White Paper

Sound Attenuation:
The Seldom-Heard Benefit of Mechanical Coupling

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Noise carried through piping systems is becoming an increasing challenge to owners, engineers and contractors. The reasons for this include changing design requirements that place mechanical rooms on intermediate and top-floor building levels, and greater use of lightweight construction materials that tend to vibrate more than traditional heavy materials.

The business risk of not specifying systems at the design stage that serve to attenuate sound is that, frequently noise issues will continue to be a problem throughout the lifecycle of the structure. This can result in unsatisfied owners, whose occupants may complain that the objectionable noise is distracting to the point that it effects concentration and productivity. In this way, noise issues can also have a bottom-line impact on the Engineer or Contractor, who may need to perform numerous call-backs to attempt to fix the problem.

Therefore, it's not surprising that a sizable industry has grown around the idea of minimizing piping-borne sound. This article will focus on the proven sound attenuation benefits of a technique commonly thought of as a productivity-enhancing tool: the grooved mechanical pipe joint. Most often specified when contractors are seeking a fast, easy, safe and reliable alternative to welding, grooved mechanical pipe joining has a long history of effectively minimizing noise and vibration in applications around the globe.

The pervasiveness of vibration

Mechanical equipment in piping systems creates vibration, which can potentially lead to significant noise issues. In most commercial and industrial applications, occupants can tolerate certain levels of background noise from the HVAC system. The issue arises

when the sounds become cyclic and droning, or on the other hand, arrive in sudden bursts when equipment switches on.
Of course, the surest way to avoid sound issues is to bring an acoustics professional into the project at the design stage. Yet budgets do not always permit this, and there are many construction-grade projects where the owner does not consider sound to be a critical issue, at least until after the fact. Those "conventional" situations are the areas being addressed here.

Traditional sound attenuation

When faced with the need to diminish noise and vibration from equipment connected to the circulation system, designers have traditionally specified elastomeric flexible arch connectors. These connectors create a discontinuity in the metal piping (as opposed to welding), so that less vibration is transferred down the line. Additionally, they are commonly constructed of nylon, Dacron® or polyester material to help absorb vibration, and are formed in a spheroidal shape to permit deflection in all directions. This advantage, however, is also the weakness of the elastomeric arch.

Because the elastomeric flex connector's shape allows pressure to exert in all directions, control units such as restraining rods, plates and/or anchors are required. These items are used to prevent excessive stretching of the unsupported elastomer due to system pressure thrusts. But when such thrusts occur repeatedly, and the connector is overextended through time, use and pressure, failure can result. Additionally Flex Connectors employ unrestrained rubber as a pressure boundary in systems which otherwise have continuous metallic encasement. This becomes a particular concern in high rise construction where large pressure differential are often present.

The complexity of the reinforcing systems also means that installation can be time-consuming and post-commissioning adjustments can be required. As a result, such

connectors are usually placed only at the point where the pump or other equipment connects directly to the piping system.

Mechanical Joining: An alternate solution

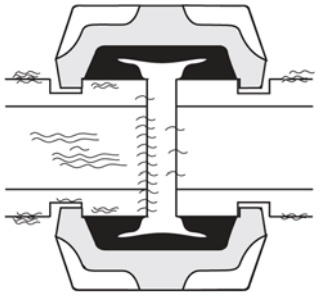
In independent tests performed by NUTECH Testing Corporation/SE Laboratories, Inc., a laboratory which specializes in environmental and field mechanical testing, another device was found to be at least as effective in sound attenuation as flexible arch connectors.

Interestingly enough, this “new” solution was invented over 90 years ago, and has a major presence in the construction industry as a means for simplifying pipe joining, assuring reliable connections and shortening production schedules. That method: grooved mechanical pipe joining, also known as grooved pipe joining.

Proven sound attenuation qualities

When the structure of a grooved pipe coupling is examined, it is easy to see why it effectively reduces sound transmission. The resilient elastomeric gasket, contained inside the internal cavity of the ductile iron housing, creates a discontinuity similar to that of a flex connector. The material from which the gasket is made also serves to absorb vibration.

Figure 1: The flexibility of grooved-pipe couplings reduces the transmission of stresses through a piping system, while the gasket and ductile iron housing combine to dampen vibration.



