

# The Silent Treatment

Fisher® Solutions to Noise Problems





## WHEN YOU PARTNER WITH EMERSON, YOU GET:

### Quality and Value

- Broad solution offerings that have been tested at actual field operating conditions in the largest, most comprehensive control valve development center in the world.
- Products qualified to more stringent specifications than industry-accepted regulatory standards, so you get the best value from plant front-end engineering design through the operation lifecycle.

### Experience and Expertise

- Applications experience that comes from over 130 years in the process industry and Fisher® products at work in every major process.
- Factory-trained engineers at local business partner and sales office locations that consider the requirements of your particular application and develop the best solution.

### Speed and Excellence

- Quick response to your local needs because Fisher products are manufactured all over the world to the same stringent customer, project, and industry requirements.
- Access to the ever-expanding, factory-qualified service network that offers services worldwide for existing control valve installations to maintain peak valve and plant performance.

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## Control Valve Noise

**C**ontrol valve noise is a concern for plant operators and maintenance personnel because it can affect plant availability and profitability. High noise levels can cause health concerns for plant personnel and cause equipment damage, vibration, and control issues.

Populated areas are moving closer to processing plants and noise attenuation is crucial to avoid complaints and potential regulatory action.

There is not one single technology or treatment that can solve all noise issues cost effectively or efficiently. For that reason, a wide range of Fisher noise-attenuation technologies are available for a variety of applications. Emerson maintains application guidelines specifically for Fisher technologies. We would never recommend using our proprietary application guidelines for non-Fisher technologies, nor using other suppliers' application guidelines for Fisher technologies.

Included in this brochure are full descriptions of Fisher technologies complete with images, specifications, and proven results. Emerson's dedicated local business partners, sales offices, and factory application engineers have experience with noise attenuation in all industries. The following sections summarize how several industries are affected by noise.



*A Fisher noise-attenuation control valve can be built to meet the requirements of your application. The valve shown above is NPS 36 x 42 and contains a Fisher Whisper Trim III cage.*

### Power Industry

Today's coal and combined cycle power plants, as well as co-generation and renewable energy plants, are subject to the damaging effects of control valve noise. With high steam pressures and large pressure drops comes the potential for excessive noise and acoustic-induced vibration within the system.

Many power plants have a specification for noise levels within the plant environment, and in some cases they are subject to fence-line noise requirements to protect the plant's surrounding environment. The primary applications in power plants where control valve noise is a concern are: main steam, auxiliary steam, turbine bypass, and sky vent. Proper selection of noise-attenuation technologies is critical.

### Hydrocarbon Industries

Hydrocarbon industries are built on reliable, accurate process control. Typical fluids include steam, flare gas, natural gas, hydrogen, light hydrocarbons, and stripper gas. These fluids are transported and processed in a variety of ways.

Applications that typically have noise issues in hydrocarbon industries include compressor antisurge, gas to flare, and other large pressure drop applications that are driven by chemical reaction, thermal processes, vertical head, or compressors. In all cases, the process equipment must be correctly sized and selected to attain the best loop control, minimize process variability, and deliver the best process results.

### Process Industries

Process industries such as chemical, metals and mining, pulp and paper, and food and beverage also experience noise challenges. The use of steam is common in these industries for a variety of applications. Large pressure drop steam applications can be associated with noise generation.

Emerson offers Fisher control valves for all of these challenging processes and industries. By utilizing local application engineers and experienced design engineers, Emerson can deliver a standard or custom solution for your process needs.



*To view a video on noise, scan the QR code or go to [Fisher.com/NoiseVideo](https://www.fisher.com/NoiseVideo).*

## Science of Noise

Understanding the sources of noise and the nature of noise-generating mechanisms is the foundation for designing and implementing effective measures to control noise.

### Noise Definition

Noise is the unwanted or undesirable sound produced by process control equipment, including control valves. Sound is produced by fluctuating pressure waves that arise from the flow of fluid through the control valve. The specific sources are either mechanical or fluid structure in nature. Dominant fluid-generated sources are specific to hydrodynamic (liquid) flow and aerodynamic (gas or vapor) flow.

