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Acoustics and Environmental Quality

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As designers, we often equate the term "environmental quality" to the indoor climate. We generally don't associate acoustics with the environment, nor have we traditionally factored in noise control as a component of the quality of a space. However, as we increase the use of natural daylighting—i.e., more windows, more noise reverberation—and other hard materials in our designs, noise has increased to the point that acoustic discomfort is fast becoming a common complaint. This makes it incumbent upon us in the HVAC industry to make noise control a consistent design consideration for all types of buildings. This column provides real-world applications in the use of acoustics design to help improve indoor environmental quality.

My colleague David Wright notes poor indoor acoustics, or noise, can be detrimental to anyone's ability to perceive and process speech and other sounds. This is particularly true for people who are hypersensitive and hyposensitive to loud sounds.[1]

Those listening to a foreign language or dialect are also more susceptible to background noise and distraction.[2] Wright adds that children learning English as a second language, for example, are especially affected by classroom noise and need quiet rooms to understand teachers and English-speaking peers.[3,4] The LEED guideline for minimum acoustics recognizes solid evidence that U.S. schools need improvement and should meet minimums for simple acoustic quality for noise, room reflection and room separation to keep noise intrusion down while people try to understand and learn.

Noise is considered in degrees of impact and not just loud versus quiet. Some spaces, for example, can have intentionally conditioned noise as a benefit for task concentration or speech privacy.

While it is not a clinical definition, I have defined noise to our staff as simply unwanted sound that is considered unpleasant, distracting, loud or disruptive to intended hearing. While typical HVAC system-related noises typically are not extremely loud or startling, they can nevertheless have an effect on the occupants of the buildings we design. I would also venture to say designers are more apt to be sued over noise than we are comfort.[5,6]

While noise is a bit subjective, it is easily quantified and then corrected with best practices. Lower background sound level is the place to start. Both room separation and mechanical noise intrusion begin the process for noise control. This will significantly improve classroom and conference room speech intelligibility for

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listeners and speakers, particularly for those at the far end of the space. Any training, conference, or assembly space begins with a reasonable low ambient noise level. The talkers and speakers will benefit because they will speak with less strain to be heard. Clarity is improved and understanding for listeners increases naturally.

In 2002, ANSI published ANSI S12.60, Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools. It is a very good standard for basic classroom design but is still overlooked in many design efforts. S12.60 provides acoustical performance criteria, design requirements and design guidelines for new school classrooms and other learning spaces.

ANSI S12.60 is designed for schools, but a practical understanding of it and how noise can affect the occupants of our design can help us improve the environmental quality and comfort for many other spaces.

Following are simple, practical things we can do to reduce the noise levels in our HVAC designs.

Reduce Turbulence

Turbulence in ductwork or piping can create noise. Straight runs and smooth transitions reduce turbulence and quiets the system.

Straight, Smooth Drops Into a Diffuser

Tightly kinked or offset flex duct into diffusers can create turbulence at the neck of the diffuser that translates into noise. Refer to *Figure 1*, which is from the *2019 ASHRAE Handbook—HVAC Applications*, Chap. 49, "Noise and Vibration Control," Figure 14b: Effect of Proper and Improper Alignment of Flexible Duct Connector. If the offset from the diffuser neck is D/2 or more, noise levels can be 12 dB to 15 dB higher than published values. Placement of the volume damper also plays a significant role in increasing noise levels.

Self-Balanced Design

Create simple self-balancing duct layouts. Designers often believe the longest run should be a straight run for the lowest possible pressure drop. This straight run does mean a slightly lower pressure drop for that specific branch. *Figure 2* shows how momentum carries the air past the other diffusers to try to flow out this last straight run. The balancer then must throttle this last diffuser to balance the system, which will create noise. Table 10 in Chapter 49 of the *2019 ASHRAE Handbook* discusses

FIGURE 1 *2019 ASHRAE Handbook—HVAC Applications*, Chap. 49. "Noise and Vibration Control," Figure 14b, Effect of Proper and Improper Alignment of Flexible Duct Connector.

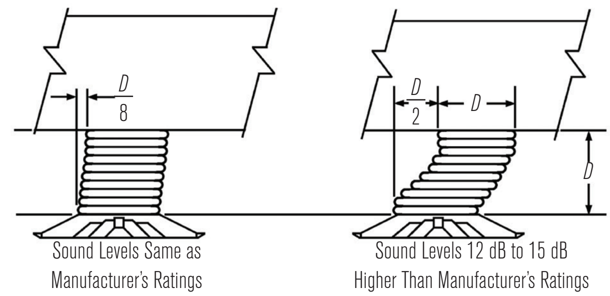
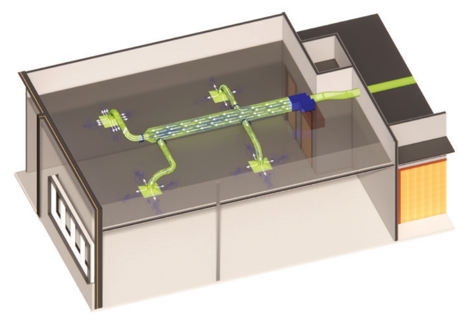


FIGURE 2 Straight run causing damper noise.



decibels to be added to diffuser sound ratings to allow for throttling of volume damper. A simple, self-balanced design reduces noise and is often lower cost (*Figure 3*).

