ENGINEERING UPDATE

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Understanding the Development of Fan Sound Data and the Product Rating Process

Sound is a very important consideration in the selection and application of fans. If not properly evaluated, fan sound can turn an otherwise completely acceptable application into a disaster. In spite of this, fan sound continues to be one of the most misunderstood topics in the air handling industry.

In an effort to provide a better understanding and point of reference on how fan sound is developed, rated, applied, and controlled, this is the first in a series of four articles covering this topic.

Part 1 - Understanding the Development of Fan Sound Data and the Product Rating Process

Part 2 - The Basics of Fan Sound

Part 3 - Radiated Sound

Part 4 - Sound Criteria, Attenuation Techniques and Preventive Measures to Limit Sound Problems

Quality products that perform in accordance with published data don't occur by accident. It is the end result of extensive aerodynamic testing and sound testing following a comprehensive product development plan.

A company's product development must be state-of-the-art. A company that knows its products and how they perform is always in a better position to serve its customers. This article provides an overview and insight into the thoroughness with which Greenheck tests and rates its products for acoustic performance.

The development process

Product development starts with aerodynamic and acoustic performance goals often determined by the market place. Computational fluid dynamics (CFD) and design history guide the making of a prototype that will satisfy the desired goals. Tests performed in Greenheck's two AMCA registered air test chambers determine aerodynamic performance in accordance with AMCA Standard 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating". Greenheck's AMCA Registered sound facility determines inlet and outlet sound power levels in accordance with AMCA Standard 300, "Reverberant Room Method for Sound Testing of Fans".

The AMCA 300 reverberant room method consists of measuring the sound pressure levels produced by a fan, and those produced by a reference sound source (RSS) in the same acoustic environment; ie, the semi-reverberant room. The RSS sound power level has been previously determined and calibrated by tests conducted at a nationally recognized independent acoustic laboratory. The sound power of a fan is determined by substitution. The sound level of the calibrated reference sound source is measured in a semi-reverberant room. The difference (amount of

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sound absorbed by the room) between the calibration numbers and what is actually measured is added to the measured values for the test fan.

Unlike most fan manufacturers, Greenheck tests and publishes inlet and/or outlet sound power levels.

