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# Sound Design in Drain, Waste and Vent Lines

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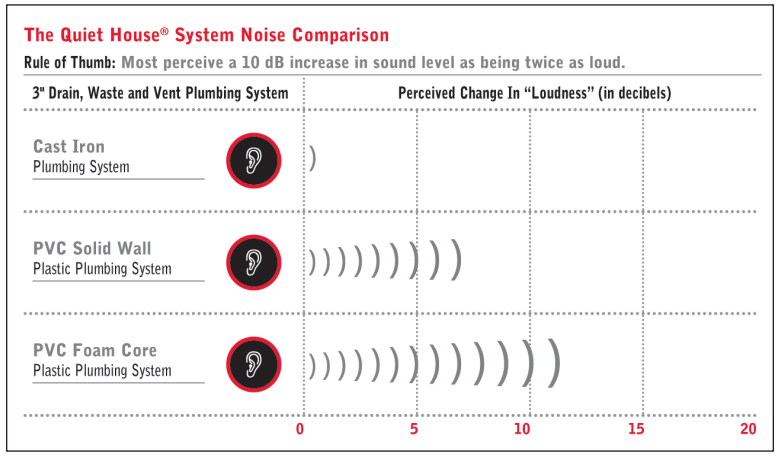
Safety, reliability and cost effectiveness are key components that drive plumbing design. In addition, environmental quality, acoustics and sound attenuation should be considered in the planning of commercial projects. Designers of commercial buildings should be aware of the acoustical performance of the facility and be very cautious of the potentially negative effects of value engineering during the process. Excessive noise from plumbing systems is typically unnoticed until the building is occupied, creating ongoing problems for the occupants.

Sound attenuation is regularly value engineered out of jobs, often the result of product substitutions and misguided cost cutting. While most building designers cringe when they hear the words value engineering, it has become an integral part of how projects unfold. Developers and owners salivate when contractors propose substituting products or methods, while the professional engineers who stamp the design documents worry about the unanticipated consequences. This is an especially sensitive subject when you consider the combination of a slower economy and the nature of the litigious society in which we work and live. Yet the questions linger: What are the consequences of substituting one product for another? Will the owner ultimately get what he wanted in his original design?

If there is going to be value engineering, it should be utilized with the proper methodologies. Genuine monetary savings, while keeping the integrity of the design, are more easily obtained if the VE process is used early in the design, when potential pitfalls can be readily identified by the design professionals. Unintended consequences, such as unacceptably loud drain lines, often result from late-term value engineering. Changes made late in the construction process may benefit the owner very little, if at all, and may have little or no input from the original designers. The result is often myriad Band-Aid solutions, which create additional issues such as inadequate design input, additional material usage, labor charge overruns, busted timelines and a great deal of annoyance for all parties involved in the process.

I was involved recently with the "Band-Aid" side of a dormitory project at a small liberal arts university in the Midwest. The engineer specified cast iron soil pipe for the drain lines, and the plumbing contractor suggested the cost savings measure of substituting plastic drain lines to the general contractor and to the owner, a change that they accepted. Soon after the university took possession of the facility, students began complaining of excessive noises when their dorm neighbors flushed toilets or took showers.

The designer was working late in her office on a difficult hospital project. She had a tight deadline and was struggling with a tricky problem. In an attempt to concentrate, she closed her eyes, but there was no silence. The vending machine in the cafeteria hummed and the fan from the A/C system produced an annoying, squeaking sound. A siren in the neighborhood shrilled and a squeaky door opened by the cleaning crew caught her attention. Someone from a floor above her flushed the toilet, and the noise resonated throughout the building. Already under stress from a long day and an impending deadline, she realized the effect of noise on her productivity.




The quick fix was an unproven retrofit of insulation around the pipe. The design team struggled with how to keep the sound from resonating through the studs in the wall without removing the pipes and drilling larger holes. The owner even considered removing the drain lines and replacing them with quieter cast iron soil pipe lines. After a great deal of extra time, energy and money, the contractor ended up cutting holes in a number of walls and stuffing sound baffling around as much of the PVC pipe as they could reach.

Sound attenuation concerns are not limited to dormitory living. The hospitality industry, hospitals, convalescent facilities, multi-family homes, schools, prisons and other commercial buildings should also pay special attention.

In 2007, *USA Today* surveyed hotel occupants to identify the most annoying sounds they were subjected to while spending the night away from home. The number one most annoying sound was toilet flushing, followed by construction repair, coughing/retching, snores/burps and hiccups. One could argue that each of these complaints is avoidable and results from inappropriate materials being substituted, due to short-sightedness and errant costing.

