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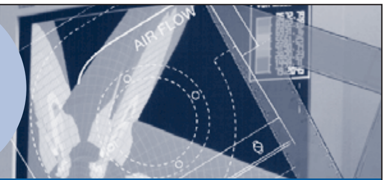

Sound Criteria, Attenuation Techniques and Preventive Measures to Limit Sound Problems

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.

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/120-02)

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)

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

Fan sound ratings are usually provided on a sound power level basis in each of 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 measure directly by instrumentation. On the surface this would seem to be a contradiction since instrumentation as well as our ears react to changes in sound pressure levels. Because instrumentation only measures sound pressure levels, all sound criteria is provided on a sound pressure level basis. Otherwise, how would you be able to determine 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. Non-critical applications such as a gymnasium, kitchen, etc. may use simplified approaches including “default assumptions” allowing use of some sound pressure levels contained in catalogs. (Part 2 of this series illustrates simplified calculations for converting sound power to sound pressure.)

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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 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

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

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 table above illustrates the number of hours per day allowed for a specific dBA level.

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 located someplace else. Some specifications specify that the fan must reach a dBA level from the table knowing that the listener will be at another location removed from the source.

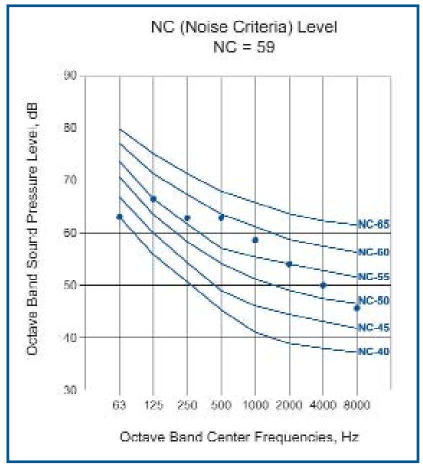
2. Recommended noise criteria (NC levels)

Sound pressure levels in each of eight octave bands at a specified distance from the source may be plotted on a Noise Criteria chart. This chart automatically

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

compensates for any "A Weighting" due to the shape of the NC curves being higher in the lower octave bands. The maximum penetration of any one NC curve is the NC level for that sound spectrum. Typical NC values are tabulated for reference. An NC chart is also illustrated for reference.

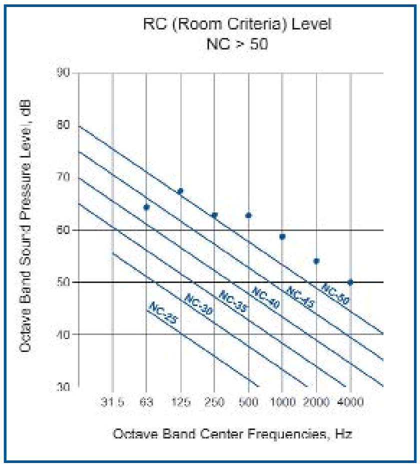
Please keep in mind that the sound pressure level spectrum must correspond to that in the actual application. In other words, it is not appropriate to apply a NC criteria for an office to a fan located in an equipment room without considering the characteristics of the ductwork and other acoustical considerations.



3. Room criteria (RC)

Another sound pressure level criteria is used to evaluate HVAC systems as a whole, not components such as a fan. The main difference between NC and RC curves is an emphasis on the lower frequencies (16 Hz, 31.5 Hz) and not the higher frequencies (8 KHz). These curves represent a well-balanced neutral type of system. There are descriptors that identify the perception of the sound as low frequency "rumble", mid frequency "roar" and high frequency "hiss". The sound pressure level spectrum is plotted on the RC curves in a manner similar to the NC curves.

Sound Criteria, Attenuation Techniques and Preventive Measures to Limit Sound Problems, continued from page 2



4. Sone criteria

Non-ducted fans such as propeller fans often have sound presented in sones. The most definitive criteria for sones is contained in AMCA Publication 302, Application of Sones Ratings. A table is contained in this document titled, 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 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 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 treatment of walls, ceiling, etc. Install the equipment in an equipment room isolated from sensitive areas. An attenuator can be mounted directly upon an 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

"The most effective attenuation technique is to place an enclosure such as the Greenheck Sound Vault around a fan."