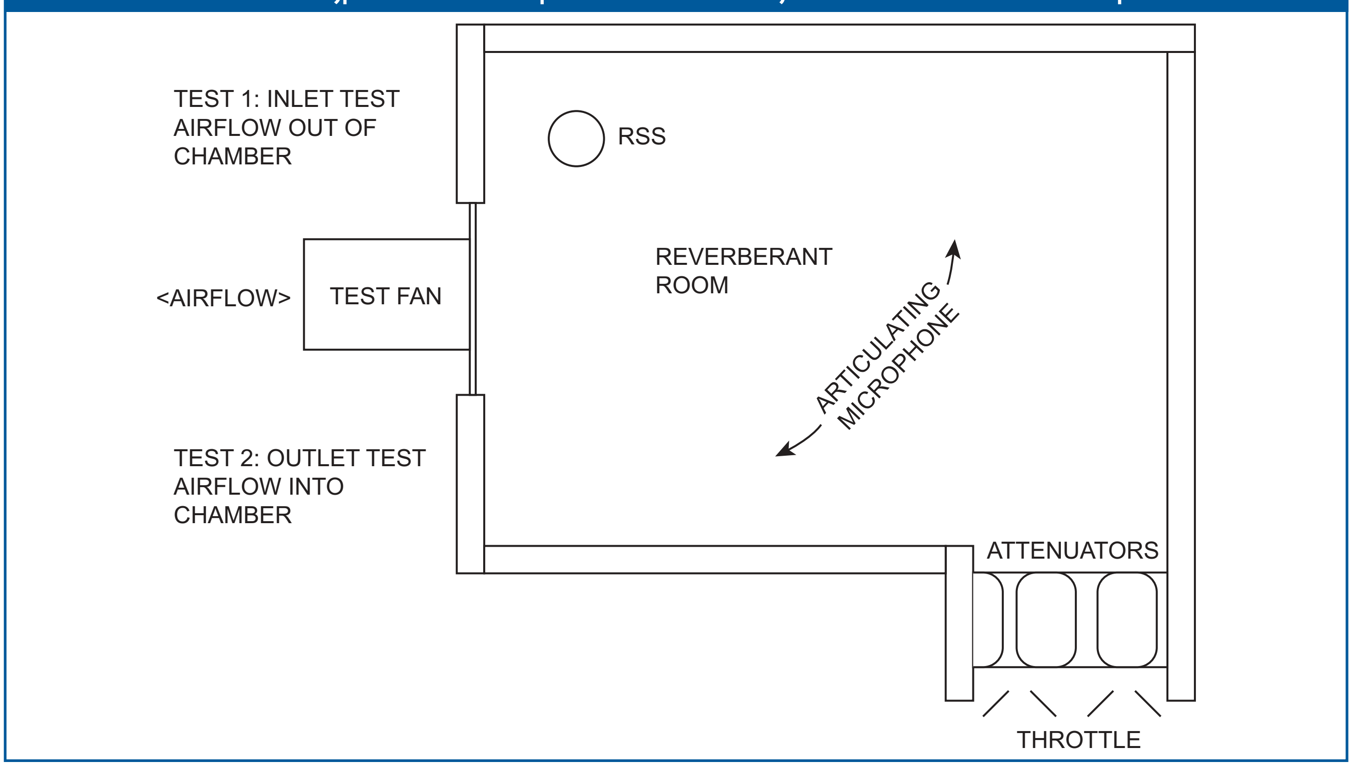
However, Greenheck does not stop there. Using AMCA Standard 320, "Laboratory Method of Sound Testing Fans Using Sound Intensity", Greenheck is able to establish the sound power level of the radiating from a fan's casing. The casing radiated sound is particularly useful when fans are to be applied next to offices or conference rooms. The concept of using sound intensity to determine sound power is relatively simple. Sound Intensity is the rate of sound energy passing through a unit area. Therefore, if a theoretical enclosure is placed around a fan and the normal average sound intensity passing through the surface area is determined, the sound power of the fan is calculated by multiplying the average sound intensity by the surface area of the enclosure.

The resulting data provided by all AMCA sound test standards is in sound power levels in dB referenced to ten to the minus twelve watts. The sound power level is provided in each of eight octave bands from mid frequencies of 63 Hz to 8 KHz. All test results are consistent and in the same format regardless of the test standard used.

Product line rating process

A product line may consist of one size or several sizes. A key element that determines the accuracy and reliability of fan catalog ratings is how well the sound test data encompasses the range of the catalog and whether the sizes have geometric similarity. Geometric similarity requires that all dimensions and angles must be a constant ratio of a smaller base size which has been tested. If geometric similarity does not exist, then each size must be tested.

AMCA Standard 300 typical test setup for determining inlet and outlet sound power



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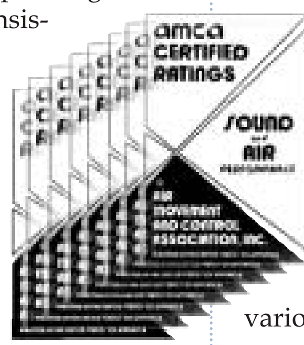
Sound does not behave in as predictable a manner as aerodynamic data. Therefore, projections of sound power levels from test data have several rather restrictive limitations in order to maintain good accuracy. Greenheck uses an extremely thorough and conservative rating process encompassing the following guidelines:

- The minimum test size must correspond to the minimum catalog size.
- Fan sizes with wheels under twelve inches in diameter must be tested individually.
- Greenheck conducts a sufficient number of tests for each product line to assure accurate and dependable ratings. Larger fans are tested using sound intensity of extrapolated results of smaller fans.
- The minimum test speed will be within five percent of the minimum catalog speed.
- Intermediate test speeds must be within .6 and 1.6 times each other
- The maximum test speed should approximate the maximum catalog speed.
- The number of test operating points must be no less than four and cover the entire operating range of the catalog. The operating points are incrementally spaced so that they are consistent along a constant system line when more than one size is involved. This means that all operating points are at consistent increments of "percent wide open volume".