These pressure waves are characterized by both amplitude (loudness) and frequency. Amplitude is measured in decibels (dB), a logarithmic measure of relative sound power level. Since the units are logarithmic in nature, a 3 dB increase represents a doubling in sound power level. Frequency is measured in Hertz (Hz) or pressure cycles per second. Industrial noise levels are often expressed in a form that takes into account human sensitivity to frequency. This is known as “A-weighting” and the units of measure are A-weighted decibels or dBA.

### Mechanical Noise

Mechanical noise results from the physical vibration of components in control valves such as worn plugs rattling in cages. Sound levels generated by this type of noise are typically in a low frequency range of less than 1,500 Hz.

Another source of mechanical noise is resonance of movable parts within the control valve, which are characterized by a single pitch, or tone, and may reach frequencies of 7,000 Hz.

### Hydrodynamic Noise

Hydrodynamic noise occurs in liquid flows and is predominately caused by cavitation. Cavitation consists of the formation and collapse of vapor cavities in the flowstream. This occurs when the pressure drops to the vapor pressure of the fluid. The energy released in this process is converted into pressure fluctuations that create sound waves. This noise occurs over a wide frequency range and is often described as sounding like gravel flowing through the pipe.

Other possible noise sources include fluid turbulence and flashing. However, testing has shown that noise generated from these mechanisms is generally not problematic.



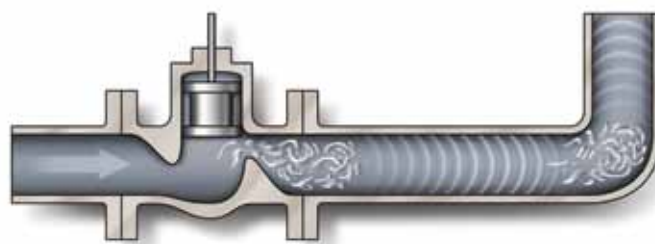
For more information on hydrodynamic noise, scan the QR code or go to [Fisher.com/D351912](https://www.fisher.com/D351912) to download the *Fisher Cavitation-Control Technologies* brochure.

### Aerodynamic Noise Sources

The primary source of aerodynamic noise is fluid turbulence. There are several locations where turbulence can be a problem.

Two locations of interest are within the control valve body. First is the throttling region where the relative fluid pressure is low and the fluid speed is high. High levels of fluid turbulence can result from the jets formed in the control valve trim. The second location is the region between the control valve trim and the body wall where high speed fluid impingement can result in significant turbulence. These two sources of noise are called the trim or valve noise source.

Another location of interest is the region downstream of the control valve trim. Here the velocity-related turbulence in the control valve outlet and downstream pipe acts as an independent noise source. In effect, there can be two independent noise sources in each installation.



**Throttling across the control valve generates high turbulence. Turbulence will eventually decrease but the acoustic pressure field will persist.**

Emerson testing and IEC standards validate that significant noise is generated by fluid expansion when control valve outlet velocity exceeds a Mach number of 0.3.

As the fluid moves downstream through the pipe the turbulence will decrease, however, the acoustic field persists. Depending on the pipe diameter, material, and wall thickness, noise at some frequencies will pass through the pipe wall (sound transmission) and create sound waves that people can hear.

Sources of noise can be classified as either a point source or a line source. Noise from a point source radiates in a spherical shape from the center and sound pressure levels decrease by 6 dBA with every doubling of the distance from the source. An example of a point source is an atmospheric vent or flare.

Noise from a line source radiates in a cylindrical shape from the center and sound pressure levels decrease by 3 dBA for every doubling of the distance from the source. An example of a line source is a pipeline.

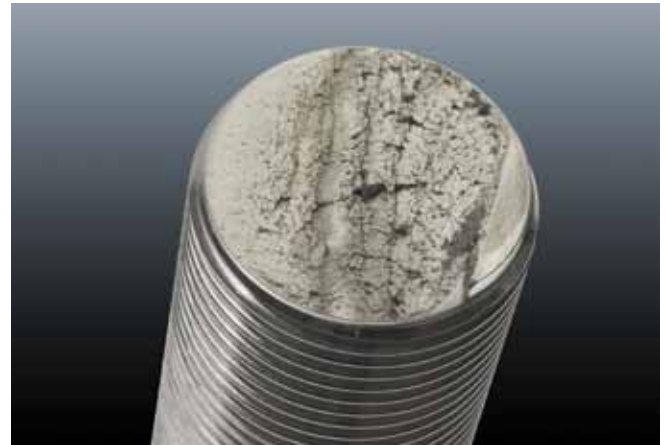
## Factors and Effects of Control Valve Noise

