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Cover Story

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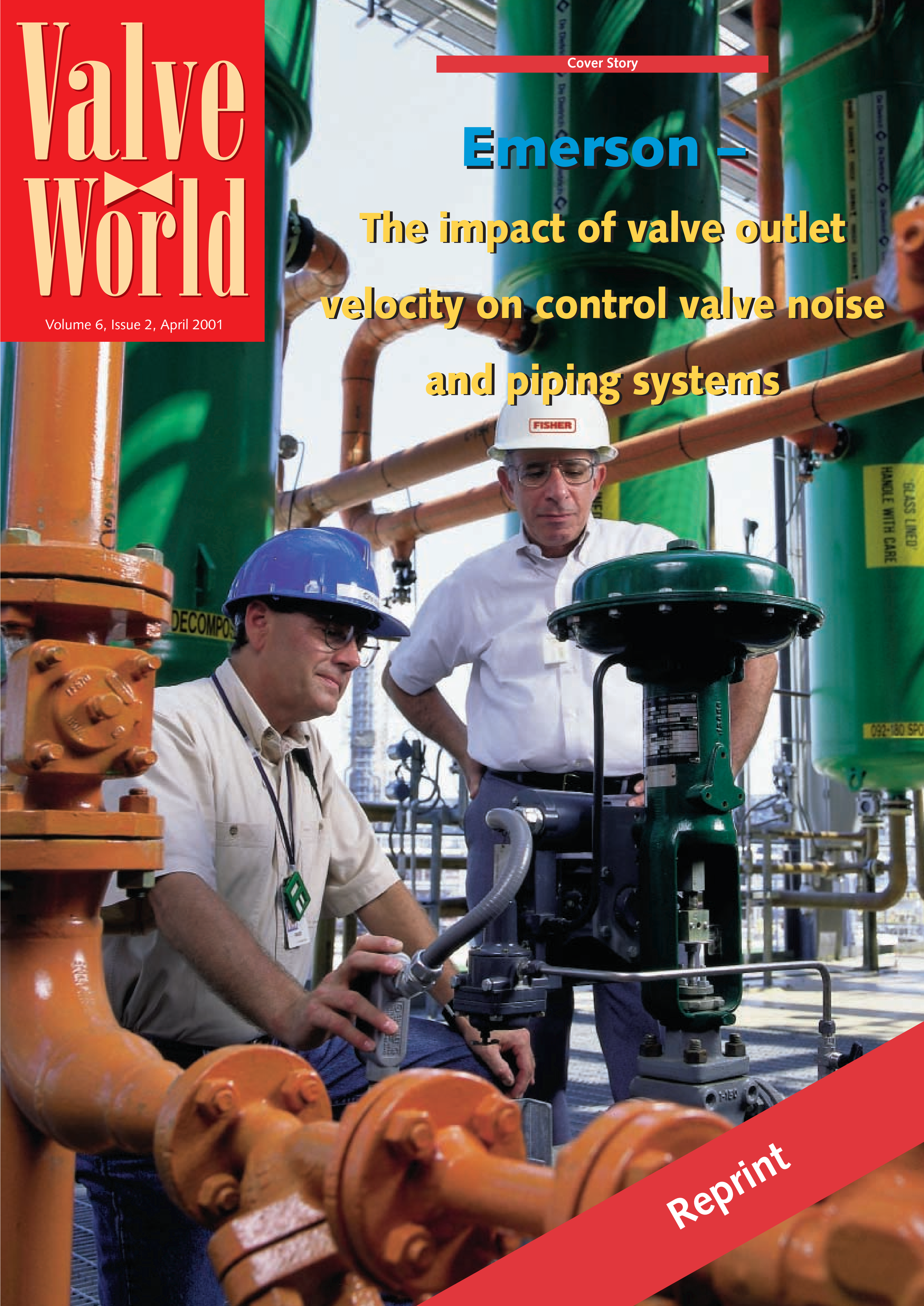

Reprint

The impact of valve outlet velocity on control valve noise and piping systems

By John Wilson, Fisher Controls International, Inc.

Control valve noise has long been an issue at many process facilities because of its effect on process equipment. During the past three decades, the task of controlling valve noise has been a major undertaking by the control valve industry. It's only been in the past few years that the environmental impact of control valve noise has been recognized and regulations put into place to limit its severity.