Sound Criteria, Attenuation Techniques and Preventive Measures to Limit Sound Problems, continued from page 3

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 thusly 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.

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 a 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 the Greenheck Sound Vault around the fan. 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 that 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
Structureborne sound

Typical Attenuation: Structureborne 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

There are several common sense approaches which 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 applies 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 or expert in addition to other authorities or personnel who need to be made aware. It is always better to address problems up front so that a plan of corrective action can be instituted. Once the equipment is installed, it is often too late and too expensive to do much about it.

Centrifugal Fan Arrangements

Centrifugal fans are typically offered in several arrangements, or in other words, the position of the motor relative to the fan. When deciding on the best arrangement of a fan there are three main criteria which may influence your choice:

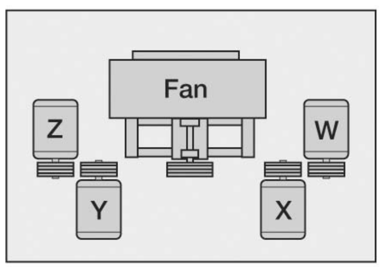
1. Fan performance (temperature, contents of airstream, etc.),
2. Drive method (belt or direct),
3. Size/location (footprint size of unit, access to various components on the fan, etc.).

The first criteria is the most important, for if you select a fan which fits in the designated area, but cannot accomplish the desired performance, then you have gained nothing. One must consider the performance of the fan first, and then make any needed concessions to place it into the allowable space.

Belt Drive Arrangement

From a performance standpoint, an arrangement 1 fan will allow the greatest flexibility. In this arrangement, both bearings are out of the airstream and theoretically, there is no limit to motor frame size. The allowance of any size motor means that only the fan's maximum speed and desired motor service factor will restrict your choice of motors. Arrangement 1 also allows the customer the flexibility of four motor positions: W, X, Y, and Z. These choices allow the motor to be placed in a location that makes it easy to inspect and/or service and avoid any possible interference with discharge ductwork.

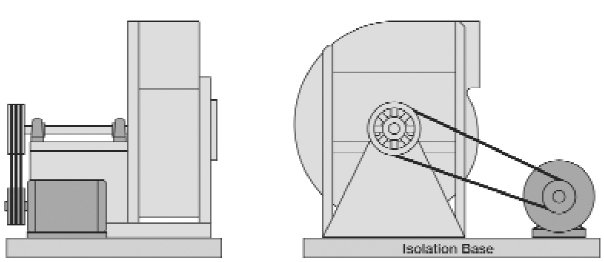
One of the drawbacks to arrangement 1 is that it has the largest footprint and takes up the greatest amount of floor space. This can lead to increased building costs as the square footage required for the ventilation equipment grows. Because the motor is not mounted directly on the fan, a structural base or other common element between the fan and motor is also required for this arrangement. This is an item that is easily forgotten on fan applications, so be sure to double check the equipment schedule to make sure one is supplied.



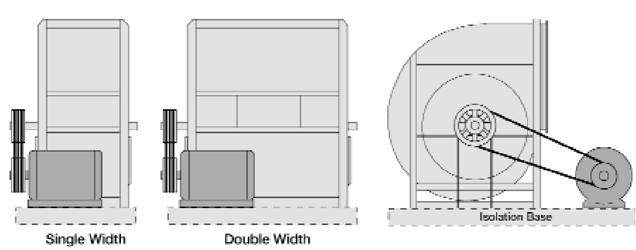
Motor position and fan rotation are determined from drive side

Arrangement 3 fans are similar to arrangement 1 fans in the fact that they require a structural base as the motor is not mounted directly on the fan. Again, this allows for a choice of motor positions as well as limitless motor size. The major limitation of arrangement 3 fans comes from the location of the bearings. Arrangement 3 fans have one bearing on each side of the wheel. This provides a very stable mount for the wheel and allows for the narrowest fan design for a given wheel size. When used in combination with a split housing, this arrangement is very popular for retrofit applications where the fan may need to be moved through

Arrangement 1, Single Width



Arrangement 3, Single Width and Double Width



Centrifugal Fan Arrangements, continued from page 5

narrow hallways, tight stairwells, or smaller personnel elevators. The disadvantage to this design is that at least one bearing (both in case of a double width fan) is in the airstream. This limits the fan's applications to those handling clean air below 180 degrees F. In the case of a single width arrangement 3 fan, which is commonly ducted on the inlet, service or replacement of the bearing in the airstream can also be a concern.

