Improving prediction of control valve noise

Producers of process control valves are required to estimate sound levels of installed control valves under specified operating conditions as part of the valve sizing and selection process. This is required to meet sound-level limitations in the interest of worker hearing conservation.

Nearly 30 years ago, producers began to offer methods for estimating noise produced by valves handling compressible flows. ISA standard S75.17, Control Valve Aerodynamic Noise Prediction, was published in 1989 after many years of effort. IEC standard 534-8-3, Control Valve Aerodynamic Noise Prediction Method, followed in 1995. The IEC standard is based on the earlier ISA standard but includes additional provisions for valves with low noise trim.

The methodology for predicting control valve noise used in IEC 534-8-3 involves first estimating the sound power generated in the fluid inside the valve and piping due to the throttling process. Then, the transmission loss due to the piping is subtracted to determine the sound level at a predetermined location outside the piping.

Noise prediction for a freely expanding jet is based on multiplying the mechanical energy conversion in the jet by an efficiency factor. This theory is modified to take into account the confined jet expansion in a control valve and the inherent pressure recovery.

To accommodate the complex nature of valve noise generation, the prediction method addresses calculation of significant variables in five different flow regimes. The significant variables include acoustic efficiency, sound power, and peak frequency. From these and other variables, the internal sound pressure level is calculated.

The transmission loss model is a practical simplification of complex structural transmission loss behavior. The simplification is rationalized based on allowable tolerances in piping wall thickness and roundness.

The downstream piping is considered the principal radiator of generated noise. The transmission loss model defines three sound-damping regions for a given pipe, with the lowest transmission loss at the first coincidence frequency. The transmission loss is calculated at the first coincidence frequency and then modified in accordance with the relationship of the calculated peak frequency to the coincidence frequency. A correction is then made for velocity in the downstream piping.

The predicted sound level is then based on the calculated internal sound pressure level, transmission loss, velocity correction, and a factor to convert to decibels (dBA). It is then corrected for a distance of 1 meter from the pipe wall.

A draft revision of the IEC standard has been prepared and circulated for comment. This draft contains two major modifications. First, the transmission loss calculation method is extensively revised. For smaller pipe sizes and common wall thicknesses, the calculated transmission loss is very similar with almost no change. However, the transmission loss differs from the previously calculated value for larger pipe sizes (16 inches and larger), particularly for those with relatively lighter walls. This newer value is closer to the result of an existing German prediction method.
The second major change is addition of an entirely new clause titled “Valves with Expanders with Higher Mach Numbers.” Previously, prediction accuracies were limited to cases where the valve outlet velocity does not exceed Mach 0.3 for conventional valves and Mach 0.2 for valves with low noise trim. This proposed modification is targeted at increasing the suitability of the method for applications with higher Mach numbers.

In the past, the need for a correction for valves with expanders having higher Mach numbers was recognized. A correction has been used in combination with the published IEC method by at least one producer for a number of years. This correction is based on the Mach number at the valve outlet with an empirical fit to test data.

The IEC draft proposal is based on the methodology introduced by H.D. Baumann in a February 1997 InTech article titled “Predicting Control Valve Noise at High Exit Velocities.” The proposal also details the revised transmission loss method.

The basic concept is to calculate valve sound level with the present method (but with the revised transmission loss method), and then calculate a sound level due to an expander using similar methodology. These two sound levels are then added together logarithmically to determine an overall sound level.

At first inspection, it seems more elegant to first combine the internal sound levels and then apply a transmission loss to the combined value. However, each noise source has its own peak frequency and its own spectral distribution. This causes a great problem when applying a transmission loss. It is much more accurate to treat each source separately and then logarithmically add the resulting sound levels together.

To assess the IEC proposal’s validity, the method was programmed. Stored laboratory air test data was run using the program to compare the predicted sound level to the measured sound level.

The result of running data from 54 different tests shows consistency, particularly for low-noise valves with expanders where the correction is most needed.

A good example is shown in Figure 1, where a plot of predicted and measured sound level versus pressure ratio for a 4-inch globe valve with low noise trim is illustrated. The predicted sound level for the valve only (LA) is shown as a dashed line. The predicted sound level for the combined valve and expander (LPO) is shown as a solid line. Actual measured sound-level data points are depicted as triangles. In this plot, the need to account for the combined valve and expander sound level is evident. Certainly not all tests performed approach perfection as closely as this example, but none shows gross deviations.

A deviation plot was made for all useful data points from test runs of 12 different valve and pipe size combinations. The plot in Figure 2 shows the deviation of predicted sound level from measured sound level for the data points versus valve outlet Mach number. Any data points above zero indicate the predicted sound level is greater than the actual measured value (i.e., the valve is quieter than predicted). Data points below zero indicate that the predicted level is less than the actual value.

Based on this evaluation, the overall conclusion is that the method proposed in the IEC draft is entirely suitable. It is the opinion of this writer that the IEC draft should be approved as an improvement to the usefulness of IEC standard 534-8-3. It is also recommended that users of control valves require noise prediction to be made by producing users IEC standard 534-8-3. This will help avoid differences in predicted sound levels based on inconsistent prediction methods rather than on actual valve performance.

**For further reading**


**Behind the byline**

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