selection of the control valve provides smooth start-up and maintains required drum level for safe, reliable and efficient plant operation.

Design considerations

- Higher design pressure and ASME class
- Capable of handling high pressure drop and chances of cavitation in low flow
- Low pressure drop with higher flow
- High rangeability requirement

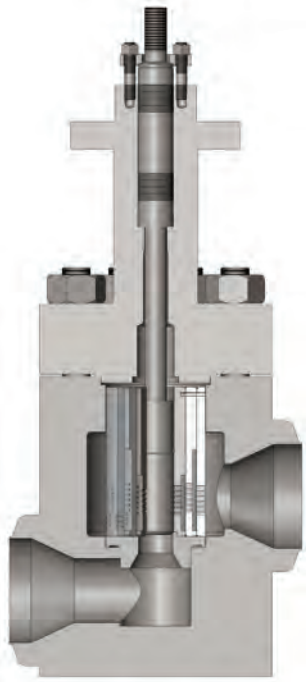
Typical parameters

Parameters	660 MW Supercritical	500 MW Subcritical
Design pressure	440 - 480 bar	315 bar
Design temperature	150°C - 200°C	260°C
Max. inlet pressure	120 - 150 bar	115 - 195 bar
Pressure drop	70 - 110 bar	90 - 135 bar
Valve size / Rating	14"/ 3000# (special)	10"/ 2500#
Rated Cv	450 - 550	360 - 400

Valve for lower capacity plant

Attemperator Spray Control Valve

MIL 91000, 6”, 2500# ASME, for 660 MW Supercritical Thermal Power Station, Maharashtra



Control of steam temperature is of utmost importance for efficient operation of thermal power plant. Spray water control valves regulate the amount of water required to control the steam temperature exiting the super heaters and reheaters. Severity of this application varies with the location of the feed water tapping which can be either BFP discharge or Intermediate stage.

In case BFP discharge is taken for spray water inlet, typically as in 210 / 250 MW power stations, this valve could be subject to very high pressure drop necessitating use of special designs.

Design considerations

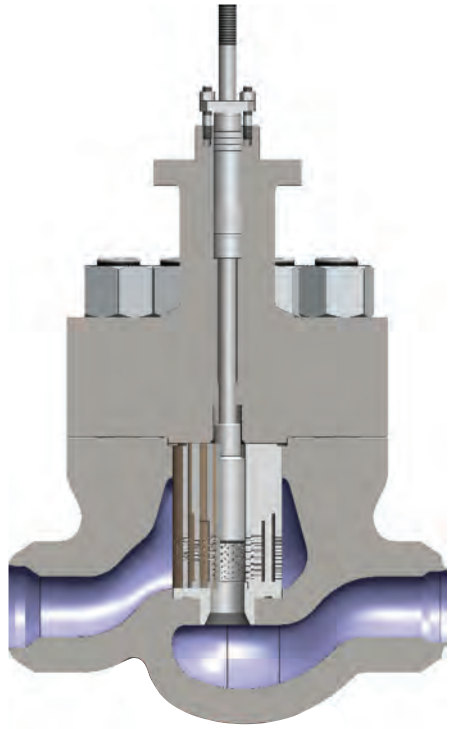
- Fine and precise flow control
- Nominal flow capacity in lower lifts to avoid low lift throttling and damage to seat
- Depending on the spray water source, valves may be subject to very high pressure drop
- Very wide rangeability
- Tight shut-off and seat protection

Typical parameters

Parameters	660 MW Supercritical		500 MW Subcritical	
	RH spray valve	SH spray valve	RH spray valve	SH spray valve
Design pressure	190 bar	355 bar	175 bar	350 bar
Design temperature	220°C	360°C	185°C	260°C
Max. inlet pressure	40 - 120 bar	120 - 300 bar	70 - 110 bar	100 - 235 bar
Pressure drop	20 - 30 bar	5 - 30 bar	35 - 45 bar	5 - 45 bar
Rated Cv	10 - 15	30 - 50	20	60

Valve for lower capacity plant

MIL 91000, 4” 3100# ASME, for 800 MW Supercritical Thermal Power Station, Andhra Pradesh



From the soot blower header, high velocity steam jets are blown through the soot blowers to clear soot accumulated in the boiler. When soot blowers open and close suddenly, the possible pressure surges in the header line is controlled by the header control valve.