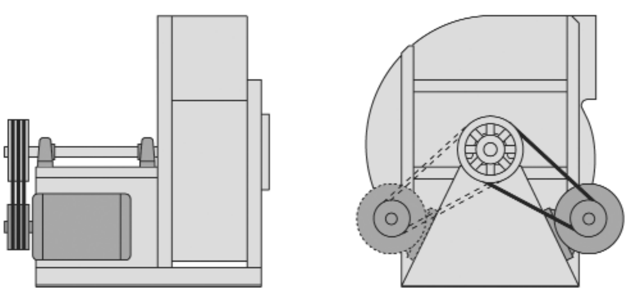
Just as arrangement 1 and 3 fans have many of the same physical characteristics, arrangement 9 and 10 fans are also very similar to each other. In fact, the only difference from an appearance standpoint, is that an arrangement 10 fan has the motor mounted under the bearing pedestal and an arrangement 9 fan has the motor mounted on the left or right side of the bearing pedestal. Arrangement 10 is generally the most widely used fan arrangement due to its compact footprint, constant overall dimensions regardless of motor used, and the ease in protecting the motors, drives and bearings if applied outdoors. Arrangement 10 fans will have limitations on motor frame size slightly more stringent than arrangement 9 because of the limited space under the bearing pedestal. In either of these arrangements the motor attaches directly to the fan, making them very compact and easy to install. In addition to motor size, one of the other limitations for these fans is operating temperature. This is due to the close proximity of the motor to the continuous airstream. Generally arrangement 9 and 10 fans are limited to airstream temperatures of 500 degrees F or less. In the case of arrangement 10, an insulating panel can be placed between the motor and the fan scroll to reduce heat radiation into the motor area.

Direct Drive Arrangement

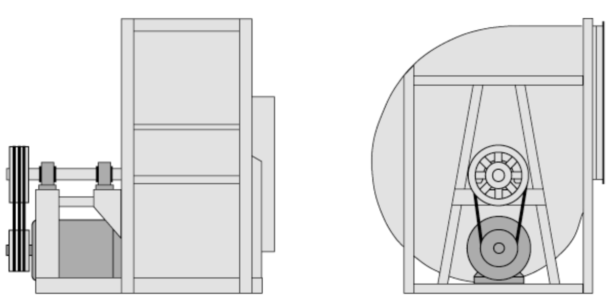
Although all of the previous arrangements use a combination of belts and pulleys to turn the wheel, direct driven fans may be used where reduced maintenance is desired. Arrangement 4 is the simplest design and has the wheel mounted directly to the motor shaft. This eliminates the pulleys, belts, and fan shaft bearings and typically leads to a much smoother running fan.

The disadvantage of this design is most noticeable when a large fan is running at a relatively slow speed. The fan horsepower may be very low, yet the motor used must be large enough to support the weight of the wheel.

