AHRI Standard 261 (SI)

2017 Standard for

Sound Rating of Ducted Air Moving and Conditioning Equipment

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Note:

This standard supersedes AHRI Standard 261 (SI)-2012 and differs in the following ways:

- Sound power shall be determined following ANSI/AHRI Standard 230 procedures if Sound Intensity is used.
- Sound ratings can be predicted for untested fan operating points and unit sizes with certain restrictions.

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SOUND RATING OF DUCTED AIR MOVING AND CONDITIONING EQUIPMENT

Section 1. Purpose

1.1 *Purpose*. The purpose of this standard is to establish for the indoor portions of factory-assembled ducted air moving and conditioning equipment and not the individual subassemblies: definitions; requirements for acquiring sound data; sound level calculations; equipment sound ratings; and conformance conditions.

1.1.1 *Intent.* This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors and users.

1.1.2 *Review and Amendment.* This standard is subject to review and amendment as technology advances.

1.2 *Rationale*. Ducted Equipment presents unique challenges when providing sound ratings since their ratings are used to both compare products and to provide the information necessary to predict application sound levels. For these reasons, the sound ratings shall define the sound coming from various portions of the equipment (Sound Components). The Sound Components are the Sound Sources that impact the application sound paths.

Ducted air-conditioning equipment can have ducted discharge, ducted inlet, and casing radiated Sound Components. Depending on its applied configuration, free discharge (or free inlet) combined with the casing radiated Sound Component may also be needed. All Sound Components are acoustically described/rated by utilizing a Mapped Sound Rating approach that is typically referenced to the product's supply fan operating map. The supply fan is contained in the Base Unit of the product. In addition, this standard defines an approach to account for the acoustical effects of product Appurtenances (such as modulation devices or discharge/inlet plena) and other Sound Sources (such as the refrigeration circuit, return and exhaust fans, etc.) to the base unit Mapped Sound Rating. Thus, a Mapped Sound Rating can be developed for a given product configuration and each of its various Sound Components defining the sound for any product operating condition. Figure 1 presents an example of a typical product application showing the relationship between the product Sound Components and the various application sound paths. Figure 2 presents an example of a typical vertically ducted product depicting the contribution of the various product Sound Sources on the Sound Components.

All Sound Components are tested utilizing either a reverberation room (qualified by test) or using Sound Intensity. Reverberation room tests are conducted using the Comparison Method and a calibrated Reference Sound Source (RSS), while the sound intensity tests are conducted using measurements made at discrete points or by the scanning method. Sound ratings are in the form of octave band Sound Power Levels, dB, from 63 to 8,000 Hz derived from one-third octave band measurements. In addition to the stated octave band ratings, this standard can be used to provide one-third octave band sound ratings from 50 to 10,000 Hz.

Note: The specified sound intensity method, ANSI/AHRI Standard 230, is derived from ISO 9614-1 and 9614-2.

In the example presented in Figure 1, there are two Sound Components present, ducted discharge and free inlet combined with casing radiated. The ducted discharge sound component affects or defines the source strength for two of the four typical application sound paths shown below 1) the supply airborne sound and 2) the supply breakout sound. The free inlet combined with casing radiated sound component affects or defines the source strength for the 3) return airborne and 4) wall transmission application sound paths.