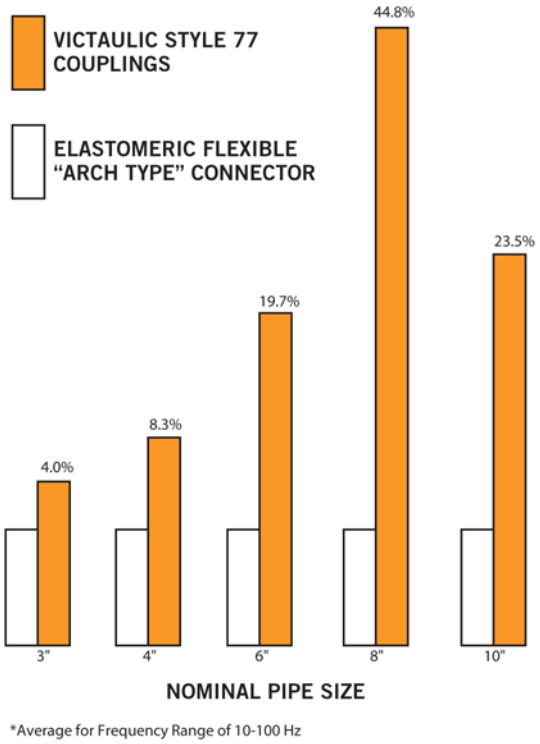
Exaggerated for clarity

The key distinctions of a grooved pipe joint over a flex connector are inherent in the proprietary design of the coupling. Its unique construction enables the gasket to seal against the pipe, while the ductile iron housing provides both space for the elastomeric material to flex and containment to prevent overstretching. Overall, the coupling works to create a permanent leak-tight seal with no need for additional reinforcement. Additionally, ductile iron has vibration dampening qualities of its own, so the external housing also serves to absorb sound.

The sound attenuation characteristics of grooved mechanical couplings are not a newly discovered phenomenon. Testing conducted by L.S. Goodfriend and Associates in 1970 – 1971 concluded that: “A substantial vibration reduction is achieved in pipe systems which employ the Victaulic Style 77 coupling.” (Actual measure reduction in decibel level ranged from 2.3 to 12.1 dB over a wide frequency range.) {Note: Victaulic is the world’s leading manufacturer of grooved mechanical joining solutions.}

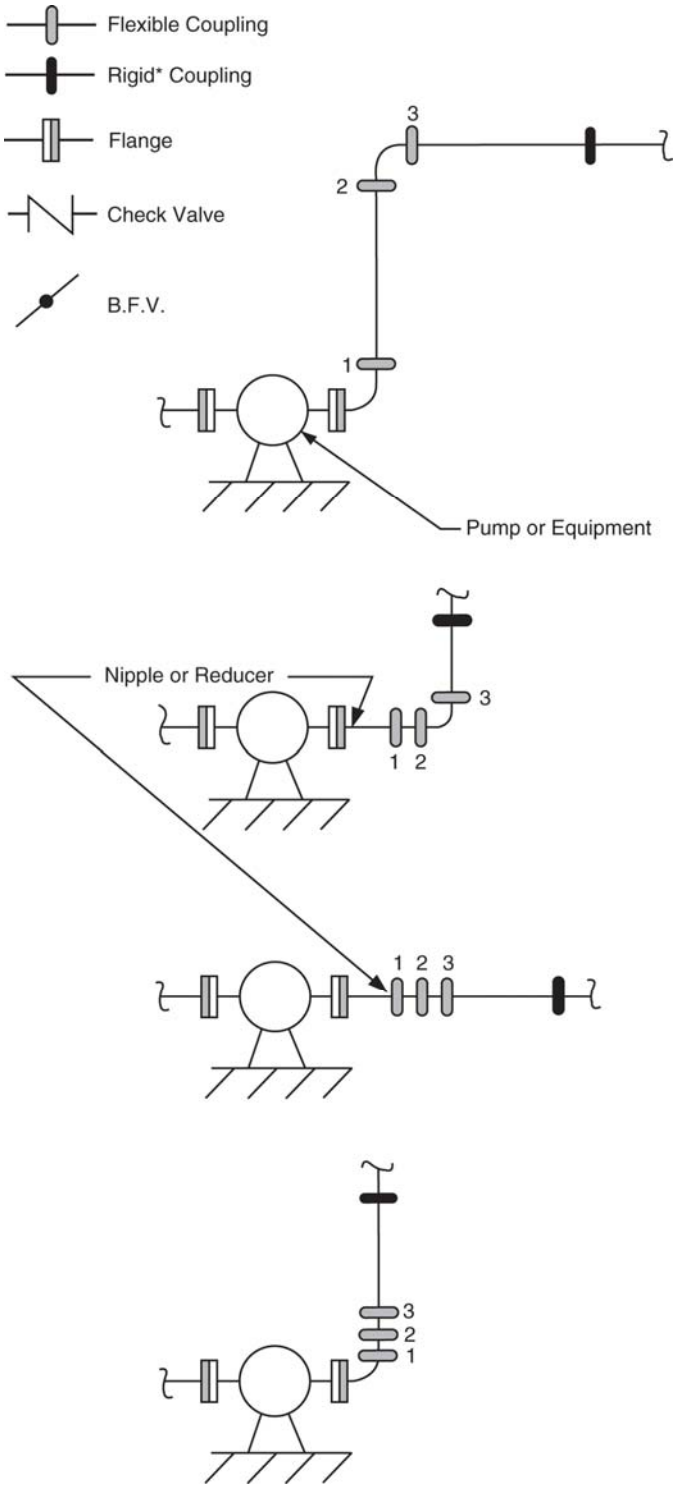
More recently, SSA Acoustics in Seattle, Washington conducted field measurements at the request of their client that showed “three Victaulic couplings placed in series in a pipe section have a comparable performance to twin-sphere neoprene connectors, and a superior performance to braided metal hoses. Victaulic couplings dampened the overall vibration amplitude by 80 – 90%.”

