PRODUCT APPLICATION

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

Radiated Sound

Radiated sound is a very important consideration in the selection and application of fans. Despite this, radiated sound continues to be one of the most misunderstood topics in the air handling industry.

This is the third article in a four-part series of articles on sound. The intent of this article is to provide a better understanding and point of reference on how radiated 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/122-24)***

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

Radiated sound is most often associated with sound energy traveling through air to a listener. In HVAC applications, the source of the sound is attributed to a fan performing work on the air, a motor and drives, or air moving through the system. Sound is a by-product of many different aerodynamic and mechanical interactions. Some aerodynamic mechanisms generating sound inside the fan include vortex shedding, eddy formations, turbulence, and discreet tones such as the blade frequency. The amount of sound produced is a function of how efficiently the energy transfer takes place between the fan and the air.

Thus, the greater the fan efficiency, the lower the sound levels. When low sound levels are required, fans with low acoustic signatures should be considered. An example is a mixed flow fan which is extremely efficient with smooth aerodynamic passages through the fan inlet, impeller, and casing. As a result, a mixed flow fan produces low levels of quality sound with very little objectionable noise content.

Sound Path Hierarchy

The sound emanating from a fan has several paths to the listener. An analogy is a water bucket with several holes in it. If we measure and add up all the water coming from the holes, we can determine the total amount of water flowing from the bucket. This same concept holds true with fan sound. We can use various test methods and procedures to measure the amount of sound coming from the various paths. In analyzing the data, we must remember that the loudest sound path is usually the most objectionable source, and so on down the list. The following describes the paths and how sound will radiate into an air space and eventually to a listener.

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Radiated Sound Paths

1. **Outlet sound:** If the fan outlet is open to an air space versus ducted away, the outlet sound will radiate directly into the air space. This sound is measured using American National Standards Institute/Air Movement and Control Association International, Inc. (ANSI/AMCA) Standard 300 "Reverberant Room Method for Sound Testing of Fans" and cataloged according to the AMCA Certified Ratings Program (CRP).

2. **Inlet sound:** If the fan inlet is open to an air space versus ducted away, the inlet sound will radiate directly into the air space. This sound is also measured using ANSI/AMCA Standard 300 and cataloged according to the CRP.

3. **Casing Sound:** If both the inlet and outlet are ducted away, the next loudest sound path is through the fan casing. It depends upon the casing construction (thickness and type of material used) as well as the quality of the construction (air leaks, cracks, shaft hole openings, etc.) This sound is measured in accordance with ANSI/AMCA Standard 320 "Laboratory Method of Sound Testing of Fans Using Sound Intensity" which uses the sound intensity technique. Currently, no AMCA Certified Ratings Program for casing radiated sound exists.

Pictured is a mixed flow fan in a radiated sound enclosure. Enclosing a fan is an excellent option for fans that will be positioned adjacent to an occupied workspace or in sound critical applications.

4. **Electrical and mechanical noise from motors, drives, and bearings:** This sound is created by accessories normally mounted outside of the fan and at times can be louder than the sound transmitted through the fan casing.

5. **Structure-borne noise:** This sound is in the form of structural vibration. It is measured by vibration analyzers using accelerometers as pickups. The results may be given in many different units and are compared to vibration severity charts to determine acceptability. Refer to ANSI/AMCA Standard 204 "Balance Quality and Vibration Levels for Fans" to quantify measurements and results.

6. **Ductwork and flex connection break-out noise:** If the ductwork is thinner than the fan casing, and uninsulated, some of the inlet and/or the outlet sound may be transmitted into the surrounding air space.

Radiated Sound

As mentioned, radiated sound can apply to any of the previous sound paths. It depends upon the listener in relation to the sound source and the intermediate path the sound travels to get to the listener. In most cases, the fan manufacturer publishes sound power levels emanating from the fan inlet or outlet or both in accordance with AMCA Certified Ratings Program requirements. In some cases, the fan manufacturer may also provide dBA sound pressure levels at a specified distance from the fan, typically 5 feet. Because the fan manufacturer does not know the environment in which the fan will be placed, assumptions are made that may or may not apply to the actual application. The designer, however, does have some guide to sound levels at a stated condition.

The assumptions include:

1. The inlet or outlet sound will dominate.

2. The fan is mounted on the floor, on a wall, or near a ceiling thus providing a hemispherical radiation pattern. Even though the sound power from the source is the same in all conditions, a hemispherical pattern provides for more sound being reflected in a specific direction than a

spherical pattern. (For example, a fly buzzing around in a room would produce a spherical radiation pattern. The same fly buzzing while sitting on a table would produce a hemispherical radiation pattern.)

3. The listener is far enough away from the fan so that the sound is free to decay with distance. This is called being in the **"far field"** where sound decays at a rate of six dB for every doubling of distance. The **"near field"** is typically within 1.5 fan wheel diameters of the fan where there is no decay and the sound dominates no matter what else is contributing to the environment.