What about non-tested sizes and speeds? There are three distinct processes utilized depending upon the situation.

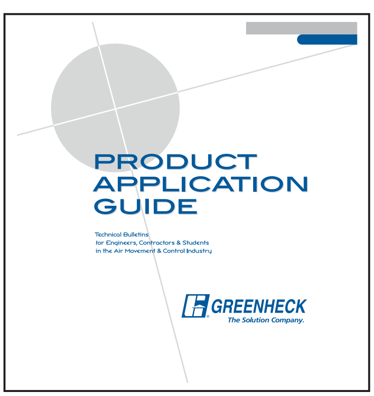
1. Interpolation may be used when catalog sizes, speeds and operating points are bracketed by known test data.

2. Extrapolation is used when catalog sizes, speeds and operating points are larger than test data. The fan laws based upon the generalized sound format contained in AMCA Standard 301 are used.

3. An alternate method of extrapolation may be used on some products based upon specific sound power. Specific sound power is the sound produced when a fan is operating at one cfm and one inch of total pressure.

AMCA Certified Ratings

Greenheck participates in AMCA's Certified Ratings Program (CRP). The program stipulates the various rules and regulations for presenting cataloging data; AMCA 211 for aerodynamic performance and AMCA 311 for acoustic performance. Having the AMCA seal is only added assurance that Greenheck fans will work the way we s they will.



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The Importance of ARI Performance Certification for Energy Recovery Ventilators

Engineers rely heavily on manufacturers' performance data for product selection. The source of the data needs to be credible to ensure that engineers meet their design intentions. In the selection process, engineers typically review data from multiple manufacturers before settling on a final design. The accepted method for comparing data from different manufacturers is industry recognized certification organizations (ARI, AMCA). History has consistently demonstrated that product performance data that is not certified overstates actual performance.

The purpose of an industry recognized certification program is to give the buyer, specifier, and user the assurance that published ratings are reliable and accurate. All manufacturers' product ratings are based on standard test methods and procedures, and are subject to impartial, third party-testing.

Greenheck and other energy recovery equipment/component manufacturers participated in the development of an industry certification program for energy recovery ventilation equipment.

This collaborative effort resulted in a new ARI rating standard, ARI 1060-2000. Components and packages certified to this new standard are shown in the ARI Certified Product Directory for Air-to-Air Energy Recovery Ventilation Equipment (AAERVE) published in January 2001. This process requires testing, rating, and independent verification of component performance (such as wheels, plates, and heat pipes) at standard conditions and rated airflow. Testing is in accordance with ASHRAE Standard 84.

ARI certified ratings include information that allows designers to fully characterize thermal and airflow performance of energy recovery devices. The program certifies the following:

- Energy transfer effectiveness at two airflows for both summer and winter (sensible, latent, & total)
- Pressure Drop
- Cross Leakage for three differential pressures across the airstreams. (displayed as EATR and OACF)

EATR – Leakage from exhaust to outdoor air (indicates how much to increase the outdoor air blower volume over design)

OACF – Leakage from outdoor air to exhaust (indicates how much to increase the exhaust air blower volume over design)

Manufacturers ratings of certified energy recovery ventilation equipment can be found at the ARI web site, www.ari.org/directories/erv.

The ARI industry performance program brings consistency to the rating process by requiring the same test procedures for all manufacturers. Required periodic performance verification tests and challenge procedures ensure that components continue to operate at documented levels. Engineers can protect themselves and their clients by writing specifications that require ARI Certification in accordance with the latest revision of ARI Standard 1060.

