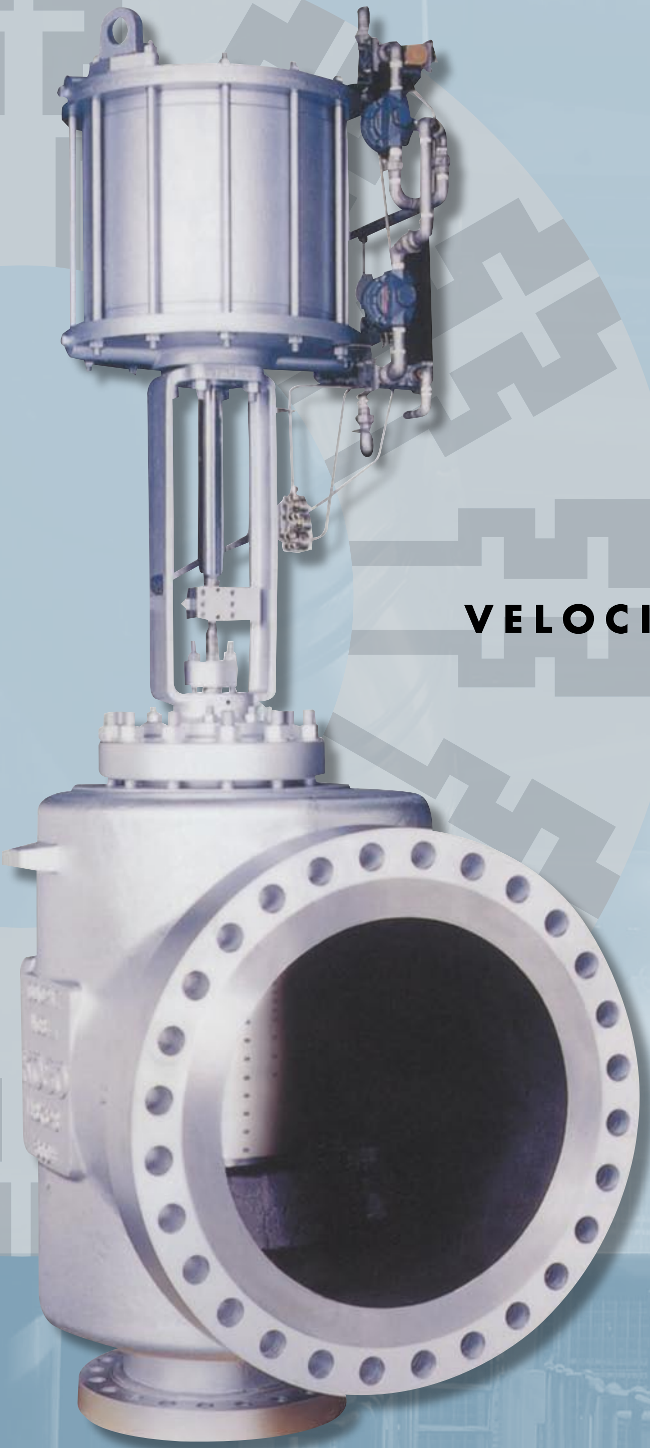
VECTOR™

VELOCITY CONTROL TECHNOLOGY



VELOCITY CONTROL TECHNOLOGY

VECTOR™

KOSO

KOSO VECTOR™

velocity control technology

Severe service valve applications, often associated with high pressure and/or high temperature are common in today's process and utility power plants. End users, looking for greater plant yields and higher efficiencies, are operating at elevated pressure and temperature, pushing the upper limits of conventional control valve technology. Often, this results in pipeline vibration, environmentally unfriendly noise and fluid velocity or cavitation induced erosion of critical valve components. These issues have led to development of new generation control valves that are dramatically different from conventional designs.

KOSO VECTOR™ trims deliver reliable control, long life and freedom from cavitation, erosion, vibration and noise problems. The design evolved through many decades of experience in solving severe service applications where durability, reliability and control precision are required.

