Tech Sheet #CVR 401

Insulation Systems Used as External Treatment for Control Valve and Regulator Noise

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1. SCOPE

This document applies to thermal and acoustic insulation systems used on valves, piping and connected vessels to reduce acoustic noise produced by control valves and regulators.
It is intended especially for gas and steam applications, where the most common needs are. However, it may also be useful for some liquid applications. It does not apply to noise radiated at the discharge of open (vent) systems.

2. PURPOSE

This document is provided as a service to the user community. It provides necessary background information and basic guidance about insulation to enable the user to make good decisions concerning the use and effectiveness of insulation.

3. BACKGROUND INFORMATION

3.1 Introduction

A basic understanding of valve noise and acoustics is given in this section.

3.2 Sources of Noise

Noise is an inherent byproduct of the throttling process in control valves and regulators. A small fraction of the pressure drop energy is unavoidably converted into acoustic energy. A portion of this energy passes through pipe or vessel walls of closed systems to the surroundings. Fortunately, in many cases, noise levels are so low that the noise is not a concern. More severe services however may require some kind of treatment.

With compressible fluids (gases and steam), there can be several aerodynamic noise producing mechanisms including turbulent mixing noise, shock waves, impingement, and shock turbulence interaction. Noise generated depends on service conditions and other factors in a complex way, but levels can be predicted with standardized methods such as IEC 60534-8-3 (1) and its counterpart ISA S75.17 (2). Liquid noise mechanisms can include turbulence and cavitation, and levels can be predicted by IEC 60534-8-4 (3). For both compressible and incompressible media, heavier wall pipe yields lower noise levels.

These methods are predictions for ideal laboratory conditions, 1 meter downstream and 1 meter away from the pipe. Computerized versions are available from many valve manufacturers, and the software packages typically include technical background and tutorial information. Actual installed levels are more complicated to predict, and can be higher due to room reflections, additive noise from other equipment, etc.

Liquid noise is not normally a problem. High levels usually indicate unacceptable cavitation, which must be controlled to prevent physical damage.

It is essential to understand where and how throttling noise radiates to the environment. The noise travels far downstream in the pipe with minimal attenuation, and is radiated from the outer pipe wall along the way. An equal or lesser amount of energy travels upstream as well. The relative upstream portion depends on fluid, valve style, whether the flow is sonic, and other service conditions. The valve body itself is a minor radiator compared to the pipe. Any equipment connected to the flow path can also become a noise radiator. Furthermore, structures supporting these noise radiators can become radiators themselves. The frequency of valve noise varies with valve style, velocities, and piping. Peak frequencies are often in the 2000 – 4000 Hz octave band range, where insulation can be effective. If possible, it is best to conduct a detailed noise survey including spectrum measurements before treating an existing problem.

3.2 The Problem With Noise

Noise can exceed workplace noise limits such as OSHA (90 dBA for 8 hours equivalent exposure maximum), community noise requirements, and can be an annoyance. High noise can even cause, or foretell equipment failure. When noise is excessive, there are two general approaches. It can be controlled at the source or along the transmission path. The more cost effective and practical solution should be sought.

3.3 Source Noise Control

- Process conditions
- Valve trim
- Static restrictors
- Staged valves

This means generating less internal acoustic energy at the source to begin with, and is the best approach where possible. Sometimes, the process or process conditions can be modified. Other solutions include using a special low noise valve, two valves in series, or using a static restrictor in series with the valve to share the pressure drop which results in less overall noise. Each approach should be examined, paying special attention to process control requirements.

3.4 Path Noise Control

- Pipe thickness
- Silencers
- Thermal Insulation
- Acoustic Insulation
- Buried pipe
- Moving noise radiators

This means changing the transmission path to hide, cover, separate, or block the noise after it is created at the source. Methods include insulation, heavy wall pipe, silencers, enclosing the noise radiating surfaces, burying pipe underground, or moving noise sources and radiators away from sensitive areas.

There are some general cautions, however. Damaging high energy (corresponding to approximately 110 dBA for schedule 40 pipe with compressible fluids), can still exist and cause damage, even when hidden. Certain external treatments can interfere with maintenance, access, and inspection. The noise transmission and radiation properties discussed above can impose limits to available reduction, or require extensive treatment. Finally, high noise in liquid flow systems usually means destructive cavitation, which is a more serious problem than noise, and this must be stopped at the source.

Depending on the circumstances, path treatment may have advantages compared to source treatment. Retrofit is possible, and sometimes very simple to do, especially when pipe lengths are short, or localized spaces need treatment. Systems operating at high or low temperature may need thermal insulation anyhow, which can provide modest acoustic benefits.

4. NOISE TREATMENT BY INSULATION

4.1 Introduction

The focus of this datasheet is treatment by external noise control, particularly insulation. When considering this approach, see the background information above. Also, carefully consider overall acoustic goals. Prioritize noise-radiating surfaces and connected equipment to be treated for the most cost effective solution.

4.2 Types and Properties of Insulation

There are many types of insulating systems in use. Calcium silicate, with an outer jacket, is a simple system, often used for thermal applications. It is recognized that thermal systems can help reduce noise as a secondary benefit, especially when non-rigid insulation is used. However, rigid structure materials such as calcium silicate and cellular glass are not highly effective for noise reduction.

At the opposite end of the scale, the most effective acoustic treatments are complete engineered "systems". An "acoustic insulation" system is one that is designed specifically to reduce noise. It includes a sound-absorbing and/or resilient material ("porous layer" – non rigid) on the piping and an impermeable outer cover ("cladding") such as aluminum or stainless steel sheet. It normally includes special features to prevent "short circuits" and sometime includes a dampening layer. Examples of effective porous layer materials are glass, rock, or ceramic mineral fiber, and open cell flexible plastic foam. For best results, the outer cladding material should be heavy, dense, limp, and structurally decoupled from the pipe.

