GREENHECK

Fan Application

FA/122-03

PRODUCT APPLICATION GUIDE

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. In spite of this, radiated sound continues to be one of the most misunderstood topics in the air handling industry.

This is the third article in a series of four articles on sound. This article may 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/120-02)

Part 2 *The Basics of Sound* (FA/121-03)

Part 3 ***Radiated Sound (FA/122-03)***

Part 4 *Sound Criteria, Attenuation Techniques and Preventive Measures to Limit Sound Problems* (FA/123-03)

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, products like Greenheck's mixed flow fan is recommended. It is an extremely efficient mixed flow fan with smooth aerodynamic passages through the fan inlet, impeller, and casing. As a result, the fan produces low levels of quality sound with very little objectionable noise content.

Sound Path Hierarchy

Sound emanating from a fan has several paths to the listener. It is comparable to a water bucket with several holes in it. If we measure and add-up all of 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 line. The following descriptions describe how sound will radiate into an air space and eventually to a listener.

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 AMCA Standard 300 and catalogued according to the Certified Ratings Program.

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 measured using AMCA Standard 300 and catalogued according to the Certified Ratings Program.

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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 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 to AMCA Standard 320 which uses the sound intensity technique. Currently, no Certified Ratings Program for casing radiated sound exists.

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. **Structureborne 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 AMCA Standard 204 to quantify measurements and results.

6. **Ductwork and flex connection break-out noise:** If the ductwork is thinner than the fan casing, it is possible that some of the inlet and/or the outlet sound will 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 five 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 user, however, does have some guide to sound levels at a stated condition. The assumptions include:

Pictured is Greenheck's Mixed Flow fan in a radiated sound enclosure. The Sound Vault housing is an excellent product for fans that will be positioned adjacent to an occupied work space or in sound critical applications.

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 particular direction than a spherical pattern. (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 wheel diameters of the fan where there is no decay and the sound dominates no matter what else is going on in the environment.
4. There are no reflecting surfaces so that 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 to 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 AMCA Standard 320, *Laboratory Method of Sound Testing of Fans Using Sound Intensity*. Sound intensity is a rate of sound energy flowing though 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 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 curves are used to define the allowed sound pressure levels per each octave band to provide acceptable sound levels in a room. As an example, NC-35 establishes sound pressure levels in eight octave bands for acceptable sound levels in a hotel or motion picture theater. The fan manufacturer cannot predict NC levels unless the same assumptions used previously are stipulated.

Attenuating casing radiated sound is not as easy as it might appear. The first criteria 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. Please note that motors and drives can make a significant contribution to the overall sound level radiated to an air space. A low sound, high efficiency motor and quality matched belts, along with an attenuated motor cover, may make significant sound reductions in radiated noise.

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 place an enclosure such as the Greenheck Sound Vault 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 flex connections are inside the enclosure so there is no flex connection breakout sound. Structureborne sound is minimized by mounting the entire fan and drive system on vibration isolators. Allowances for motor cooling are designed right into the enclosure. NC 35 sound levels are normally obtained using this technique.

Radiated sound is an important consideration in any low sound application. The purpose of this article is to acquaint you with sources of radiated sound and available techniques for attenuating it. Remember that a properly selected mixed flow fan will eliminate most worries about radiated sound right in the beginning.

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