VECTOR™ trims are suitable for compressible and incompressible fluids. This advanced design, fluid velocity controlling trim prevents generation of noise and/or cavitation at the source, eliminating need for supplementary devices such as diffusers, silencers and related expenses. VECTOR™ trims provide many advantages that result in improved performance, reduced maintenance and system simplification.

Typical KOSO VECTOR™ applications

KOSO VECTOR™ valves are used in severe service applications worldwide. Years of research and experience in numerous applications have proven the superiority of the VECTOR™ valves in critical applications.

Power applications

- Turbine bypass
- Condenser dump devices
- Turbine stop & control valves
- Main and booster feedpump recirculation
- Startup and main feedwater regulation
- Startup system
- Attemperator spraywater control
- Deaerator level control
- Auxiliary steam
- Soot blower control
- Deaerator pegging steam
- High level (emergency) heater drain
- Steam vent
- Desuperheating systems
- Steam conditioning
- Sampling systems

Oil & Gas applications

- Anti-surge
- Compressor recycle
- Emergency depressurizing
- Emergency steam vents
- Feedwater regulators
- Gas storage injection/withdrawal
- Gas to flare
- Gas treating
- Hot oil letdown
- Import/export
- Methanol injection
- Oil and gas chokes
- Overboard dump
- Pump minimum flow
- Surge relief
- Water injection
- Wellhead pressure control

LNG applications

- Acid gas separator level control
- Amine pump recirculation control
- Boiler feedwater pump recirculation
- Boiler feedwater regulator
- C2/MCR/BOG compressor anti-surge
- Compressor recycle
- Desuperheating spray
- Emergency depressurizing
- Feedgas regulator
- Hot gas bypass
- JT (Joule Thompson)
- Slug catcher/ acid gas separator gas-to-flare
- Slug catcher level control
- Steam header pressure control
- Steam vent

Pulp & Paper applications

- Feedpump recirculation
- Feedwater regulation
- Steam conditioning
- Attemperator spraywater control
- Atmospheric vent
- Digester pressure
- Heater injection

VECTOR™ valve features and advantages

Benefits	Features	VECTOR™	Competition
Vibration free operation	Fluid velocity controlling trim addresses problems at their source	X	
Reduce fluid velocity caused erosion			
Eliminate cavitation caused vibration and damage			
Longer cycles between maintenance			
Low noise operation			
May eliminate costly additional equipment (baffle plates, silencers, acoustic lagging…)			
Improve reliability, efficiency and plant output	Designed to meet the pressure drop and capacity needs of the application	X	
Wide control rangeability may eliminate a need for a second valve			
Quicker, less costly maintenance	No welded or screwed-in trim parts	X	
Provide repeatable, tight shut-off	"Edge" contact seating, with extra shut-off force	X	
Eliminate costly leakage losses			
Easy to repair seating surfaces			
Lower initial costs	High quality, economic design and manufacturing	X	

Figure 1: Conventional valve profile

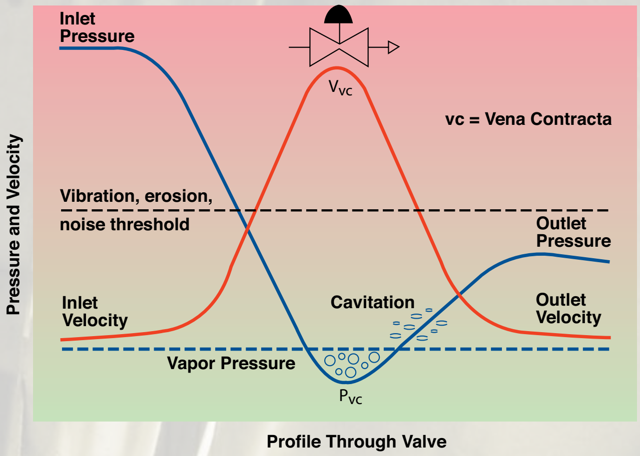
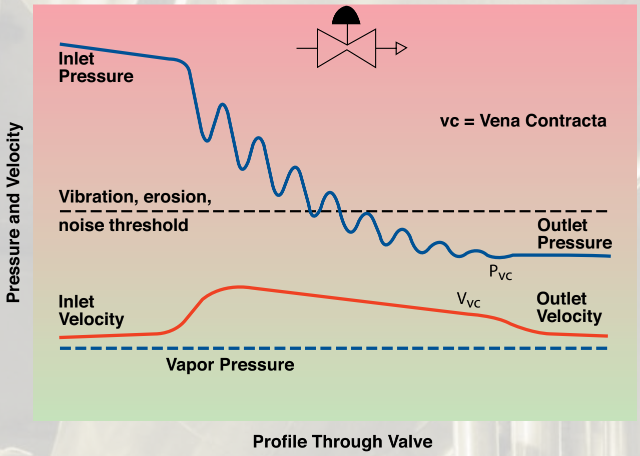