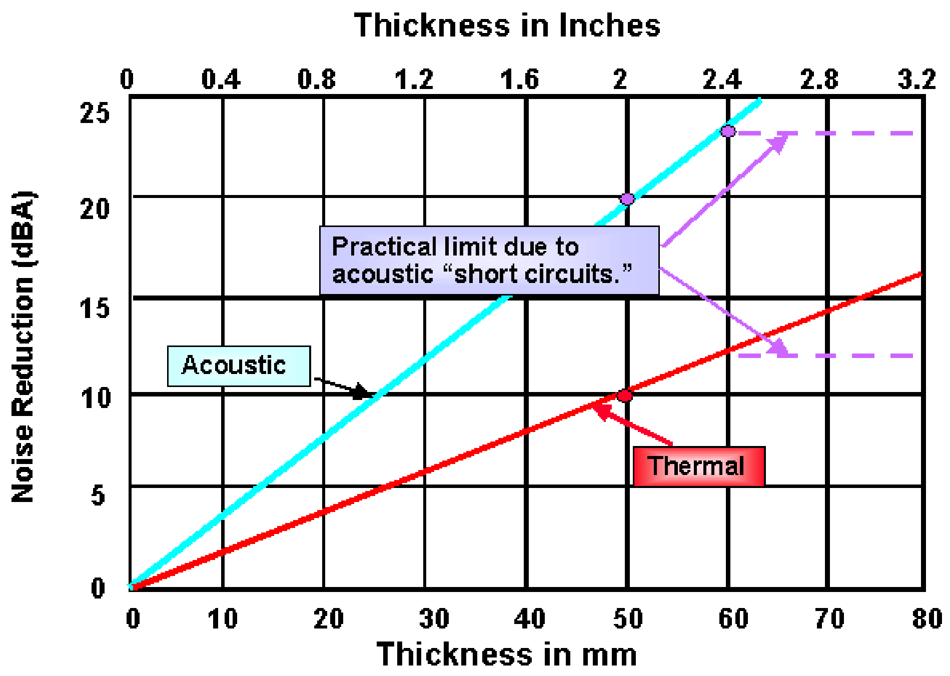
General noise control principals, and information on the use of insulation can be found in several references (4) (5) (6) (7). Technical performance is best expressed as "insertion loss" in dB at different frequencies (8). The commonly used terms "noise reduction" and "attenuation factor" are related to insertion loss and also describe performance. For most practical purposes, the three terms are equivalent. The insulation performance represents the difference in valve sound, with and without the insulation installed. Other noise sources in the space, untreated surfaces, and "short circuits" must be taken into account.

Effectiveness is a function of material type and properties, material thickness, pipe size, and sound source frequency. While insulation is effective at typical valve peak frequencies, lower frequency components of valve noise impose a limitation on the overall benefit that can be achieved.

In real systems, "short circuits" also limit performance. There are many types. It is not always possible or practical to insulate all pipes, valve components, flanges, etc. Sound can "leak" from these surfaces. Further, sound can be carried structurally from pipe supports and radiate from other surfaces. Sound can also escape from joints and penetrations through the insulation system. The more sophisticated acoustic systems can raise the "short circuit" limit. To prevent re-radiation, nothing should contact the outer jacket of an insulating system.

A generalized performance chart is shown below based on Reference (5), (9), and other similar charts found in valve handbooks. The user is cautioned that actual performance depends on many factors, and can vary. It shows noise reduction versus insulation thickness. Acoustic "short circuits" can limit or reduce the performance of insulation as shown. This is for pipe treatment, but other surfaces such as vessels are expected to have similar reductions. The "thermal" curve is typical of simple thermal insulation treatment. The "acoustic" curve is typical of some acoustic systems. In all cases, manufacturer and / or contractor data should be used when available.

Typical Sound Control Performance of Thermal and Acoustic Insulation Systems



5. CONCLUSION

Using the methods and information outlined above, determine the acoustic goals. When expected or measured noise exceeds goals, consider all alternative solutions. In those cases where insulation is identified as the appropriate solution, proper insulation systems should be chosen based on the amount of noise reduction needed. This should be done in conjunction with manufacturer / supplier / contractor discussions and data, plus suitable specifications. "Typical" performance data shown in this data sheet is provided only as a general guideline. The effectiveness of the insulation treatment should be verified by noise measurements after installation.

6. REFERENCES

1. IEC 60534-8-3, Industrial-Process Control Valves, Part 8-3: Noise Considerations – Control Valve Aerodynamic Noise Prediction Method.

2. ISA S75.17, Control Valve Aerodynamic Noise Prediction.

3. IEC 60534-8-4, Industrial-Process Control Valves, Part 8-4: Noise Considerations – Prediction of Noise Generated by Hydrodynamic Flow.

4. Sound Control for Commercial and Residential Buildings, North American Insulation Manufacturers Association, 1997.

5. ISO 15665, Acoustics – Acoustic Insulation for Pipes, Valves, and Flanges.

6. Beranek, L.L. and Ver, I.L., Noise and Vibration Control Engineering, Principles, and Application, Wiley Interscience, 1992.

7. Insulation for Mechanical Systems, Owens Corning, 2001

8. ASTM E 1222, Standard Test Method for Laboratory Measurement of Insertion Loss of Pipe Lagging Systems.

9. Control Valve Selection and Sizing, Les Driskell. ISA. 1983.