Noise doesn't always cause damage. The potential for noise damage and vibration are dependent on the following factors:

- **Pressure Drop and Pressure Drop Ratio** – Greater drops in pressure and higher pressure drop ratios increase the potential for noise. The pressure drop ratio—the change in pressure divided by the inlet pressure—is an indicator used to determine the performance level required of the control valve trim.
- **Valve/Trim Geometry** – Tortuous flow paths can increase turbulence and noise, which can cause damage to the control valve trim, body, and pipeline. Other factors affecting noise include flow path size, shape, and location.
- **Valve Outlet Area** – High fluid velocity at Mach numbers at or above 0.3 through the control valve outlet or pipe can result in increased turbulence and noise. Valve outlet area must be accounted for to obtain the most accurate noise prediction.
- **Flow Rate** – Higher flow rates have a potential to increase turbulence and noise.
- **Time of Exposure** – The longer an area is subject to high vibration, the more likely it is to be damaged.
- **Project Noise Assessment** – Factors external to the control valve can affect the overall noise being generated in the plant. These factors include:
  - **Flow Path** – Orifice plates, elbows, manifolds, and other downstream equipment can obstruct and/or disrupt the flow. These changes generate acoustic pressure fluctuations that can alter the intensity of the noise.
  - **Combined Noise Sources** – Two similar noise sources in close proximity can be up to 3 dB higher than the greater of the two original sources.
  - **Material, Thickness, and Diameter** – Thicker and larger diameter pipelines reduce the ability of noise to radiate through the pipe wall and create sound waves that people can hear.

### Vibration Damage

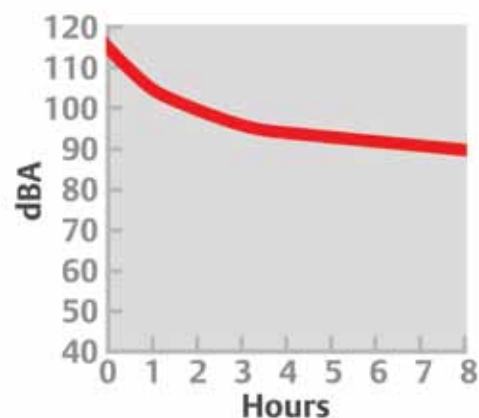
Noise can cause vibration in control valves, pipe, and other system elements. This vibration can shorten the life of your equipment.



*Control valve stem/shaft breakage is a common fatigue failure due to heavy vibrations within the system.*

### Environmental Noise

Noise frequencies between 20 and 20,000 Hz are audible and can be a nuisance to plant operators, maintenance personnel, and others who come into contact with the noise. At high levels, noise can cause damage to human hearing and radiate to surrounding environments where it may result in further problems such as fines and restrictions on operations.



*Most regulatory agencies have placed restrictions on workplace noise exposure. For instance, allowable sound pressure levels in the U.S. are shown above.*



## Control Valve Noise Technologies

Two primary challenges face the control valve supplier:

1) effectively control unwanted noise and 2) accurately predict the noise levels associated with a specific control valve in a given set of operating conditions. Both of these challenges require a deep understanding of the foregoing fundamentals.

Effective control of noise arising from mechanical sources has been accomplished by improving control valve design and implementing good maintenance protocols.

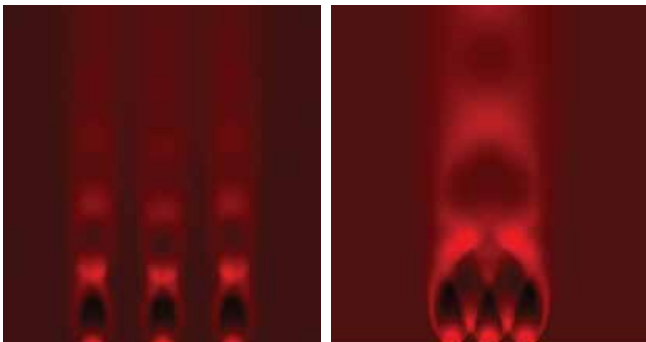
Controlling fluid-generated noise requires a number of different strategies dependent on control valve style and degree of attenuation.