The majority of these noisy control valves are found in pressure reduction applications involving gases or steam. (As a pressure drop is taken in a control valve, most of the resultant energy is lost in heat while the rest is converted to noise.) Prior to the introduction of specially designed valve trims that lower the effective noise level at the device, the first efforts at quieting these valves involved installing fixed restrictions in the downstream piping to create a back pressure. This back pressure would in turn reduce the pressure drop taken across the control valve, lowering the noise generated at the valve.

While this technique may work well for one set of process conditions, it usually fails to reduce noise should the conditions vary in the slightest. Since the inlet and outlet pressures of the valve vary throughout the valve's entire range of travel, the likelihood that a fixed restriction could lower the noise in all cases is extremely unlikely.

Today's technology has evolved from drilled-hole valve trim that shifts the peak frequency of the noise above the audible range of the human ear to trim designs that exhibit a variety of noise control techniques. These techniques include frequency shifting, staging the pressure drop, shaping the flow passages to control turbulence, keeping the flow jets independent as they exit the trim and lowering the velocity of the process fluid.

While these trims reduce the audible noise generated by the throttling process at the valve, the overall noise is still dependent upon the selection of the proper valve type and size. If the valve body size is too small, the outlet velocity will overpower any noise reduction that occurred at the trim.

Practical example

Several years ago, a gas plant in Saudi Arabia experienced cracking of an Acid Flare Header. The site engineers carried out vibration tests to determine the cause and proposed several changes to the piping system to eliminate the cause of the damage. The changes were implemented, but the problem continued and eventually led to cracks in the piping as well as the header supports.

A historical review of the problem was conducted once again, but this time with process data also being included in the evaluation. A fluid dynamics calculation was performed utilizing computational fluid dynamics (CFD) software to simulate overall process conditions. The detailed simulation included sonic velocity calculations, gas velocity and vibration correlation and pressure drop calculations.

The analysis revealed that 10" valves in the header system were the main contributors to the excessive vibration. While the valves incorporated noise abatement trims, they were undersized and generated outlet velocities over 0.7 Mach. This not only created unacceptable noise levels at the valve, but also led to velocity induced vibration of the piping system. It was proposed to install a new type of noise abatement trim, but adjusting only the trim would have had no effect, as the valve outlet velocity was the driving factor behind the excessive noise.

The proper valve for the application proved to be a 16" valve that had the appropriate level of noise abatement trim, and the correct body size to eliminate any outlet velocity effects.

The velocity at the 16" valve was reduced to 0.3 Mach, which significantly reduced the noise at the valve and eliminated the vibration that could affect the downstream piping.

This example is typical with some manufacturers in the control valve industry. A control valve is selected based on the required Cv to pass the flow and address the noise generated by the trim. The outlet size of the valve is normally ignored. If an inadequately sized valve is chosen, the valve, piping system and downstream equipment are in jeopardy of premature failure.

How outlet velocity increases noise levels

Control valves are typically selected in sizes smaller than the adjacent piping for economic reasons, but the piping is still subject to the typical selection process using gas density and mass flow rate. This selection process usually leads to a larger pipe downstream of the pressure-reducing valve.

With a smaller size control valve, a reducer or expander is required to mate the control valve with the piping. Problems can occur with this configuration because the velocity related turbulence generated by the expander at the valve outlet creates its own noise that often exceeds that of the noise abatement trim. This turbulence is caused by the difference in gas velocity between the valve outlet and downstream pipe that creates an additional noise source.

The effect of this velocity related turbulence can be seen in Figure 1 as the outlet pressure decreases in a given application where an 8" valve with low noise trim is installed in a 12" line. The noise due to the reducer begins to become the overriding factor at downstream pressures of less than 22 psia. As the outlet pressure continues to drop, the noise calculated one meter from the pipe increases over the predicted valve trim noise. In the case noted below, the actual noise is four to five dBA greater than that predicted by standard noise prediction methods. Noise predicted by combining both the valve trim noise and reducer noise nearly matches that of the measured values.

Figure 2 shows the effect of valve outlet velocity on the overall noise created by a 4" valve installed in an 8" line. The standard valve sizing programs take into account only valve trim noise, which leads to inaccurate noise prediction. However, actual test data show that the valve noise is much greater and dominated by outlet velocity effects. This also shows that different piping expansions will have different effects on the overall noise at the control valve.

Both valve trim and valve outlet velocity noise must be taken into account when predicting the noise at the control valve. Only by combining these two noise sources can one truly estimate the effect of the control valve on the downstream environment and equipment.

