PRODUCT APPLICATION

A technical bulletin for engineers, contractors and students in the air movement and control industry

Sound Criteria, Attenuation Techniques, and Preventive Measures to Limit Sound Problems

This is the fourth article in a series of four articles on sound. The topics included may help you better understand how fan sound is developed, rated, applied, and controlled.

Part 1 - *Understanding the Development of Fan Sound Data and the Product Line Rating Process (FA/120-23)*

Part 2 - *The Basics of Sound (FA/121-23)*

Part 3 - *Radiated Sound (FA/122-23)*

Part 4 - *Sound Criteria, Attenuation Techniques, and Preventive Measures to Limit Sound Problems (FA/123-23)*

This article contains descriptions of the most common sound criteria and the approaches used to attenuate sound if the criteria are not satisfied. Also included are some commonsense approaches to making sure the likelihood of sound problems is minimized.

Fan sound ratings are usually provided on a sound power level basis in each of the eight octave bands. It has been emphasized that these ratings are independent of distance and environment not only of the source, but also the listener. Sound power also cannot be measured directly by instrumentation. Instrumentation as well as our ears react to changes in sound pressure levels. Because instrumentation only measures sound pressure levels, all sound criteria are provided on a sound pressure level basis. Sound pressure measurements allow the determination of whether sound levels are satisfactory or whether attenuation is necessary to either silence the source or acoustically treat the environment.

The success of calculating sound pressure levels from sound power levels varies considerably depending upon the sensitivity of the application. Sound pressure level predictions for a library or music concert hall should be performed by an acoustical consultant. Noncritical applications such as a gymnasium, kitchen, etc. may use simplified approaches including “default assumptions” allowing the use of some sound pressure levels contained in catalogs. (Part 2 of this series illustrates simplified calculations for converting sound power to sound pressure.)

Simplified Sound Pressure Level Criteria

The following sections describe several different criteria used to evaluate the acceptability of sound pressure levels.

1. OSHA permissible noise exposure

Sound power levels can be converted to sound pressure levels in each of the eight octave bands. These sound pressure levels can then be “A weighted” and combined into a single dBA sound pressure level number. This process is covered in Part 2 of this series. OSHA Standards are a means of limiting exposure to various dBA sound levels so that loss of hearing does not occur. The following table illustrates the number of hours per day allowed for a specific dBA level.

Duration/Day Hours	Sound Level dBA
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

Many specifications assume the strictest interpretation by specifying a maximum of 90 dBA. In reality, it is very unlikely that a person will spend a full eight-hour day at any one level. The combined effect should be considered rather than the individual effect of each exposure. Also keep in mind that this is the exposure the listener experiences at the dBA level indicated, not the dBA level of the fan that may be remotely located from the listener. Some specifications state that the fan must reach a dBA level from the table knowing that the listener will be at another location other than at the source.

2. Recommended noise criteria (NC levels)

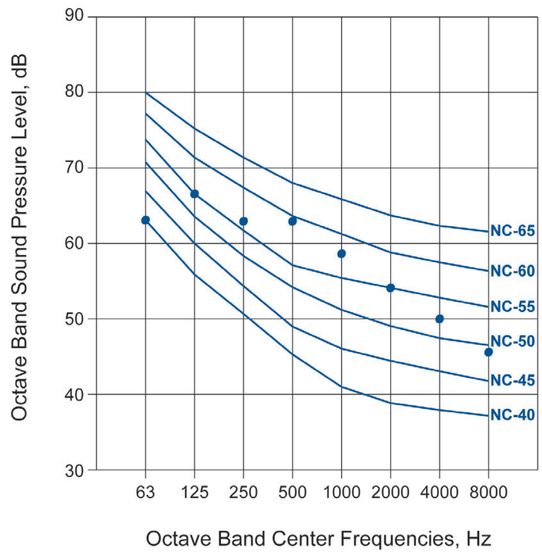
Sound pressure levels in each of the eight octave bands at a specified distance from the source may be plotted on Noise Criteria curves. These curves automatically compensate for any “A Weighting” due to the shape of the NC curves being higher in the lower octave bands. The sound pressure level (dB) at the highest NC curve is the NC level for that sound spectrum. Typical NC values are tabulated for reference. NC Curves are illustrated in Figure 1.