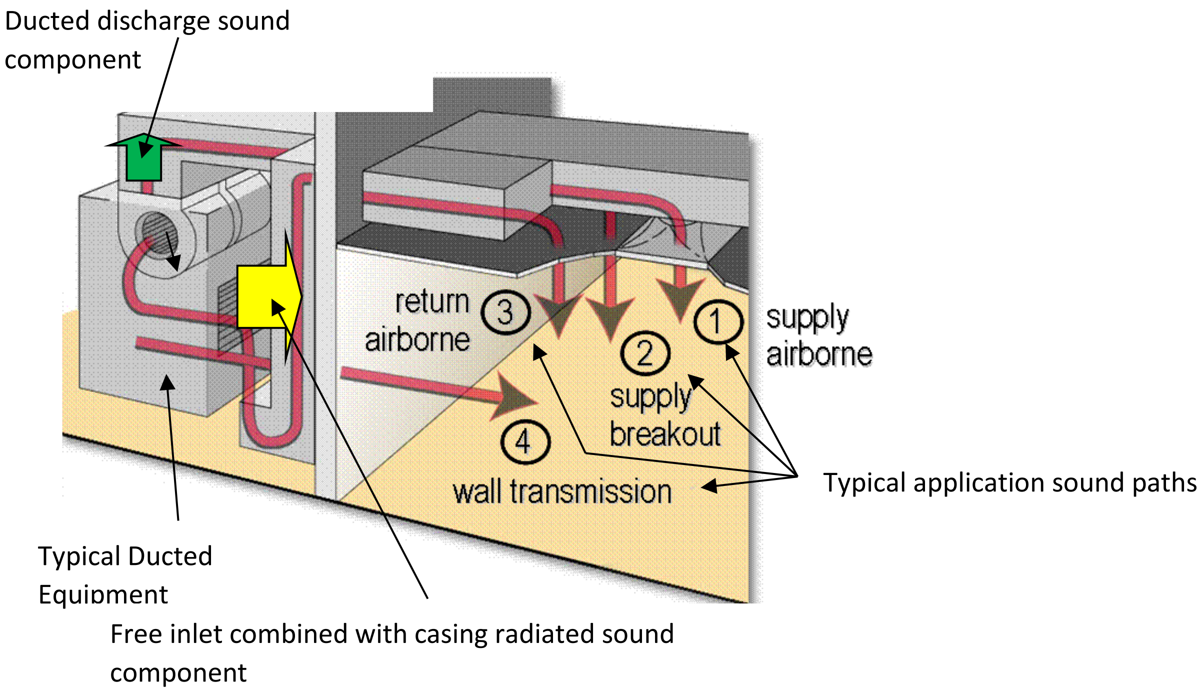

Figure 1. Typical Ducted Product Application

In Figure 2, a typical vertical ducted unit is presented with its Sound Components and their contributing product Sound Sources. In this example, there are two Sound Components, the ducted discharge and the ducted inlet. The ducted discharge sound component is first defined by the supply fan discharge sound in the Base Unit coupled with the discharge plenum. The contribution of appurtenance sound from supply fan discharge airflow impinging the heat exchanger in the discharge plenum must also be added to the supply fan discharge sound. Finally, the effects of the other sources on the ducted discharge sound from the condenser fans and the refrigerant circuit must be considered. For the ducted inlet sound component, the sound from the return side of the return fan is first considered. In this case, the return side sound from the supply fan contributes as another sound source.