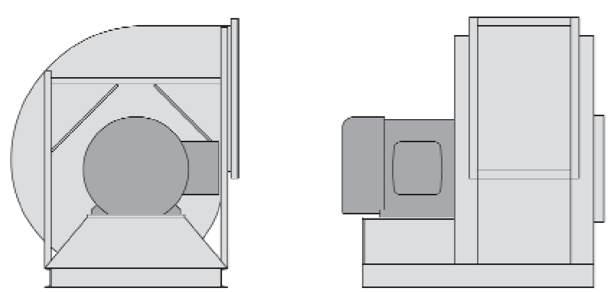
Arrangement 9, Single Width



Arrangement 10, Single Width



Arrangement 4, Single Width

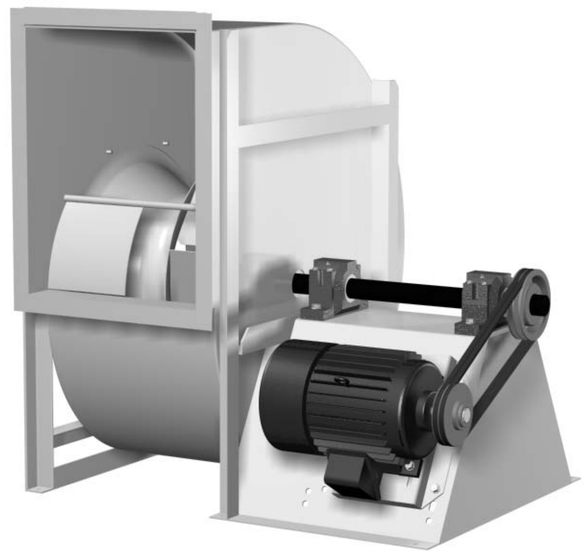


Centrifugal Fan Arrangements, continued from page 6

For example, a 36 inch fan may only require 5 bhp to operate, but will need a 15 to 20 hp motor to ensure that the frame size is large enough to get the proper motor shaft diameter and length. This is not only a problem concerning the initial purchase cost, but the motor is also more costly to operate over the life of the product. One way to minimize the problem, if airstream conditions allow, would be to use an aluminum wheel construction to reduce the weight of the wheel.

There are several other considerations involved in Arrangement 4 applications. The motor bearings must provide an acceptable L_{10} bearing life since they must withstand the radial load and axial thrust load from the fan wheel in addition to the weight of the motor rotor. The motor must also be sized to satisfy fan wheel inertia during startup.

Since the fan wheel is direct connected to the motor shaft, the fan will fun at 60 cycle (or 50 cycle) synchronous speed. An outlet damper, inlet guide vanes, percent width wheel or variable frequency drive must be considered as a means of control in order to obtain the design performance rating or other ratings in the system's operating cycle.



Greenheck's centrifugal fan Arrangement 9, single wide centrifugal fan shown.

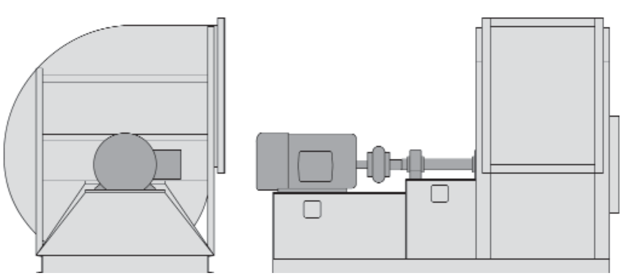
Another solution to this is an arrangement 8 design. This design is also directly driven via a coupling connected to a normal fan shaft and bearing combination. The advantage to this design is that the motor horsepower can be closely matched to the fan horsepower requirement. Arrangement 8 will also allow for higher airstream temperatures due to the motor being located farther from the scroll.

Summary

As a general rule of thumb for choosing a fan arrangement, try to select an arrangement 10 fan first. If this is not available, try changing to an arrangement 9. Again, these are the most compact fan arrangements and the easiest to install. If neither of these work, then you will have to select an arrangement 1 or 3, keeping in mind how the bearing locations will affect the allowable contents of the airstream. If direct drive is desired, arrangement 4 will give you the most compact fan, while arrangement 8 will typically allow the smaller motor sizes.

For more information, refer to AMCA Publication 201-90 (Fans and Systems).