An Outline for Successful Fan Selections

This article outlines the considerations involved to properly select, apply and control fans. Emphasis is placed upon matching the fan equipment to the requirements of the system from several different perspectives. However, specific fan design and construction details are not within the scope of this article.

An improperly selected and applied piece of equipment can be rendered completely ineffective if the application itself is not properly defined right at the beginning. It is imperative to address each and every item listed in the following section.

Define the application

- What is the application and what is the fan supposed to do?
- How many systems are there and are they interdependent?
- How many fans per system?
- Where is the fan equipment located (inside, outside, next to an office, on the ground or several stories up in a building?) If outside, what are the ambient conditions?
- What space limitations exist? Is there adequate space for maintenance and removal of parts?
- What facility limitations exist in the form of weight, electrical capability, noise or vibration?
- What fan orientation is best suited for the application?
- What fan arrangement is best suited for the application?
- Are there any leakage requirements for the fan or ductwork?
- Are there any sound limitations including casing radiated or duct breakout noise?
- Are there any storage requirements? If so, how long and under what conditions?
- The cost of electricity and any support functions required?

Performance and system duty cycle

In order to analyze and make fan and control selections it is necessary to define the system duty cycle. All of the design and operating points must be defined and how long the system operates at each point. This should include present as well as future ratings.

The following information for each operating point is necessary:

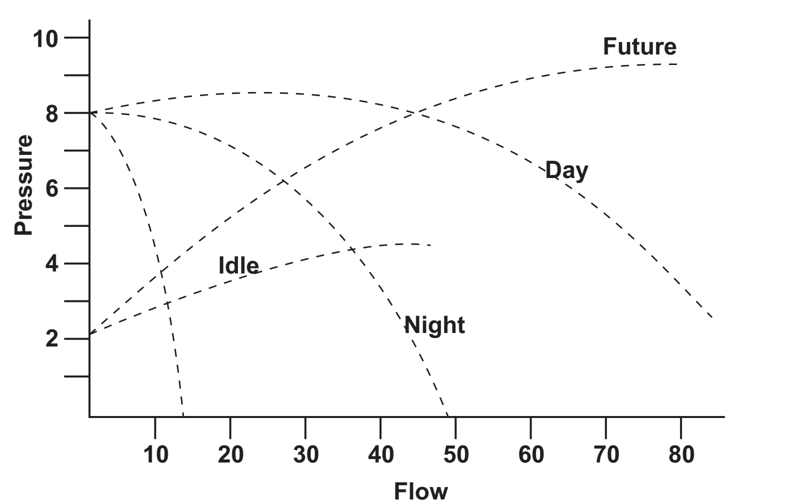
- Volume flow rate,
- Inlet and outlet static pressures,
- Temperature: design, operating and rate of change,
- Gas composition if other than air,
- Gas contaminants taking into account erosion and corrosion,
- Elevation and barometric pressure or gas density,
- Single fan, series or parallel operation,
- Method of control..

It is also necessary to create a system duty cycle plot if several performance points are given. That is, plot all operating points on a single graph at a common density. By overlaying the fan performance curve information, it is easy to evaluate the basic fan selection along with the control characteristics. All operating points in the system duty cycle must fall within the fan's performance envelope. If any operating points fall outside of the envelope, those points will not be realized. This concept is illustrated in Figure #1.

Life cycle considerations

The overall effectiveness of the fan/system selection should be

Figure #1: System Duty Cycle



An Outline for Successful Fan Selections, continued from page 5

evaluated taking each of the following into account:

- Initial cost — What is the purchase price and cost of installation?
- Operating cost — What is the total cost per year to operate the fan, accessories and any support equipment?
- Maintenance — Is maintenance costly and frequent? And, is the equipment accessible for ease of maintenance?
- Frequency of repair and downtime — What is the reliability of the equipment and the cost of downtime?
- Spare parts — Are spare parts expensive and readily available? Must an inventory of spare parts be maintained?
- System availability — What percentage of time must the system be operable? There may be the requirement to have a "stand-by fan".
- Expected life — What is the expected life of the equipment before it is to be replaced?