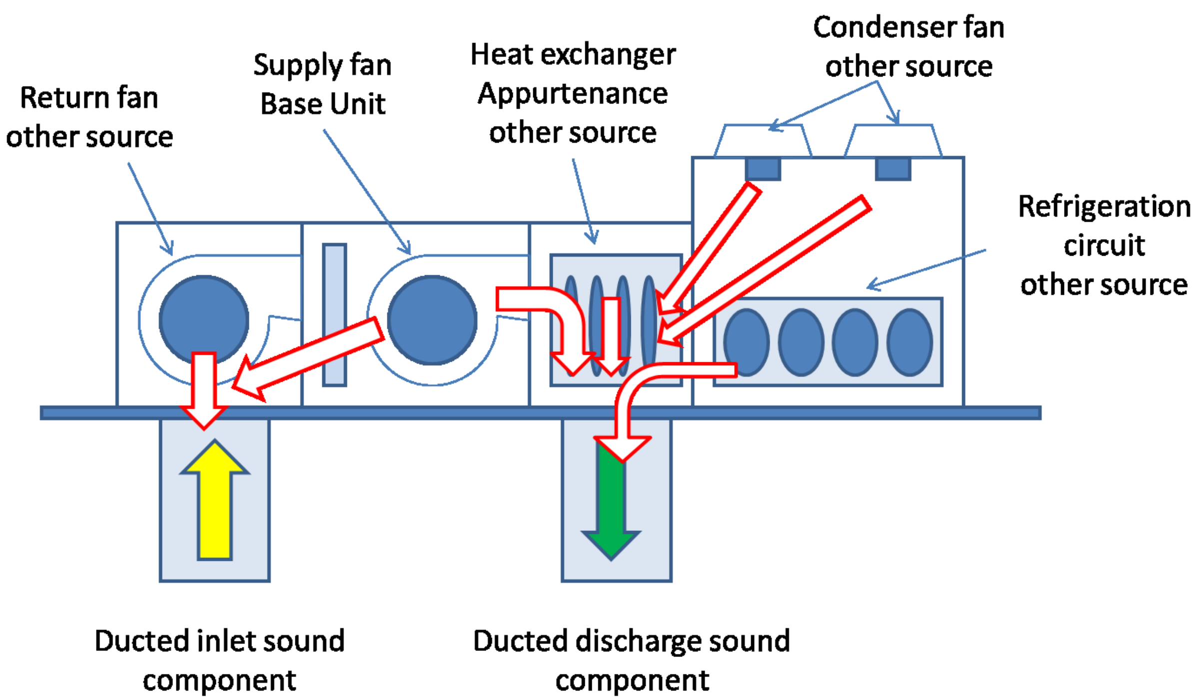

Figure 2. Relationship Between Sound Components and Sound Sources

Section 2. Scope

2.1 *Scope.* This standard applies to Ducted Equipment containing fans and specifies methods for determining the sound power ratings, using sound data for rating the various product Sound Components across the operating range. Mapped Sound Ratings reported are octave-band Sound Power Levels from 63 Hz to 8,000 Hz. In addition to the stated octave band Mapped Sound Ratings, this standard can additionally be used to provide one-third octave band Mapped Sound Ratings from 50 to 10,000 Hz.

2.2 *Exclusions*. This standard does not apply to the following AHRI classes of equipment:

2.2.1 Outdoor heat rejection sections of equipment addressed in AHRI Standard 270 and AHRI Standard 370
2.2.2 Non-ducted equipment addressed in AHRI Standard 300 and AHRI Standard 350
2.2.3 Terminal equipment addressed in AHRI Standard 881 (SI)
2.2.4 Ductless fan coil units addressed in ANSI/AHRI Standard 440
2.2.5 Active Chilled Beams addressed in AHRI 1241 (SI).

Section 3. Definitions

All terms in this document will follow the standard industry definitions in the ASHRAE Terminology website (https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology) unless otherwise defined in this section. For acoustic related terms refer to ASA Standard Term Database (http://asastandards.org/asa-standard-term-database/.)

3.1 *Acoustic Baffle*. A barrier that creates a well-defined duct termination and test surface for a ducted sound intensity measurement. The barrier is rigid and non-absorbing.

3.2 *Acoustic Test Duct*. A duct used to convey the sound of the unit configuration under test to the reverberation room or intensity surface during a ducted discharge or ducted inlet sound component test. A Duct End Correction shall be added to the sound data measured in the reverberation room or from the intensity method to account for the presence of the duct termination.

3.3 *Acoustic Test Duct Elbow.* An elbow that may be added to the Acoustic Test Duct to facilitate testing. An Acoustic Test Duct Elbow Correction, shall be made (in addition to the Duct End Correction) to the sound data to account for the presence of the Acoustic Test Duct Elbow.

3.4 *Acoustic Test Duct Elbow Correction (E_2)*. A correction in a frequency band to account for insertion loss effects of the elbow on the sound propagating through the Acoustic Test Duct. The table in Appendix C of this standard defines the Acoustic Test Duct Elbow Correction.

3.5 *Appurtenance*. An addition to a Base Unit for purposes of air modulation, heat transfer, control, isolation, safety, static pressure regain, etc. Examples of Appurtenances include:

3.5.1 Coil(s)
3.5.2 Electric heater(s)
3.5.3 Air filter(s)
3.5.4 Damper(s)
3.5.5 Moisture eliminator(s)
3.5.6 Fan-motor drive(s)
3.5.7 Gas heat exchanger(s)
3.5.8 Inlet or discharge plena
3.5.9 Air mixing device(s)
3.5.10 Flow straightener(s)
3.5.11 Modulating device(s) in the fan inlet/discharge
3.5.12 Application duct geometry(s) (such as duct elbow configurations)
3.5.13 Alternate unit casing construction(s) (such as double walled, lined, perforated face)

3.6 *Air-conditioner*. One or more factory-made assemblies which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function. Where such equipment is provided in more than one assembly, the separated assemblies shall be designed to be used together.

3.7 *Base Unit*. A factory-made encased assembly consisting of one or more fans meant to be connected to a duct and other necessary equipment to perform one or more of the functions of circulating, cleaning, heating, cooling, humidifying, and mixing of air, but which may or may not include a source of heating or cooling.

3.8 *Comparison Method*. A method of determining Sound Power Level by comparing the average Sound Pressure Level produced in the room to a Reference Sound Source of known Sound Power Level output. The difference in Sound Power Level is equal to the difference in Sound Pressure Level when conditions in the room are the same for both sets of measurements.