Figure 2: Independent testing shows the use of three grooved couplings provides significant reduction in sound (vibration).



Because the sound attenuation outcome of this arrangement depends only on the three couplings being placed near to each other in close proximity to the source of vibration, there are still numerous opportunities for design flexibility. In this way, grooved mechanical pipe joints can be used to deliver unsurpassed vibration isolation and sound attenuation characteristics, while still allowing owners, engineers and contractors to achieve their vision.

Figure 3: This diagram shows three possible ways to arrange grooved couplings in a piping system to deliver proven and effective vibration/sound attenuation.



Learning a lesson from seismic protection

The sound attenuation characteristics of mechanical pipe joining are directly related to the coupling's seismic benefits. Used around the world in earthquake zones for their ability to absorb seismic stress, grooved mechanical pipe joints provide the flexing qualities needed in structures subject to movement.

For example, the Taipei Financial Center, currently the world's tallest building at a height of 1676 feet, is located in the Pacific Rim seismic zone. Its piping systems must be able to withstand not only high pressures, but the motion of the building caused by seismic and wind forces. To maximize safety, the Center's mechanical systems team selected Victaulic grooved mechanical pipe joining for its HVAC, plumbing and fire protection systems. This was due both to the unique ability of mechanical pipe joints to enable a system to flex with seismic vibration without breaking apart, and to the productivity benefits of the coupling's simple-to-install design.

The same qualities that all mechanical pipe joining systems possess to accommodate seismic movements are what enable them to diminish vibration and noise. For example, seismic waves are characterized by a very high amplitude and very low frequency. As the frequency increases, the resulting vibration starts to resonate, producing sound. By reducing the transference of vibration, mechanical couplings reduce sound.

Cumulative sound attentuation

A further benefit of mechanical coupling is that each successive joint creates a further reduction in vibration. Builders of such sound-critical applications as the Alexandria Library in Egypt, the Esplanade theatre in Singapore, the Chateau Frontenac luxury hotel in Montreal, and the Miami Performing Arts Center in Florida have used mechanical joining throughout their HVAC and fire protection systems to take advantage of this feature.

The net effect can be viewed in this way: Take continuous welded pipe to be the factor of one (all vibration is transferred without interruption). Install one grooved coupling, and the elastomeric gasket reduces noise transference and the ductile housing absorbs an additional amount of noise. That lowered vibration is then reduced by the same factor at the next joint. The same effect occurs again at each subsequent joint where a mechanical coupling is installed, providing a cumulative reduction in sound.

As the findings of the NUTECH Testing Corporation/SE Laboratories, Inc. research, which used Victaulic mechanical couplings in its testing, concluded: "For any given pipe diameter, vibration isolation increases as the number of Victaulic couplings increases (i.e., less vibration is transmitted with each additional Victaulic coupling) regardless of whether Victaulic flexible or rigid couplings are used."

This cumulative effect results in such significant attenuation of piping-borne sounds, that builders using mechanical joining have successfully installed equipment rooms in areas which previously may never have even been considered as possibilities. For example, in the elegant Esplanade theater in Singapore, the equipment room is located next to the theater hall. In the innovative Swiss Re office tower in London, the pumping systems are placed on mid-level floors to provide greater energy efficiency. The sound attenuation qualities of mechanical joining contributed greatly to these designs being realized and constructed.

In any application where undesired noise is being transferred through the piping system, owners and engineers who specify mechanical joining receive two vitally important benefits: significantly higher productivity combined with significantly reduced sound. This provides both economic and quality advantages to all involved.

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