The basic fan selection

The fan type and its performance characteristics influence the basic fan selection. The fan and system must be compatible both structurally as well as from a performance standpoint. For any one performance point, there are many different fans which will satisfy that rating. However, based upon any one set of priorities such as fan size, efficiency, motor size etc., there is only one best fan for that application.

As an example, for a single operating point of 60,000 cfm at 7.0 inches total pressure at a density of .075 lbs/cf (70 degrees), several different fans will satisfy that rating. The possible selections are tabulated in the chart above taking into account impeller size, operating speed, horsepower, relative selling price and recommended motor size. Depending upon which priority is chosen with regards to acceptability, the optimum fan selection will change. Based upon selling price the 48 inch axial fan would be selected. Based upon operating costs, the 48 inch axial or the 60 inch backward inclined fan could be selected. If there was dust in the airstream, the radial tipped fan might be selected taking into account erosion. The optimum fan to satisfy the future rating would be the 48 inch axial utilizing a blade angle change since the centrifugals would have to be increased in speed 16% with a corresponding horsepower increase of fifty-eight percent. The motor for the 48 inch axial would simply require better initial insulation so as to handle the increased power.

Influence of fan size and type
60,000 cfm at 7" total pressure

Item	Axial	Radial			Backward		
Diam.	48"	66"	60"	54"	66"	60"	54"
Speed (rpm)	1750	603	685	816	630	729	870
Power (Bhp)	81.4	91.0	95.0	103	77.1	77.1	80.0
Eff (%)	81.0	72.5	69.5	64.0	85.5	85.5	82.5
Cost Factor	1.0	2.5	2.1	2.0	2.6	2.2	2.1
Motor (hp)	100	100	125	125	100	100	100

Fan selection and rating point location

A very important concept is the relationship between size and the rating point location on the fan curve. The generic performance curve for the three backward curved fans from the chart is shown in Figure #2. This figure illustrates that the relative position of the rating point on the fan curve changes with a change in fan size for a particular rating. As can be seen, the smaller the fan size used to satisfy a rating, the faster it must run and the farther it will be to the right on the fan curve. In general, it will also be less efficient. It will be louder and wear out faster. This concept is important when considering types of control and fan stability when operation is near peak pressure.

Fan control and moving the operating point

The following is intended to provide an understanding of the interdependence of the fan and its control with how effectively the system's performance envelope is satisfied. The fan control method is the means by

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which the fan/system operating point is manipulated in order to change the desired flow/pressure somewhere else in the system. If you change the system resistance, the operating point will move along the fan curve. Fans equipped with an outlet damper, opposed bladed inlet box damper or a system damper are examples. If you change the fan performance capability, the operating point will move along the established system resistance curve. By having the ability to adjust both the system and the fan performance, the operating point can be moved to almost any desired position under the fan curve. This is illustrated in Figure #3. Controls which move the operating point along the system curve include variable inlet vanes, parallel bladed inlet box dampers, blade angle changes on axial fans and the many techniques used to change fan speed. It is extremely important to know the individual performance characteristics for each type of fan control.