### Source Treatments

A principle aerodynamic strategy is to break the flow stream into many small, parallel flow passages. Not only does this reduce the strength of the noise source, but also shifts the frequencies to a higher, non-problematic range. These and other techniques are known as source treatments.

Source treatments prevent noise at its source, which can involve the control valve. Common source treatments include noise-attenuation control valve trims, inline diffusers, and vent diffusers that minimize turbulence.

Emerson utilizes unique flow passage shapes and multi-stage pressure reduction in noise-attenuation control valve trims as source treatments. These unique flow passage shapes reduce turbulence to minimize shock-associated noise and place turbulent shear layers away from solid boundaries to reduce noise. The multi-stage pressure reduction utilized with sound engineering principles control jet size, formation, interaction, and accommodates fluid expansion. It is important to control these aspects of the exiting jets to reduce the noise and vibration. Emerson has developed a variety of noise-attenuation control valve trims that offer attenuation levels of up to 40 dBA.



**Computational fluid dynamics show jet independence from three properly spaced holes (left). The same three holes spaced too closely (right) show jet interaction, which leads to additional noise. Being able to predict and control jet interaction can reduce the noise produced by up to 40 dBA.**

### Path Treatments

In addition to eliminating noise at its source, noise levels can be attenuated by impeding the propagation and transmission of the sound waves. Solutions of this type are referred to as path treatments. Path treatments help eliminate noise heard outside of the pipe wall by increasing the resistance of the noise path. Typical path treatments include increasing the pipe thickness, adding acoustical or thermal insulation, or adding inline pipe silencers. Noise levels can be decreased by as much as 45 dBA depending on treatment and application.

The weakness of path treatments is that both the fluid stream and the piping itself are very effective at transmitting noise; therefore complete noise attenuation is difficult. This means that attenuation is only effective for the area where the treatment is applied.

### Noise-Attenuation Technologies

Fisher noise-attenuation technologies, listed below, are compatible with many Fisher control valve types.

- Whisper Trim I Cage
- Whisper Trim III Cage
- WhisperFlo Cage
- Vee-Ball Control Valve with Rotary Attenuator
- V260A Control Valve with Aerodome Attenuator
- Vent Diffusers
- Inline Diffusers

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Emerson routinely fulfills custom orders for noise solutions not offered in the standard product line using the dedicated application engineering team. Emerson is the only custom control valve provider in the world who can offer the combination of experience, control valve engineering, research understanding, and worldwide manufacturing capabilities. The track record of custom Fisher control valves is proven many times over. Tens of thousands have been produced in recent decades.

## Accurate Noise Prediction

### Emerson Innovation

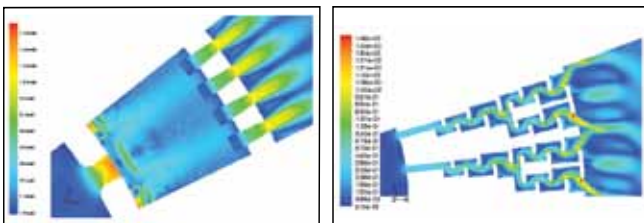
You can get a larger selection of noise solutions from Emerson because we spend more time studying control valve noise than anyone else. Emerson studies the major sources of control valve noise and has determined not only how to predict noise, but also how to minimize it.

Emerson utilizes IEC 60534-8-3 for noise prediction and is actively involved in developing the standard. The most recent version of the IEC standard has sanctioned the use of experimental data. We leverage our flow lab to provide accurate aerodynamic noise data, validated through tests in compliance with the IEC standard.



*Fisher control valve designs undergo thorough and extensive flow testing in the 2,323 m<sup>2</sup> (25,000 ft<sup>2</sup>) flow lab in the Emerson Innovation Center—the largest, most comprehensive control valve development center in the world.*

Aerodynamic noise testing is performed using real-world plant conditions. We utilize a 3,500 psi air source and line sizes up to NPS 36 pipe for noise testing. Control valves are flow tested in the pipe, the aerodynamic noise is measured, and attenuation concepts are studied to maximize noise reduction.