A 2008 survey by A.H. Jha in *The New England Journal of Medicine* showed that patients in healthcare facilities identified the noise levels around rooms at night as the quality of care factor with the most room for improvement. This is especially true in hospitals with multiple levels. In these structures there are additional opportunities for potential noise pollution from water evacuation from toilet flushing, mop sinks, shower and storm drains. Excessive noise can lead to sleep disruption and increased levels of stress for both healthy people and people struggling in a hospital bed.

Correctional facilities have discovered that noise levels have a direct correlation on the stress levels and activities of the inmates and the staff. As a result, the American Correctional Association has created noise standards limiting daytime noise levels to less than 70 decibels and night levels to less than 45 decibels.

Similar research by the Acoustical Society of America has shown that children in schools learn better and perform at higher levels when background noise is kept at levels below 50 decibels. ANSI Standard S 12.60-2002 Design Requirements and Guidelines for Schools recommends a maximum of 35 decibels for background noise. This is roughly equivalent to the sound of a soft whisper at a distance of two meters.

While plumbing noise has been a major distraction in nearly all types of housing for years, condo and apartment residents suffer the most. Single-family home dwellers can typically run showers, laundry and dishwashers on their own schedule so as not to interfere with meals and sleep time. Multi-unit residents do not have the same luxury; they must live with the water use practices of their neighbors. This problem is often compounded by water lines installed within shared walls or in very tight spaces right up against the drywall or studs.

**What causes sound in a plumbing system?**

According to Jon Mooney's article, "Flushing Out Plumbing Noise," plumbing noises are the result of cavitation, impact, drainage and hammer. He adds that drainage noise is caused by the rush of water and air through traps and drainpipes. Mooney argues that metal drainpipes, such as cast iron, perform better than plastic at insulating noise from the surrounding structure.

Many facilities also struggle with the mysterious "ticking noise" of plastic pipes. They are often unaware that plastic pipe will expand and contract as a result of changes in temperature. Designers and contractors must design and install plastic piping with consideration for movement by utilizing either expansion/contraction joints or loops. This can be difficult to engineer properly because of the relative size of the pipe, the necessity of maintaining proper pitch and the tight spaces in which the pipe is installed.

Proper design and installation of expansion loops is complex due to the variables involved. These variables include the coefficient of linear expansion (which varies for each plastic material), temperature differential between the minimum and maximum the pipe will be subjected to, length of the run, modulus of elasticity at maximum temperature (which varies for each plastic material), working stress at maximum temperature (which varies for each plastic material) and the outside diameter of pipe. In contrast, cast iron will expand and contract at roughly the same rate as concrete pipe; virtually not at all.

So, how does a designer mitigate sound from their drain lines? Using sound-deadening pipe such as cast iron soil pipe is the easiest answer. Cast iron is a natural sound deadening material with a dense molecular structure and a natural heavy mass. According to a study by Polysonics Acoustical Engineers, cast iron is 750% more effective in silencing plumbing noise when compared to PVC. With cast iron soil pipe, sound is effectively muffled rather than transmitted, as it is with plastic pipe.

Mooney suggests that you can also mask the sound with plastic pipe by utilizing sound-deadening insulation that is carefully installed with neoprene foam jacketing. He notes that careful attention should be given to pipe penetrations by utilizing rubber grommets. In addition, to keep sound from resonating through the walls of the building, plastic pipes should not be rigidly attached to the structure.

Sound and acoustic performance is also being reviewed in the green building industry. One of the major areas of focus for green design is designing a facility to maximize the indoor environmental quality for the occupants. LEED speaks to a number of goals including, but not limited to, increased ventilation and thermal comforts.

Under the LEED 2012 Rating System Draft a new credit for acoustic performance is proposed, which, if adopted, would include all new construction, schools, data centers, warehouses/distribution centers, hospitality and healthcare. While a bit confusing at first glance, this change would adopt similar wording as that in the previous version of LEED, which included maximum sound levels for LEED for schools.

As you can see, significant research has gone into the study of sound and its effect on building occupants. Noise pollution can lead to stress, hypertension, indigestion, sleep and memory problems and more. While sound is often overlooked during the design process, designers can solve this problem by specifying products and systems that naturally deaden sound.

**Conclusion**

The acoustical performance of the plumbing system should not be bulldozed by the value engineering process and should be thoroughly considered before giving in to the promise of cost savings. There is value in quiet pipe performance. Plumbing designers should be cautious of significant deviations from their original design intentions. Experience can provide an expensive education with regard to the unintended consequences of hasty decisions. Designers beware: Excessive plumbing noise typically isn't a problem until after the building is occupied. Satisfying dissatisfied occupants by cutting holes in walls is not a simple process, and it is rarely inexpensive. ■

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