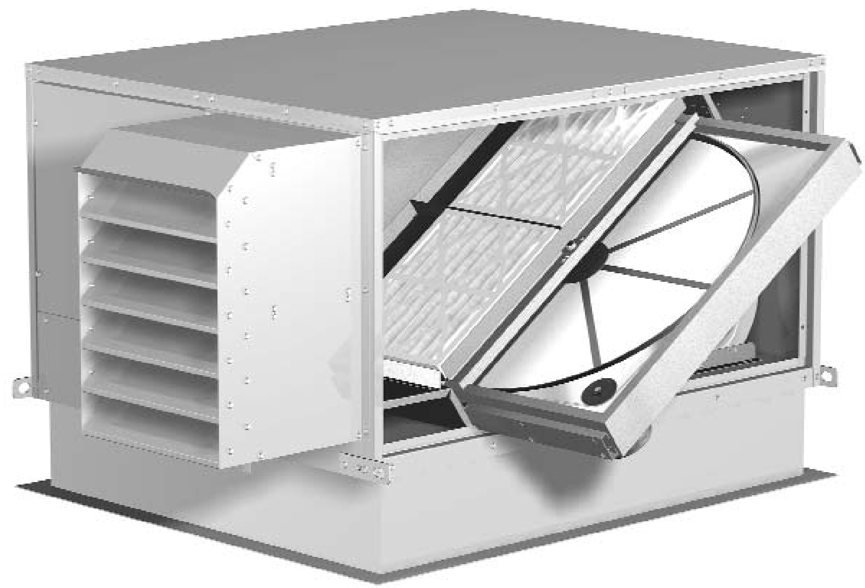
Arrangement 8, Single Width



ASHRAE Standard Addendum 62y – Acceptable Cross Leakage for Energy Recovery Applications

With addendum y of ASHRAE Standard 62-2001 (Ventilation for Acceptable Indoor Air Quality), HVAC system designers now have clear-cut parameters for allowable ERV cross leakage/cross contamination. This article communicates some of the key elements of this addendum.

Probably the most common question from specifying engineers on this topic is: "How much ERV cross leakage is acceptable when the exhaust air is from a rest room?" As defined by addendum y, the answer is 10%.



Greenheck's Energy Recovery products provide fresh outdoor air to meet ASHRAE 62-99 ventilation rates, while recovering energy from the exhaust air stream.

Air Classification

As a starting point, addendum y classifies air with respect to contaminant and odor intensity. In doing so, four classes of air have been defined as follows:

Class 1: Air with low contaminant concentration and inoffensive odor and sensory-irritation intensity, suitable for recirculation or transfer to any space.

Examples: office spaces, classrooms, assembly rooms, churches, corridors

Class 2: Air with moderate contaminant concentration, mildly offensive odors or sensory-irritation intensity, suitable for recirculation or transfer to any space with Class 2 or Class 3 air that is utilized for the same or similar purpose and involves the same or similar pollutant sources. Class 2 air is not suitable for recirculation or transfer to spaces with Class 1 air, or dissimilar spaces with Class 2 or Class 3 air.

Examples: rest rooms, swimming pools, dining rooms, locker rooms, warehouses

Class 3: Air with significant contaminant concentration or significant offensive odor or sensory-irritation intensity that is suitable for recirculation with the same space. Class 3 air is not suitable for recirculation or transfer to any other space.

Examples: kitchens, dry cleaners, beauty salons, laboratories, pet shops

Class 4: Air with highly objectionable fumes or gases or potentially containing dangerous particles, bioaerosols, or gases at a concentration high enough to be considered harmful, not suitable for recirculation or transfer to any other space.

Examples: paint spray booths, laboratory fume exhaust, kitchen grease exhaust

Energy Recovery Re-designation

Now that we understand the air classification system, we can move on to the portion of this addendum that addresses energy recovery, which states:

Class 2 air may be re-designated as Class 1 air in the process of recovering energy when it is diluted with outdoor air such that no more than 10% of the

ASHRAE Standard Addendum 62y – Acceptable Cross Leakage for Energy Recovery Applications, continued from page 8

resulting airstream is Class 2 air. Class 3 air may be re-designated as Class 1 air in the process of recovering energy when it is diluted with outdoor air such that no more than 5% of the resulting airstream is Class 3 air.

This means that you could recover energy from rest room exhaust (Class 2 air) to pre-condition outdoor air for a Class 1 space (i.e., classroom or office space) as long as the energy recovery cross leakage is no greater than 10%. The same logic applies to recovering energy from Class 3 air, with the cross leakage limit reduced to 5%.

This information combined with ARI certified energy recovery data will give specifying engineers greater confidence to use ERVs on a broader range of exhaust applications. Keep in mind that the ARI 1060 certification program includes cross leakage (EATR – Exhaust Air Transfer Ratio) as part of the certification. *(Greenheck ERVs are ARI certified with typical EATR values in the 1% to 4% range.)*

For comfort ventilation applications (Class 1 and Class 2 air), the 50% to 75% fan energy penalty for a purge system can not be justified.