*A top-down look at flow through Fisher WhisperFlo trim (left) using computational fluid dynamics illustrates the independence of fluid jets as they exit the cage. In contrast, the exit jets of some tortuous path trims (right) impinge upon one another in pairs, creating an additional noise source.*

There are many environmental factors that affect noise, so isolating a test valve from other noise sources is important. Emerson uses an acoustic test chamber to do exactly that. The mobile, acoustic test chamber is placed around the control valve being studied and noise measurements are taken as defined by the IEC noise test standards.

Utilizing our world-class noise test room, we can accurately quantify noise from devices in real-world installations. This room allows Emerson to test a wide variety of configurations at conditions well beyond the IEC standard.



*Noise testing of an NPS 12 vent diffuser.*

## Additional Selection Factors

### Quality Manufacturing

Emerson is a pioneer in understanding noise-related problems in control valves. Through this understanding, Emerson leads the way in engineering and manufacturing noise control solutions that solve a variety of problems across an assortment of applications.

Holding tight tolerances and selecting correct materials—which are part of a genuine Fisher solution—can extend control valve service life. Confidence in noise solutions relies on true OEM engineering and manufacturing specifications. Non-OEM solutions may appear to be cost effective in the short term, but introduce new risks of unexpected shutdowns and lost production. Are you willing to take this risk?



*Advanced manufacturing techniques lead to consistent quality and reduced lead-times. Laser cut disks produce tight tolerances consistently for stacked-disk cages. The twelve spindle, high-speed drilling machine reduces the manufacturing time for drilled-hole cages such as Fisher Whisper Trim III.*

### Proven Results



Case histories have been written about the noise solutions that Emerson has provided to customers. To view them, scan the QR code or go to [Fisher.com/CaseHistories](https://fisher.com/CaseHistories). They are listed by industry, application, and subject.

### Serving You for the Life of Your Plant

Emerson is a provider of trusted expertise for reliability-centered control valve maintenance. A network of service centers, manufacturing sites, local business partners, and sales offices puts experienced professionals where and when they are needed. Highly skilled technicians provide cost effective maintenance, control valve reliability, and increased process availability through flexible, local service.

### Local Service and Repair

Emerson can provide immediate answers and world-class service through a vast network of factory-trained and factory-certified technicians. Service Centers are factory supported to provide instant access to Emerson product manufacturing records and engineering drawings. Service locations house state-of-the-art equipment to address control valve problems in a plant or process. Emerson technicians are factory qualified with in-depth, hands-on training, safety awareness, and ongoing education throughout their service career. A comprehensive vehicle fleet is available to bring the right capabilities, tools, and equipment directly to plant sites to assist with repairs.

### On Demand Services

Whether starting up a new plant or process, troubleshooting maintenance issues, or preparing for new installations, Emerson can help address immediate problems through On Demand Services. Backed by years of application expertise, Emerson service professionals provide innovative insight into your process to maximize operation results throughout the plant life cycle.



## Fisher® Whisper Trim™ I Cage

offers proven attenuation of aerodynamic noise in vapor, gas, or steam applications involving low to medium pressure drops. The Whisper Trim I cage offers economical, dependable noise attenuation in a variety of globe and angle valve bodies. It is widely used across all process industries, is incredibly effective, and offers great application flexibility.

The shape, size, and spacing of the passages in the Whisper Trim I cage reduce noise and associated vibration across the control valve. These passages break up turbulent fluid streams and ensure exit jet independence, thereby reducing noise.

- Up to 18 dBA of attenuation
- ASME Class 125–900
- NPS 1–12
- Available in Fisher easy-e™ control valves



## PROVEN RESULTS

PRODUCTION:	Steam
APPLICATION:	Steam letdown
CHALLENGE:	The previous general service valve generated high noise and vibration, which exceeded fenceline noise requirements and caused process system damage.
SOLUTION:	Fisher easy-e valve with a Fisher Whisper Trim I cage.
RESULTS:	Reduced fenceline noise to an allowable level and eliminated vibration-related damage.

## Fisher® Whisper Trim™ III Cage

is a drilled hole trim available in a variety of control valve sizes and styles. It delivers excellent noise reduction for a wide range of vapor, gas, and steam applications. The design architecture allows for flexibility of size, pressure class, materials, rangeability, and attenuation.