TYPICAL NC VALUES	
Application	**NC Curve**
Conference rooms	25 - 35
Hospitals / Libraries	30 - 40
General offices	35 - 45
Factories	50 - 70

Please keep in mind that the sound pressure level spectrum must correspond to that in the actual application. In other words, it is not appropriate to apply NC criteria for an office to a fan located in an equipment room without considering the characteristics of the ductwork and other acoustical considerations.

Figure 1 Noise Criteria Curves

Plotted dB measurements indicates NC=59



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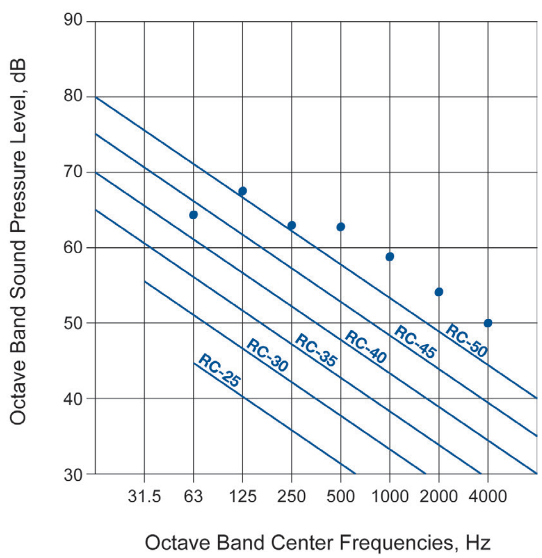
3. **Room criteria (RC)**

Room Criteria Levels are another sound pressure level criteria used to evaluate HVAC systems as a whole and not just components (such as a fan). The main difference between NC and RC is that RC is used to determine the allowable background noise in a room with an emphasis on lower frequencies below 8 KHz. These curves represent a well-balanced neutral sound system. Some descriptors that identify the perception of the sound are low-frequency "rumble", mid-frequency "roar" and high-frequency "hiss". The measured sound pressure level spectrum is plotted on the RC curves in a manner similar to the NC curves. (See Figure 2.)

Figure 2 Room Criteria Curves
Plotted dB measurements indicates RC>50



4. **Sone criteria**

Ceiling-mounted bath fans and non-ducted fans such as propeller fans often have sound presented in sones. The most definitive criteria for sones are contained in the Air Movement and Control Association International, Inc. (AMCA) Publication 302, *Application of Sones Ratings*. A table is contained in this document entitled, *Suggested Limits for Room Loudness*. Again, these limits are not for fan sones, but sones present at the location of a listener in a room. Fan sones are given at a distance of five feet from the fan, but this data may not match the actual application. The limits are given in a range of sones for a particular location such as a hotel lobby (4 to 12 sones). This emphasizes the subjective nature of sound in that not all people find a particular sone level objectionable. The sone range given in some applications is sometimes quite large.

Attenuation Techniques

When the sound is louder than the allowable project criteria, then some form of attenuation technique must be used to reduce the sound to acceptable levels. It is critical to determine the source of the objectionable sound and the path it is taking to reach the listener. This establishes the attenuation technique because, in all instances, the sound path to the listener must be interrupted to reduce the sound level being experienced.

In general, there are four major sound paths to a listener and each sound path has its own most practical approach to attenuating the sound.

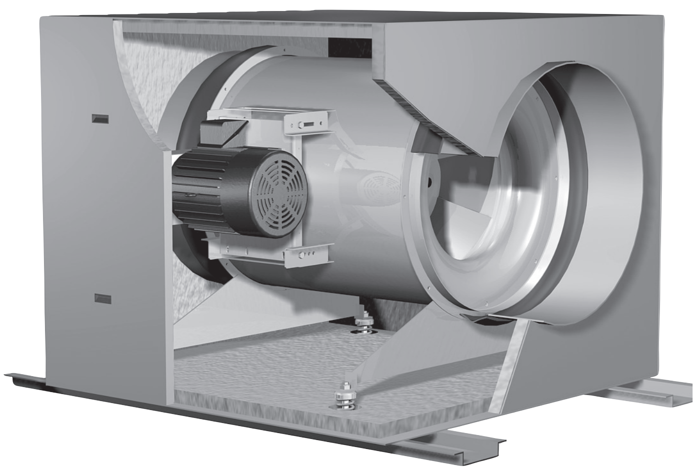
SOUND PATH #1 - Airborne sound from a fan inlet or outlet radiating directly into the atmosphere