Figure #2: Rating Point Location

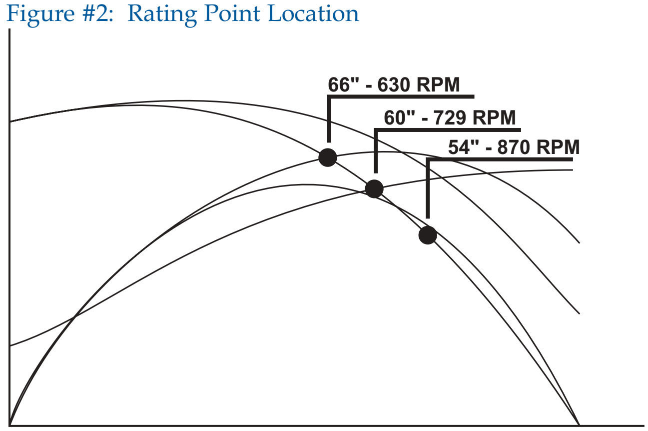
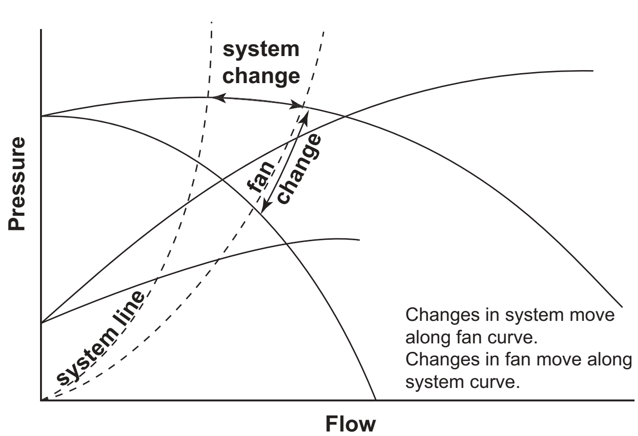


Figure #3: Moving the Operating Point



Fan control criteria

Having the ability to move the operating point creates a whole new set of considerations. These range from performance to physical equipment limitations. Most of these considerations are listed below. Depending upon the installation, some are more important than others; however, all should be considered.

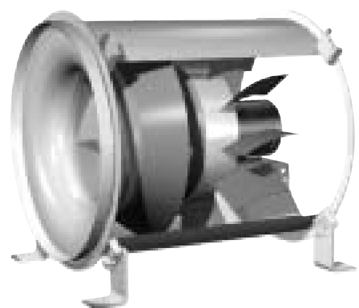
- Turndown/leakage
- Sensitivity to change/stability/transients
- Repeatability
- Reliability
- Efficiency expected
- Sound considerations
- Structural considerations
- Environmental considerations
- Interface considerations to computer control.

Summary

This article has attempted to outline the major considerations which should be included in any fan and control selection. This can act as a form of checklist or reminder for those who are not involved in selecting fans on a regular basis. It does not guarantee a successful application, but it goes a long way in eliminating many of the common problems associated with a lack of information and communication up front in the selection process.

What's new at Greenheck

Mixed Flow Fans now available in Direct Drive (Model QEID) and Belt Drive (Model QEI)



Model QEID, Mixed Flow Fan

Greenheck recently introduced the Model QEID, direct drive mixed flow fan. The QEID offers the same advantages of the belt driven QEI – extremely low sound levels and reduced brake horsepower. For most applications, mixed flow fans will be 5-15 dB quieter than tubular centrifugal fans and vane axial fans.

The QEID is an excellent product for return air, supply, or general ventilation applications. The primary advantages include reduced maintenance, a compact design, and a wide range of performance. The inherent motor in the airstream design of a direct driven inline fan reduces the overall size of the product. As a result, the QEID will be more flexible for mounting in space restricted areas.

The QEID is available with 50 to 100% partial wheel widths to provide a wide range of direct drive performances. The overall performance range of the QEID is 1,000 to 96,000 cfm (1,700 to 163,000 m3/hr) and pressures up to 9.5 inches w.g. (2,370 Pa). Greenheck's entire mixed flow line is licensed to bear the AMCA label for Inlet Sound, Outlet Sound and Air performance.

Sound Vault Housing

Sound Vault Housing for Model QEI/QEID

The Sound Vault Housing is an ideal option for mixed flow fans operating adjacent to occupied spaces where radiated sound reduction is a necessity. Overall, the Sound Vault will reduce radiated sound in excess of 50%. Standard construction includes a galvanized enclosure lined with two inches of sound-attenuating insulation, integral isolators, and flexible connections to lock-in radiated sound and minimize vibration transmission.

The Sound Vault option can be used with both the QEI and QEID. Visit www.greenheck.com/quiet to hear how our Sound Vault works.

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