- Up to 30 dBA of attenuation
- ASME Class 150–4500
- NPS 1–42
- Available in Fisher easy-e, EW, HP, EH, FB, TBX, and GX control valves
- Hundreds of standard constructions as well as a readily-available process to routinely provide custom, application-specific constructions
- Typical materials ranging from carbon, alloy, and stainless steels to titanium

Control valves utilizing Whisper Trim III cages reduce noise through the following three means:

- Exit Jet Independence: Parallel passages ensure jet independence and prevent additional noise.
- Frequency Shifting: Higher frequencies are less problematic to hearing and process systems.
- Complementary Body Design: Emerson-engineered valve bodies prevent secondary noise sources.



## PROVEN RESULTS

PRODUCTION:	Baseload fossil power
APPLICATION:	Gland steam
CHALLENGE:	High steam velocity at the outlet of the previous control valve plus large pressure drops created excessive noise and vibration, which posed a serious risk of stress or fatigue-related damage to both the control valve and adjacent piping.
SOLUTION:	Emerson-engineered Fisher NPS 2 HPS control valve with a Fisher Whisper Trim III cage.
RESULTS:	Damaging noise was reduced and vibration was eliminated.

## Fisher® WhisperFlo™ Cage

offers state-of-the-art attenuation of noise in vapor, gas, or steam applications involving large pressure drops. WhisperFlo trim is a laser cut, stacked-disk cage assembly that is available in a variety of globe and angle bodies for the most severe applications.

- Up to 40 dBA of attenuation
- ASME Class 125–2500
- NPS 4–42
- Available in Fisher easy-e, EW, FB, HP, and TBX control valves
- Customized flow characteristic for your specific application

Every WhisperFlo cage assembly provides noise attenuation across the following six areas:

- Unique Passage Shape: Reduces acoustic efficiency and turbulence.
- Staged Pressure Reduction: Further reduces acoustic efficiency.
- Exit Jet Independence: Parallel passages ensure jet independence and prevent additional noise.
- Frequency Shifting: Higher frequencies are less problematic to hearing and process systems.
- Velocity Management: Accommodates natural fluid expansion.
- Complementary Body Design: Emerson-engineered valve bodies prevent secondary noise sources.



**Closeup View of  
WhisperFlo Cage Section**

## PROVEN RESULTS

<b>PRODUCTION:</b>	Liquefied natural gas (LNG)
<b>APPLICATION:</b>	Compressor antisurge
<b>CHALLENGE:</b>	The high flow rate experienced by the previous antisurge control valve generated unacceptable noise and vibration levels, posing a risk to process availability.
<b>SOLUTION:</b>	Fisher FBT valve with a Fisher WhisperFlo cage, Fisher 585CLS actuator, and Fisher antisurge accessory package.
<b>RESULTS:</b>	Damaging noise and associated vibration were reduced to a safe level, while maintaining high turndown and fast stroking speed, which re-established process availability.

## Fisher® Vee-Ball™ Control Valve with Rotary Attenuator

combines the efficiency of a rotary valve with noise control trim to provide improved performance for demanding applications. This design is used to reduce aerodynamic noise for steam, gas, and vapor applications. The Vee-Ball control valve features an attenuator welded on the back of the V-notch ball, which separates the flow into multiple smaller jets, reducing flow turbulence.

Precise contouring of the V-notch ball provides an approximately equal percentage inherent flow characteristic, which is optimal for most flow control applications.

- Up to 10 dBA of attenuation
- ASME Class 150–600
- NPS 4–20



### PROVEN RESULTS

PRODUCTION:	Ethylene
APPLICATION:	Steam pressure-reducing valve
CHALLENGE:	The previous control valve experienced excessive noise due to a demanding flow and pressure drop application.
SOLUTION:	Fisher NPS 12 Vee-Ball control valve with rotary attenuator.
RESULTS:	Field noise measurements indicated the rotary attenuator achieved attenuation of -8 to -10 dBA, which was on target with the customer requirement.