Design considerations

- Tight shut-off is essential [excessive leakage would increase the header pressure]
- Trim design to take care of high pressure drop and high noise levels
- Avoid detrimental effects of thermal cycling of the valve body and internals
- Higher rangeability take care of flow variations in soot blowing cycle
- Unbalanced plug construction without seal rings
- ASTM A217 Gr. C12A body material with Inconel trim is generally offered to minimize the effect of thermal cycling

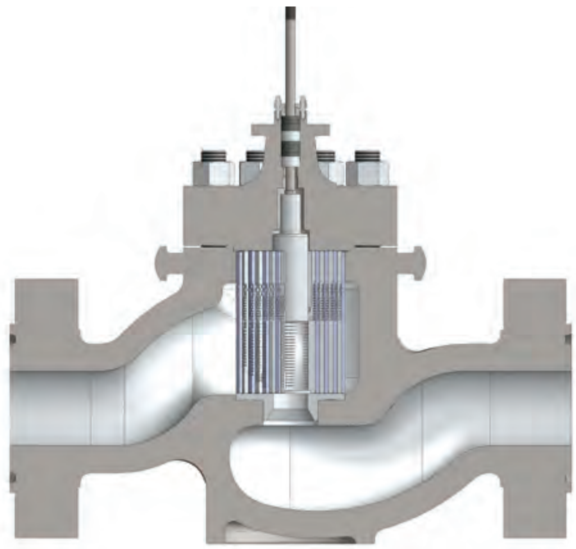
Typical parameters

Parameters	660 MW Supercritical	500 MW Subcritical
Design pressure	270 bar	195 bar
Design temperature	570°C	480°C
Max inlet pressure	125 - 260 bar	85 - 185 bar
Pressure drop	95 - 230 bar	60 - 150 bar
Rated Cv	25 - 30	10 - 30

Valve for lower capacity plant

Pump Test Loop Control Valve

MIL 91000, 12”, 2500# ASME,
for Pump Test Bed, Brazil



High pressure pump manufacturers require factory-based pump tests for the various operating conditions like reduced suction pressure, full-train operation at variable speeds and hot transient conditions prior to shipping. Hydraulic performance, bearing temperatures, vibration and noise levels are also generally verified in the test loops to ensure reliability of pumping equipment. Control valves with high pressure drop capability are located at the discharge of the pumps and are throttled at varying openings to simulate the various test conditions.

Design considerations

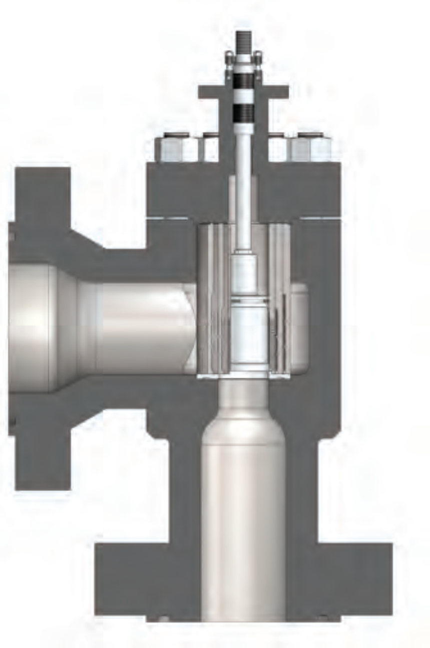
- Very high pressure drop and elimination of cavitation potential
- Stringent kinetic energy criteria employed in trim design to eliminate vibration due to excessive fluid velocities and high pressure drop
- High rangeability in the varying load conditions
- Class V tight shut-off

Typical parameters

Parameters	Typical values
Design pressure	400 bar
Design temperature	50 °C
Max. inlet pressure	390 bar
Pressure drop	380 bar
Rated Cv	75

High Pressure Steam Letdown / Pressure Control Valve

MIL 91000,12”x16”, 2500# ASME High pressure steam reducing valve for Petrochemical Complex, Uttar Pradesh.



Control of high pressure steam, while the pressure is being reduced drastically, is among the most challenging applications in process control. This is due to the combined effects of high temperature, high pressure, high volumetric expansion & high noise generation. The applications gain further severity when large mass flows are handled by the control valve. Often the valves are required with special metallurgy of the body / bonnet in line with the piping. C12A / F91 castings / forgings respectively are employed in severe service applications. This material is known for excellent high-temperature, creep and stress rupture properties due to the formation of submicroscopic carbides. It also offers increased resistance to erosion and corrosion due to addition of Chromium and Molybdenum.

Design considerations

- Multi-stage, multi-path, radial flow design suitable for compressible fluid application
- Trim provided with sufficient fluid expansion area in intermediate stages to accommodate the increase in specific volume of fluid due to pressure reduction
- Flow tending to open design to provide smooth expansion to the body exit without any choking
- Trim design to limit noise levels below 85 dBA

Typical parameters

Parameters	Typical values
Design pressure	120 bar
Design temperature	540 °C
Max inlet pressure	110 bar
Pressure drop	105 bar
Valve size / Rating	12” inlet, 16” outlet / 2500#
Rated Cv	240

Technology that makes its mark

Your local KSB representative:

KSB
KSB MIL Controls Limited
Meladoor, Annamanada, Pin - 680741
Thrissur District, Kerala, India
Tel. +91 480 2695700, Fax. +91 480 2890952
E-mail: sales.mil@ksb.com, www.ksb-mil.com

You can also visit us at:
www.ksb.com/socialmedia