Summary

Addendum y is expected to be published as an official subsection to ASHRAE Standard 62 in the fall of 2004 and included in the subsequent building code revision cycle.

This addendum will be in the standard by the time today's new building designs are under construction.

We recommend you begin incorporating this new standard into your specifications today. You can confidently incorporate energy recovery ventilators in your applications — without the need for energy consuming purge sections.

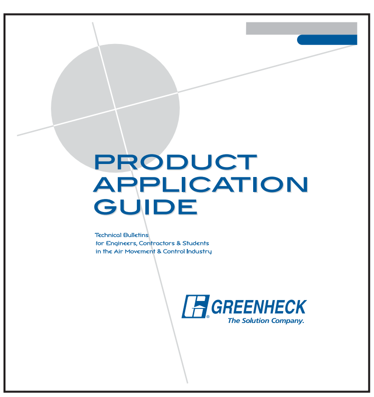
What is ARI?

The Air-Conditioning and Refrigeration Institute (ARI) is the national trade association representing manufacturers of more than 90 percent of North American produced central air-conditioning and commercial refrigeration equipment.

ARI Standards

ARI develops and publishes technical standards for industry products. ARI standards establish rating criteria and procedures for measuring and certifying product performance. Products are rated on a uniform basis, so that buyers and users can properly make selections for specific applications. In its certification programs, ARI verifies manufacturers' certified performance ratings.

On your next project, select products that are ARI certified and listed in the ARI 1060 directory of certified Air-to-Air Energy Recovery equipment.



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Gauge and Weight Chart for Sheet Steel, Galvanized Steel, Stainless Steel, and Aluminum

This article provides a quick reference to gauges of material, pounds per square foot, and gauge decimal equivalents.

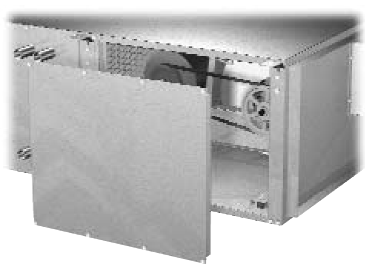
	Sheet Steel		Galvanized Steel		Stainless Steel		Aluminum	
Gauge	Gauge Decimal	Lbs. per Sq. Ft.	Gauge Decimal	Lbs. per Sq. Ft.	Gauge Decimal	Lbs. per Sq. Ft.	Gauge Decimal	lLs. per Sq. Ft.
30	0.0120	0.500	0.016	0.656			0.0100	0.141
29	0.0135	0.563	0.017	0.719			0.0113	0.160
28	0.0149	0.625	0.019	0.781			0.0126	0.178
27	0.0164	0.688	0.020	0.844			0.0142	0.200
26	0.0179	0.750	0.022	0.906	0.018	0.756	0.0159	0.224
25	0.0209	0.875	0.025	1.031			0.0179	0.253
24	0.0239	1.000	0.028	1.156	0.024	1.008	0.0201	0.284
23	0.0269	1.125	0.031	1.281			0.0226	0.319
22	0.0299	1.250	0.034	1.406	0.03	1.26	0.0253	0.357
21	0.0329	1.375	0.037	1.531			0.0285	0.402
20	0.0359	1.500	0.040	1.656	0.036	1.512	0.0320	0.452
19	0.0418	1.750	0.046	1.906			0.0359	0.507
18	0.0478	2.000	0.052	2.156	0.048	2.016	0.0403	0.569
17	0.0538	2.250	0.058	2.406			0.0453	0.639
16	0.0598	2.500	0.064	2.656	0.06	2.52	0.0508	0.717
15	0.0673	2.813	0.071	2.969			0.0571	0.806
14	0.0747	3.125	0.079	3.281	0.075	3.15	0.0641	0.905
13	0.0897	3.750	0.093	3.906			0.0720	1.016
12	0.1046	4.375	0.108	4.531	0.105	4.41	0.8080	1.140
11	0.1196	5.000	0.123	5.156	0.12	5.04	0.0907	1.280
10	0.1345	5.625	0.138	5.781	0.135	5.67	0.1019	1.438
9	0.1495	6.250	0.153	6.406			0.1144	1.614
8	0.1644	6.875	0.168	7.031	0.165	6.93	0.1285	1.813
7	0.1793	7.500			0.1874	7.871	0.1443	2.036
6	0.1943	8.125					0.1620	2.286
5	0.2092	8.750						
4	0.2242	9.375						
3	0.2391	10.000						

