VELOCITY CONTROL TECHNOLOGY

VECTOR™

KOSO
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

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Features</th>
<th>VECTOR™</th>
<th>Competition</th>
</tr>
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<tbody>
<tr>
<td>Vibration free operation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce fluid velocity caused erosion</td>
<td>Fluid velocity controlling trim addresses problems at their source</td>
<td></td>
<td>X</td>
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<tr>
<td>Eliminate cavitation caused vibration and damage</td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Longer cycles between maintenance</td>
<td></td>
<td></td>
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<tr>
<td>Low noise operation</td>
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<td></td>
<td></td>
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<tr>
<td>May eliminate costly additional equipment (baffle plates, silencers, acoustic lagging…)</td>
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<tr>
<td>Improve reliability, efficiency and plant output</td>
<td>Designed to meet the pressure drop and capacity needs of the application</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Wide control rangeability may eliminate a need for a second valve</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Quicker, less costly maintenance</td>
<td>No welded or screwed-in trim parts</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Provide repeatable, tight shut-off</td>
<td>“Edge” contact seating, with extra shut-off force</td>
<td></td>
<td>X</td>
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<tr>
<td>Eliminate costly leakage losses</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Easy to repair seating surfaces</td>
<td>High quality, economic design and manufacturing</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Lower initial costs</td>
<td></td>
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**Note:** The table above lists various features and advantages of VECTOR™ valves compared to traditional competition.
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 cavitational erosion**
- 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

\[ \text{Figure 1, Figure 2} \]
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.

### Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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<tbody>
<tr>
<td><strong>Body type</strong></td>
<td>5000D series</td>
</tr>
<tr>
<td><strong>Body style</strong></td>
<td>Globe, angle</td>
</tr>
<tr>
<td><strong>Body size</strong></td>
<td>1” – 42”</td>
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<tr>
<td><strong>Body rating</strong></td>
<td>ASME 150 – 4500 class &amp; API-6A 3000 – 15000</td>
</tr>
<tr>
<td><strong>Fluid temperatures</strong></td>
<td>-196 °C to 620 °C (-320 °F to 1150 °F)</td>
</tr>
<tr>
<td><strong>Connections</strong></td>
<td>Flanges (RF, RTJ), butt welded, socket weld, hubs</td>
</tr>
<tr>
<td><strong>Body materials</strong></td>
<td>WCB, LCB, LCC, C5, WC6, WC9, C12A, CF3, CF8M, A105, LF2, LF3, F11, F22, F91, F316, 254SMO, Duplex, AISI 4130</td>
</tr>
<tr>
<td><strong>Trim materials</strong></td>
<td>Carbon Steel, 410 SS, 17-4 PH, F11, F22, F44, F91, 304 SS, 316 SS, Inconel, Duplex, Tungsten Carbide, PSZ</td>
</tr>
<tr>
<td><strong>Rangeability</strong></td>
<td>50:1 (typical)</td>
</tr>
<tr>
<td><strong>Flow characteristics</strong></td>
<td>Linear, modified linear, equal percentage</td>
</tr>
<tr>
<td><strong>Metal seat leakage</strong></td>
<td>Cv x 0.01%, Class IV or V, MSS-SP61</td>
</tr>
<tr>
<td><strong>Soft seat leakage</strong></td>
<td>Class VI</td>
</tr>
<tr>
<td><strong>Trim stages</strong></td>
<td>Up to 40 stages</td>
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<tr>
<td><strong>Actuation options</strong></td>
<td>Pneumatic diaphragm or piston, electric, electro-hydraulic</td>
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