4. There are no reflecting surfaces so the sound just keeps going and going without bouncing around. This is called the **"free field"**. The opposite is the **"reverberant field"** where the sound bounces all around.

The following discussion centers around the sound transmitted from the fan casing, the third most prevailing sound path. This path will dominate if the fan inlet and outlet are ducted away from the rest of the system. Casing radiated sound is important because the fan may be located in a sound-sensitive location such as above an office ceiling or next to a conference room where sound interference cannot be tolerated.

Casing radiated sound is measured using ANSI/AMCA Standard 320, *"Laboratory Method of Sound Testing of Fans Using Sound Intensity"*. Sound intensity is the rate of sound energy flowing through a specified area. Modern directional microphones and sound analyzers measure the average sound intensity in eight-octave bands over a defined surface area enclosing the test unit. The average intensity is then multiplied by the surface area to establish the sound power radiating from the casing. The sound power is in the exact same units and format as the sound power levels provided by ANSI/AMCA Standard 300 for fan inlet and outlet sound per the AMCA Certified Ratings Program. However, there is no Certified Ratings Program for Sound Intensity.

The criteria for casing radiated sound may be used in the exact same manner as for inlet or outlet sound. Sound pressure levels can be provided using the same assumptions previously listed. In some cases, Noise Criteria (NC) curves are used to define the allowed sound pressure levels per each octave band to provide acceptable sound levels in a room (See Figure 1). When frequency spectrum sound pressure measurements are taken in a room, the dB reading that intersects the highest NC curve determines the NC rating for the room. As an example, NC-35 establishes sound pressure levels in eight-octave bands for acceptable sound levels in a hotel or movie theater. The fan manufacturer cannot predict NC levels unless the same assumptions used previously are stipulated.

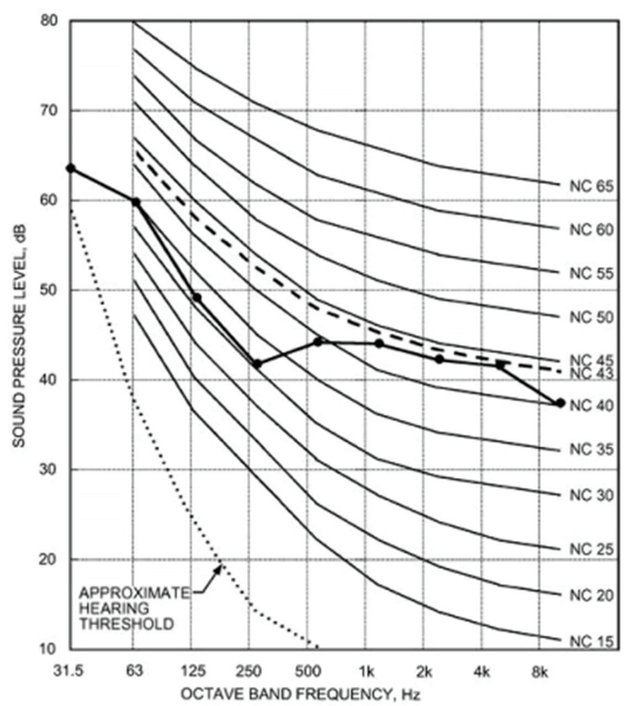

Figure 1
NC (Noise Criteria) Curves and
Sample Spectrum (Curve with Symbols)
2017 ASHRAE Fundamentals Handbook Chapter 8

Attenuating casing radiated sound is not as easy as it might appear. The first criterion is to select a good sound quality fan such as a mixed flow fan. The lower the sound level of the source, the lower the radiated sound will be. The selection should be a large fan running at a slow speed and operating at a point near peak efficiency. This alone will produce sound levels several dB lower than a high-speed fan operating at an inefficient point.

Note that motors and drives can make a significant contribution to the overall sound level radiated to a space. A low sound, high-efficiency motor, and quality matched belts in a belt drive, along with an attenuated motor cover, may make significant sound reductions in radiated noise. If the application permits, high-efficiency direct drive fan motors, and variable frequency drives should be utilized eliminating the belt drive.

Additional attenuation may be obtained by using lead vinyl coverings applied to the outside of the fan. Unfortunately, this is expensive and only attenuates higher frequencies.

The most effective attenuation technique is to utilize a sound vault enclosure around the fan. This enclosure is specifically designed to reduce sound in all octave bands and attenuates fan as well as motor and drive noise. The fan inlet and outlet flex connections are inside the enclosure so there is no flex connection breakout sound. Structure-borne sound is minimized by mounting the entire fan and drive system on vibration isolators. Allowances for motor cooling are designed integral to the enclosure. NC 35 sound levels are normally obtained using this technique.

Radiated sound is an important consideration in any low-sound application. Understanding the sources of radiated sound and available techniques for attenuating it is essential to a successful fan application.

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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