Figure 2: Vector™ valve profile



Symptoms of poor velocity control

- Unplanned shutdown
- Lost production
- High maintenance costs
- Reduced efficiency
- Manual control required
- Noise
- Trim and body wear
- Pipe and valve vibration
- Leakage
- Pipe erosion

Severe Service

Principles of velocity control

Uncontrolled fluid velocities can be costly in many ways.

In conventional valve trims, fluid velocity increases significantly as the fluid is channeled through the restricted flow area where the flow is throttled. The fluid velocity increases in proportion to the pressure drop pushing the fluid through the throttled opening. High velocity fluid passing through a valve's trim is a primary source of problems. This high velocity fluid can cause vibration, erosion, cavitation and high noise levels, all of which can damage critical valve components. Even before damaging the valve, severe vibration, excessive noise, performance degradation and poor process control can limit the plant's ability to operate at maximum capacity and thereby reduce output. This often results in inferior plant performance, unstable control, seat leakage, increased maintenance and other costly propositions.

Severe service applications, often associated with high pressure drops of liquids, gases or steam are particularly susceptible to high velocity fluid damage. KOSO Vector™ trims are specifically designed to control the potentially destructive effects of high velocity fluids experienced in some control valves. Unlike valves with conventional designs, Vector™ trims ensure fluid velocity never exceed the threshold that could affect system performance or damage critical valve components.

KOSO Vector™ trims solve these problems at the source with a time-proven design and decades of experience in today's most demanding applications.

As fluid passes through a conventional valve and its trim, (from left to right in *Figure 1*), there is a velocity and pressure profile. As the fluid moves from the large area associated with the valve inlet to the much smaller area where the flow is throttled, (or controlled), the fluid velocity goes up. As the velocity (or kinetic energy) of the fluid increases, the pressure energy decreases. Fluid velocity will reach its highest point and the pressure will drop to its lowest point at the valve's vena contracta, which is slightly downstream of the point where the flow is throttled inside the trim. After passing through the vena contracta, the flow area gets larger, the fluid velocity reduces and some of the fluid pressure recovers.

In a conventional valve, the high velocity fluid passing through the throttling point is controlled by the pressure drop across the valve. Increasing the flow area at the throttling point will NOT reduce the fluid velocity. It will only allow more flow through. In applications with large pressure drops, the fluid velocities through the throttling point can be more than 10 times higher than the fluid velocities at the inlet and outlet of the valve body. In high pressure drop applications, as shown in *Figure 1*, the fluid velocity may be high enough to cause vibration, erosion or noise problems.

Figure 2 shows the velocity and pressure profiles for a valve with KOSO VECTOR™ trim. VECTOR™ trim breaks the large pressure drop across the valve trim into a series of smaller pressure drops by forcing the fluid through a tortuous path of right angle turns. Because this tortuous flow path is more restrictive than the simple flow path of a conventional valve trim, a larger throttling flow area is needed to pass the same amount of flow. A larger throttling flow area means lower fluid velocities. For any given pressure drop, the fluid velocity can be reduced by increasing the number of stages (or right angle turns) in the VECTOR™ valve trim.

Symptoms of cavitation

- High levels of vibration
- Sporadic, pinging noise, that sounds like rocks passing through the valve
- Valve components showing "pitting" damage

Preventing cavitation erosion

In addition to vibration, high velocity fluid erosion and noise, conditions may exist where there is a potential for cavitation related problems. Cavitation can be a source of high levels of vibration, which can lead to damaged actuators and piping connections. It can occur in any liquid application.