What's new at Greenheck

Model AX Direct Drive Axial Fan

Greenheck's new Model AX direct drive axial fan is designed for inline air ventilation in commercial or industrial buildings.

Typical applications include general ventilation or emergency smoke exhaust. Model AX is available in 14 sizes that efficiently cover a wide range of volumetric flow and pressure conditions up to 115,000 CFM (54 m3/s) and 5 inches wg. (1250 Pa). The model AX is designed to reduce operating costs with improved efficiency and is available in a variety of casing configurations. The AX is licensed to bear the AMCA Seal for Air Performance and is UL 705 Listed.



Low Profile Fan Coil Indoor Air Handling Unit

Greenheck's newest indoor air handler, Model LFC, provides a low cost method of cooling and/or heating in applications where space is limited, such as schools, office buildings, churches, apartments and condominiums.

The horizontal Model LFC Low Profile Fan Coil is available in eight different sizes, each saving as much as 4 to 6 inches in height, and covers a performance range from 300 through 4,700 cfm and up to 3.5 in wg. Every fan features insulated double wall housing and an internally isolated drive frame, reducing the potential for noise transmitting through the ductwork. Model LFC has a standard removable stainless steel drain pan and four access panels for easy accessibility for cleaning and maintenance.

New Line of Severe Environment Dampers

Greenheck is the first manufacturer to offer 316 stainless steel construction in a standard product. This new line of Severe Environment Dampers offers an excellent corrosion-resistant option for applications such as paper mills, wastewater treatment plants, swimming pools, food processing plants, laboratories, coastal buildings and maritime applications.

When tested against 140 different corrosive mediums, 316 stainless steel was by far the best material. As a result, Greenheck's Severe Environment Dampers are made completely of 316 stainless, including all options and accessories. These dampers are available in more than 20 Greenheck models, providing fire life safety, control, and backdraft damper functions; and in configurations including round, commercial, industrial, dynamic fire, smoke, and fire smoke dampers.

What's new at Greenheck

The Model TCB-LE is suitable for high school and university laboratories.

The Vektor ™ system is suitable for hospital, pharmaceutical, university, biotech and other laboratory applications.

Greenheck Laboratory Exhaust Systems

Greenheck now offers two models for a tubular centrifugal laboratory exhaust systems, Model TCB-LE and the Vektor™. Both systems are designed to be a cost-effective alternative to standard field built-up fan and stack assemblies.

Model TCB-LE — The model TCB-LE is a laboratory exhaust system typically specified for high school and university laboratories. A high velocity exhaust cone incorporated in the TCB-LE displaces hazardous or noxious laboratory fumes high above the roof, preventing roof damage or re-entry into the building's make-up air system.

An optional bypass air plenum and damper adds ambient air to the exhaust, to further dilute fumes and provides additional exhaust displacement. The system bears the AMCA Seal for sound and air performance, meets ANSI Z9.5 and ASHRAE guidelines, and is suitable for flow applications from 500 to 24,000 cfm per fan.

The Vektor — Greenheck's new Vektor™ High Plume Dilution Blower is a self-contained exhaust system for institutional and industrial laboratories. The result of Greenheck's advanced computational fluid dynamics and testing analysis, Vektor employs a unique discharge nozzle design that entrains additional ambient air to mix with the potentially hazardous exhaust fumes.

The additional air dilutes the lab effluent and increases the discharge flow and velocity, displacing the exhaust high above the roof and away from building makeup air systems—without the need for unsightly exhaust stacks. Vektor's mixed-flow impeller is available in AMCA spark resistant construction for laboratories that exhaust flammable and explosive solvent vapors.

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