Typical attenuation: Select the quietest fan available for the intended service. This typically requires larger, lower speed, higher efficiency fan designs. Install acoustical barriers, acoustical louvers or create an acoustical plenum through the treatment of walls, ceiling, etc. Install the equipment in an equipment room isolated from sensitive areas. An attenuator can be mounted directly to a fan inlet or outlet, but the pressure losses through the attenuator or resulting system effect can be substantial. Some reduction in attenuation from catalog values will also result.

SOUND PATH #2
Airborne sound from a fan inlet or outlet traveling through a duct system

Typical attenuation: Select the quietest fan available for the intended service. This typically requires larger, lower speed, higher efficiency fan designs. Acoustically line the ductwork with duct liner. Insert dissipative attenuators into the ductwork making sure pressure drops and self-generated noise have been considered and taken into account. Dissipative attenuators incorporate absorptive material into their construction. There are also reactive attenuators that do not use absorptive material but are tuned by wavelength, and thus are effective over a narrower frequency range. Active attenuators utilize electronics to reduce sound by creating sound opposite in phase to the offending sound. This cancels the offending sound. This technique is good when a narrow frequency range is present such as a tone like the blade frequency or a rumble due to air rolling over itself. This technique is used for lower frequencies up to 250 Hz.

Figure 3
Fan acoustic sound enclosure ("vault")



SOUND PATH #3
Casing radiated sound

Typical Attenuation: The fan casing itself forms the first layer of attenuation assuming there are no flanking paths through the ductwork or flex connections. This is called transmission loss and is a function of the type of material and its thickness. Additional attenuation can be obtained using leaded vinyl coverings. This is typically expensive on a per-square-foot basis and attenuates only the higher frequencies. The most effective attenuation technique is to place an enclosure such as a sound vault around the fan as shown in Figure 3. This type of enclosure is designed to reduce sound in all octave bands and attenuates motor drive noise as well as the fan sound. The flex connections are inside the enclosure so break-out noise is not a consideration. Special attenuated air passages allow for motor cooling. NC levels down to 35 are possible using this approach.

SOUND PATH #4
Structure-borne sound

Typical Attenuation: Structure-borne sound paths can usually be interrupted quite efficiently by using flex connections on the fan inlet and outlet and isolators under the fan. Isolators may be elastomeric for lighter fan equipment or springs for larger equipment. Isolation bases in combination with inertia bases can obtain 95% efficiency levels.

Preventive Measures to Limit Sound Problems

Several commonsense approaches can be used to minimize the likelihood of a sound problem. Some of these include:

- Select the quietest fan for the application. The lower the sound at the source, the lower the sound at the listener.
- Establish the location of all low sound requirements and what levels are required under what operating times and under what operating conditions. Establish the appropriate sound criteria that apply to the application.
- Obtain sound power or pressure values in each of the eight octave bands and compare them to generally accepted criteria. Determine whether there is a likely problem right in the beginning.
- Establish and follow all possible sound paths that exist for the sound to travel from the source to the listener.
- For each sound path look for locations that may result in system effects at the fan inlet or outlet, result in excessive turbulence within the ductwork, or short circuits that would cause unwanted sound to leak from one location to another. Look for excessive velocities and/or pressure losses. Make sure areas requiring low sound are not located adjacent to loud sound sources. Locate storerooms or lavatories between loud sound sources and the listener.

Summary

If there is a question about sound requirements and whether they are being met, contact a sound consultant in addition to other authorities or personnel who need to be made aware. It is always better to address acoustic concerns during the design phase so that a plan of corrective action can be instituted. Once the equipment is installed, it is often too late and too expensive to enact a solution.

AMCA Certified Ratings

A manufacturer that participates in AMCA's Certified Ratings Program (CRP) assures the industry that the products and equipment will perform as stated by the manufacturer. The program stipulates the various rules and regulations for presenting cataloging data: AMCA 211 for aerodynamic performance and AMCA 311 for acoustic performance.

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P.O. Box 410 • Schofield, WI 54476
Phone: 715.359.6171 • greenheck.com