Referring back to the velocity and pressure profiles shown in *Figure 1*, for any given liquid, there is a pressure where the liquid will vaporize. The vapor pressure depends on the temperature of the liquid. The vapor pressure line can be anywhere. It can be below the lowest pressure inside the valve or above the valve inlet pressure (in which case the fluid passing through the valve is a gas).

In *Figure 1*, the temperature of the fluid is such that the vapor pressure is higher than the fluid pressure at the vena contracta, but lower than the fluid pressure at the outlet of the valve. In this case, at the vena contracta, some of the liquid vaporizes as the pressure drops below the vapor pressure. As the pressure recovers in the outlet of the valve body, the fluid's vapor bubbles will collapse back to liquid. This is a violent, high energy process. When the vapor bubbles collapse near metal surfaces, they can tear away the metal, (even fully stellited surfaces), leaving a rough, pitted surface. Often, the metal just downstream of the valve's vena contracta is a seating surface. Once a seating surface is destroyed, the valve will not shut-off.

As shown in *Figure 2*, the KOSO VECTOR™ trim reduces the pressure drop in a series of smaller pressure drops. The pressure recovery at each stage is much less and the vaporization is less likely to occur. The smaller flow paths and lower fluid velocities associated with the VECTOR™ trim eliminate the damaging effects of cavitation.

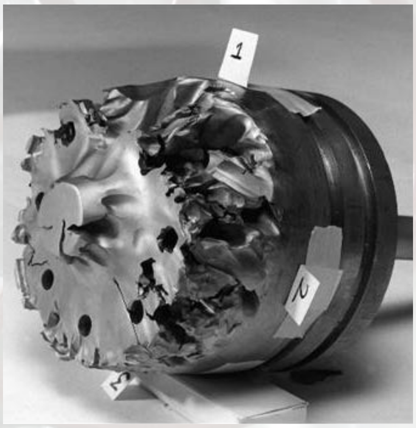
Symptoms of leakage

- High temperature in the downstream pipe for a normally closed valve
- Loss of process control, even when valve is fully closed
- Steam or gas leaks through vents
- Inability to hold the pressure inside the condenser
- Noise produced by valve even when closed