Velocity and Friction

Higher velocity will create additional friction in the ductwork. Keep ducts in the room and downstream of terminal air boxes below 800 fpm (4.1 m/s). Stay below 500 fpm (2.5 m/s) for sound-sensitive spaces.

Velocity at the Air Terminal Neck

An increase in velocity within the air terminal neck increases noise in the space. Table 9 in Chapter 49 of the *2019 ASHRAE Handbook* shows the effects of velocity within the air terminal. Refer also to the manufacturer's tabulated data. I recommend drawing a line and selecting all devices at < NC20. In doing so, I tend to look at noise more so than dumping (e.g., cold air falling out of a diffuser onto the occupants rather than well mixed diffusion), as occupants may object to unwelcome noise more than improper air distribution. Many supply air terminal designs can combat dumping at lower velocities.

Understand the Manufacturer's NC Values

Tabulated air terminal (grilles, registers and diffusers) noise criteria (NC) values assume only one device in a room. NC is based on the decibel (dB), which is a logarithmic scale. This means that for every 10 dB up or down, the noise level is doubled or halved, respectively. When two equal noise sources are added, the dB number goes up by three. Two NC 25 grilles added in a space create an NC 28 noise source. Four NC 25 grilles then create an NC 31 noise source [25 (first air terminal) + 3 (second air terminal; first doubling) + 3 (air terminals 3 and 4; second doubling)] (*Figure 4*). Due to this, we should aim to select air terminals with an NC value approximately 10 NC points lower than our target NC value (e.g., NC 25 grilles for an NC 35 space).

FIGURE 3 Simple, lower noise, lower cost layout.

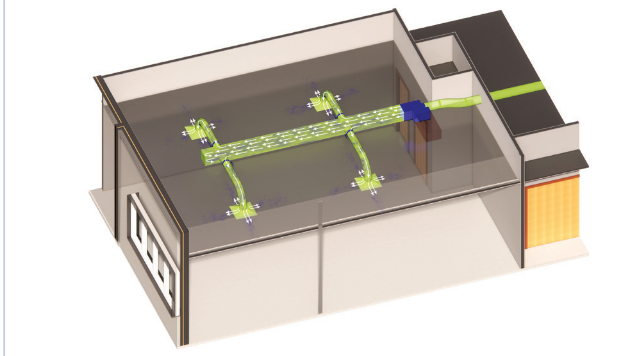
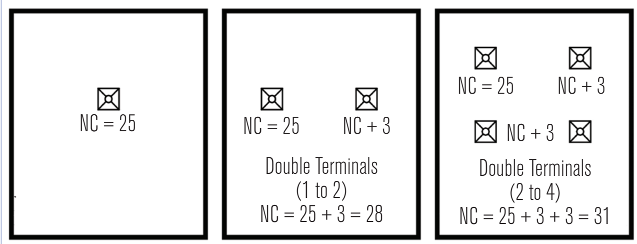


FIGURE 4 Doubling terminals NC example.



Remove Line of Sight Into a Noise Source

Sound waves follow a similar path as sight. If you can see the source noise, you are more apt to hear it. If you can look into a blower coil unit and see the fan shaft, you will undoubtedly hear it. If you can see the balancing damper through the air terminal, you will hear it. Add distance and elbows to block line of sight. Again, refer to Table 10 in Chapter 49 of the *2019 ASHRAE Handbook*.

Acoustic-Rated Flexible Duct

Use acoustic-rated flexible duct. The cost difference is insignificant, and results can be dramatic. A 6 ft (1.8 m) long acoustic flex in a 90° elbow can provide 10 dB or higher insertion loss at each of the eight octave bands. A 10 dB reduction will cut noise in half, and application of proper entrance and standoffs into the terminal will reduce turbulence.

Use Liner Where Possible

Liner has come under scrutiny, but we cannot deny the acoustic benefits as it absorbs and reduces sound wave energy. Use coated and sealed liners where allowed by code and accepted by clients.

Silencers

If necessary, add duct silencers to the system.

Remove Air from Hydronic Systems

Air is a compressible fluid. Water is incompressible. Air entrained in hydronic piping leads to noise. Every time air-entrained water slams up against an elbow, the air bubbles get compressed and that makes noise. Every time water hits a feature that creates turbulence, the air bubbles get compressed and that makes noise.

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