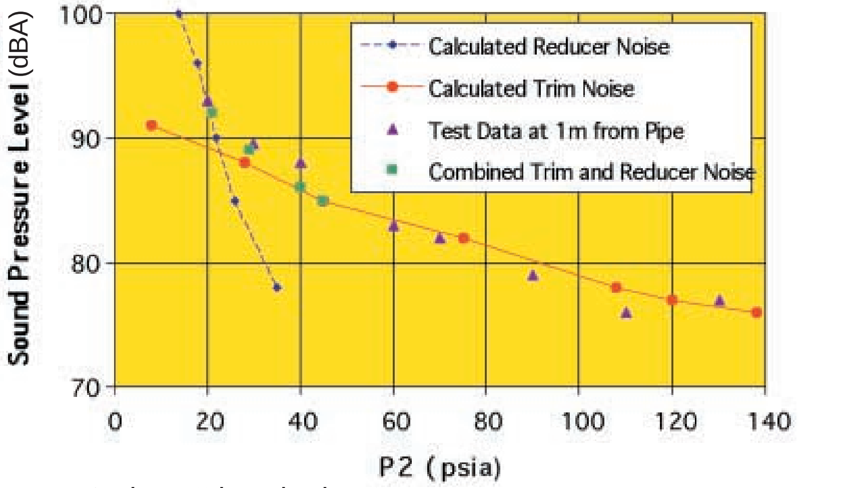

Figure 1. Combining Valve and Reducer Noise

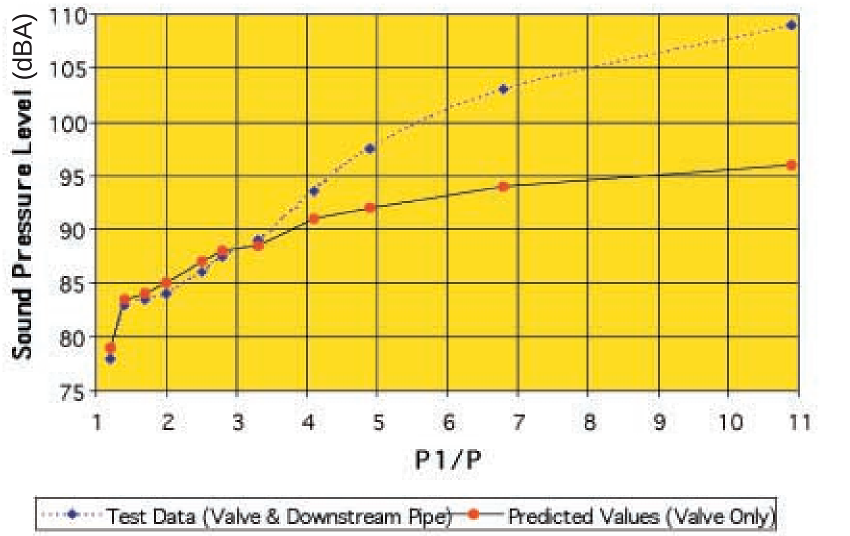

Figure 2. Predicted vs. Actual Control Valve Noise

Choosing the correct solution

Now that it has been determined that control valve noise is due to more than just valve trim, how is it possible to be sure that a valve selection is the correct one? The IEC established the guideline to reduce the velocity at the valve to 0.3 Mach or less. It is possible, however, to install a control valve where the velocity is greater than 0.3 Mach. This is assuming that the effect of outlet velocity has been taken into account during the sizing of the control valve, and that the subsequent additional noise source will not cause the valve to be louder than required. IEC 534-8-3, "Control valve aerodynamic noise prediction method," accounts for effects of valve outlet noise up to 0.8 Mach. This is due to advancements in the noise prediction technique that take into account the presence of reducers/expanders and piping effects. Prior to these recent advancements, the standard was limited to Mach levels of 0.3 or less and only included the valve trim noise in the calculations.

Only by incorporating the IEC 534-8-3 standard can users be sure of the noise level to expect from a control valve once it is installed. The standard was developed to allow a noise level to be calculated for any type of valve with any type of standard trim or noise abatement trim. By better understanding the actual system noise that will be created once a control valve is installed, valve users can be sure that they are protecting their plant's equipment and ensuring environmental compliance. ■

References

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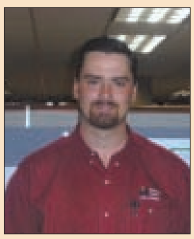
About the author



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