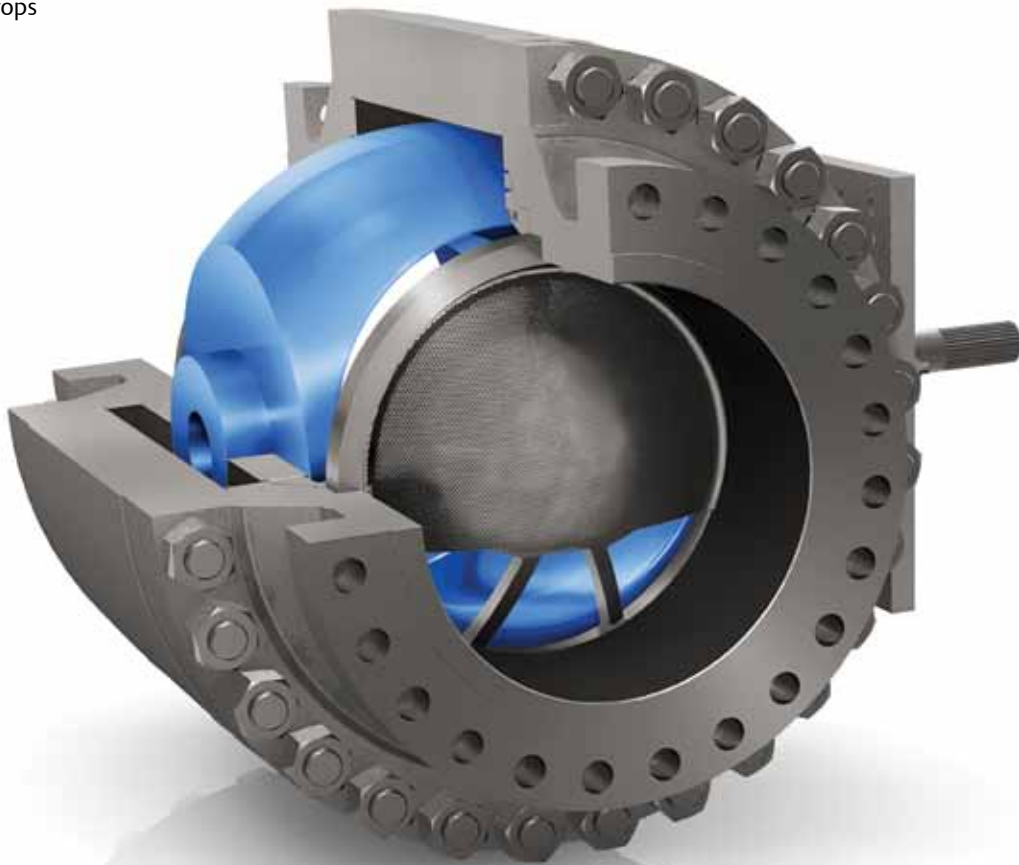
## Fisher® V260A Control Valve with Aerodome Attenuator

is designed for gas and vapor service to help eliminate or reduce noise and vibration. The V260A is a full bore ball valve designed with features for optimized pressure, flow, and process control. The integral, drilled Aerodome attenuator controls noise and vibration from large pressure drop and high flow processes.

The V260A ball valve is available with single or dual-stage Aerodome attenuator configurations that provide a variety of noise reduction levels.

The Aerodome attenuator is active throughout the ball rotation for very demanding services or a characterized attenuator (as shown) is used to match specific service conditions.

- Up to 25 dBA of attenuation
- ASME Class 300–900
- NPS 8–24
- Large pressure drops



## PROVEN RESULTS

PRODUCTION:	Gas transmission
APPLICATION:	Pressure control to distribution service
CHALLENGE:	The previous control valve suffered excessive noise and vibration, which caused damage.
SOLUTION:	Fisher NPS 8 V260A control valve with characterized Aerodome attenuator.
RESULTS:	Resolved the noise and vibration that were attributed to an unattenuated control valve design.

## Fisher® Vent Diffuser

offers proven noise attenuation in steam, gas, or vapor venting applications. A vent diffuser places backpressure on the control valve while venting process to the atmosphere.

The Fisher vent diffuser shares the total system pressure drop with the vent valve. The benefits are: 1) the vent valve noise is reduced and 2) the noise at the atmospheric vent point is reduced.