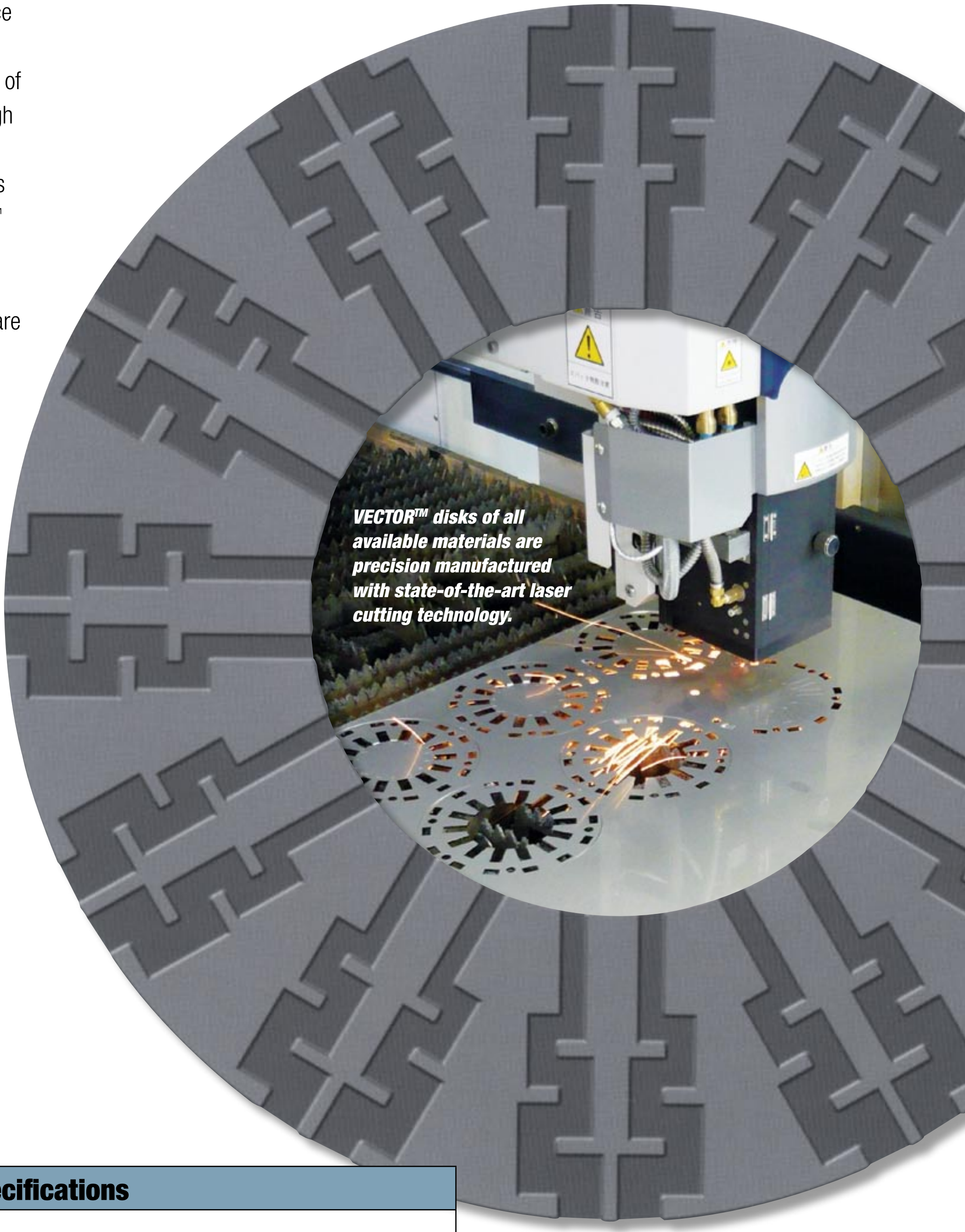
Preventing leakage

When control valves leak, this can significantly reduce plant efficiency resulting in higher overall operational and maintenance costs. This translates into significant expense every year. Leakage is often manifested in the following ways:

- Unscheduled plant shutdowns
- Increased maintenance schedules to replace damaged valve and system components
- System efficiency losses resulting in increased fuel and power consumption
- Heat rate losses and unit load limitations
- Control system oscillations or outright loss of control



Controlling leakage through a severe service control valve requires a combination of technologies and a dynamic understanding of the behavior of the fluid as it passes through the valve. KOSO engineers understand this and have ensured the VECTOR™ valve meets our customer's requirements. The VECTOR™ valve provides repeatable tight shutoff and reliable operation to assure customers that the costs associated with system leakage are truly being controlled.



VECTOR™ disks of all available materials are precision manufactured with state-of-the-art laser cutting technology.

Specifications	
Body type	500D series
Body style	Globe, angle
Body size	1″ – 42″
Body rating	ASME 150 – 4500 class & API-6A 3000 – 15000
Fluid temperatures	-196 °C to 620 °C (-320 °F to 1150 °F)
Connections	Flanges (RF, RTJ), butt welded, socket weld, hubs
Body materials	WCB, LCB, LCC, C5, WC6, WC9, C12A, CF3, CF8M, A105, LF2, LF3, F11, F22, F91, F316, 254SMO, Duplex, AISI 4130
Trim materials	Carbon Steel, 410 SS, 17-4 PH, F11, F22, F44, F91, 304 SS, 316 SS, Inconel, Duplex, Tungsten Carbide, PSZ
Rangeability	50:1 (typical)
Flow characteristics	Linear, modified linear, equal percentage
Metal seat leakage	Cv x 0.01%, Class IV or V, MSS-SP61
Soft seat leakage	Class VI
Trim stages	Up to 40 stages
Actuation options	Pneumatic diaphragm or piston, electric, electro-hydraulic

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