- Up to 40 dBA of system noise attenuation
- ASME Class 150–2500
- Inlet sizes NPS 2–26
- End connections include raised-face flange, ring-type joint flange, or butt-weld end
- Optional outer shell directs the vented process away from components and personnel



## PROVEN RESULTS

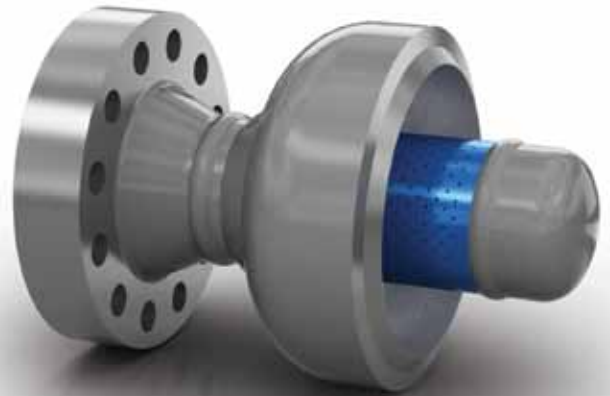
PRODUCTION:	Combined cycle power plant
APPLICATION:	Sky vent
CHALLENGE:	Noise and vibration occurred during high flow venting of the heat recovery steam generator.
SOLUTION:	Engineered system of Fisher NPS 16 valve body, Fisher WhisperFlo cage, and Fisher vent diffuser.
RESULTS:	Damaging noise and vibration were reduced to a safe level for plant personnel and at the fenceline.

## Fisher® Inline Diffuser

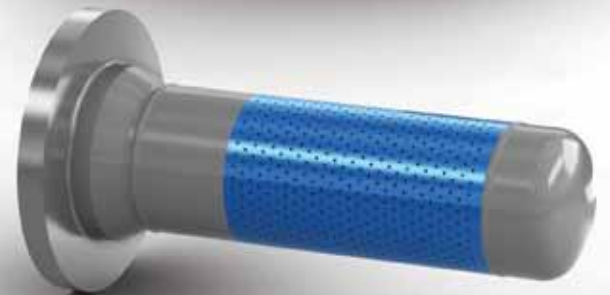
offers noise attenuation in vapor, gas, or steam applications. A diffuser places back pressure on the control valve, thereby reducing the turbulence and pressure drop across the valve, which are main contributors in damaging noise and vibration. When paired with a Fisher control valve and Whisper Trim cage, the resulting solution is one that will provide the greatest level of noise attenuation for the most severe application.

Specially-designed flow passages featured in all three Fisher diffusers provide a custom-engineered product. Furthermore, these diffusers can be placed at almost any point in the pipe; they do not need to be placed immediately after a control valve.

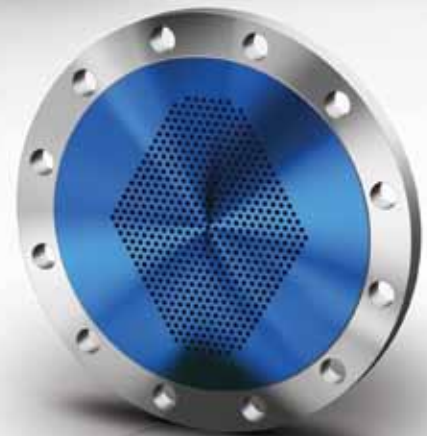
- Up to 50 dBA of system noise attenuation
- ASME Class 150–2500
- The Fisher 6010 has inlet and outlet connections (available in sizes up to NPS 72)
- The Fisher 6011 has a wafer flange mounting (available in sizes up to NPS 48)
- The Fisher Whisper Disk is a flat plate (available in sizes up to NPS 36)
- Customized flow characteristic for your specific application



**6010 Inline Diffuser**



**6011 Inline Diffuser**



**Whisper Disk Inline Diffuser**

## PROVEN RESULTS

<b>PRODUCTION:</b>	Co-generation for a process plant
<b>APPLICATION:</b>	Steam letdown
<b>CHALLENGE:</b>	The previous control valve experienced damage from high pressure and temperature steam letdown.
<b>SOLUTION:</b>	Fisher HP control valve with a Whisper Trim III cage paired with a Fisher 6010 inline diffuser.
<b>RESULTS:</b>	Staged pressure drop on the valve and diffuser effectively reduced the noise and vibration.

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