3.9 *Ducted Equipment*. Heating, ventilating and air conditioning equipment having one or more supply fans which employ ductwork to convey the conditioned air to and/or from the desired space. Ducted Equipment may have various combinations of discharges and inlets as follows:

3.9.1 Ducted discharge(s) and ducted inlet(s)
3.9.2 Ducted discharge(s) with free inlet(s)
3.9.3 Ducted inlet(s) with free discharge(s)

This equipment may be ducted in various configurations horizontally and vertically, and may incorporate multiple inlets and outlets.

3.10 *Duct End Correction (E_1)*. A correction in a frequency band that accounts for the acoustic energy in an Acoustic Test Duct that is prevented from entering the test space by the impedance mismatch created by the termination of the Acoustic Test Duct. A method for computing the Duct End Correction is described in Section 5.2.1 of this standard.

3.11 *Effective Diameter (D_e)*. The diameter of a circular duct which is equal in area to a specific Acoustic Test Duct.

3.12 *Heat Pump*. One or more factory-made assemblies which normally include an indoor conditioning coil, a compressor and outdoor heat exchanger (including means to provide a heating function), and may optionally include a cooling function. When such equipment is provided in more than one assembly, the separated assemblies shall be designed to be used together.

3.13 *Hertz (Hz)*. Unit of frequency in cycles per second.

3.14 *Mapped Sound Rating.* Equipment sound ratings that are based upon a series of tests performed across the range of operating conditions determined typically from a flow pressure map for the product supply fan and as defined by the equipment manufacturer. Contributions due to Appurtenances and other sources such as return fans, exhaust fans, and the refrigeration circuit are superimposed on the supply fan sound rating map. One-third octave band Sound Power Levels are obtained for each test point of the series to provide octave band sound power ratings. The mapped rating process is defined in Section 6.2. A special case exists when a supply fan is used in conjunction with a return or exhaust fan in the Base Unit (See Appendix D).

3.15 *Octave Band*. A band of sound covering a range of frequencies such that the highest is twice the lowest.

3.16 *One-third Octave Band*. A band of sound covering a range of frequencies such that the highest frequency is the cube root of two times the lowest frequency.

3.17 *Reference Sound Source (RSS).* A portable, aerodynamic sound source that produces a known stable broad band sound power output as defined in ANSI/AHRI Standard 250.

3.18 *Reproducibility*. The degree of agreement in test results obtained with the same method on identical test items in different laboratories with different operators using different equipment.

3.19 *Sound Components*. The product sound that can be independently defined to describe a product's contribution to the various sound paths in a typical application. The Sound Components that may need to be defined for a given product consist of one or more of the following:

3.19.1 Ducted discharge
3.19.2 Ducted inlet
3.19.3 Casing radiated
3.19.4 Free discharge (or free inlet) combined with casing radiated
3.19.5 Free discharge (or free inlet)

3.20 *Sound Sources*. Any phenomenon occurring within the unit that contributes to the product sound.

Section 4. Requirements for Acquiring Sound Data

4.1 *General Test Considerations.* This standard incorporates a reverberation room Comparison Method and/or a sound intensity method to obtain the Sound Power Levels of the various Sound Components for ducted air-moving and air-conditioning equipment. These methods yield the Sound Power Levels for a complete ducted unit by adding the effects of Appurtenances and other Sound Sources to the sound of the Base Unit as required. For the purposes of this standard there are three types of Sound Sources. 1) Sound generated by the primary fan(s) in the Base Unit 2) Sound generated by or attenuated due to an Appurtenance having airflow through or impacting it 3) Sound generated by other sources such as the refrigerant circuit, airborne noise from a variable frequency drive (VFD) ventilation fan, motor noise, gas burner combustion noise, outdoor air condenser fans, and secondary fans; such as return fans and exhaust fans (See Appendix D). Their combined effects are added together to obtain the total sound for a given product sound component.

When using the reverberation room method, Sound Power Levels shall be determined using ANSI/AHRI Standard 220. The reverberation room method of qualification, sound power calculation method, and facility requirements shall be per ANSI/AHRI Standard 220. The method of test and test configurations shall be as defined in the body of this standard in Sections 4.2 through 4.6.

When using the intensity method, Sound Power Level shall be determined using ANSI/AHRI Standard 230. The performance verification using a RSS, measurement method, and sound power calculation method shall be per ANSI/AHRI Standard 230. The method of test and test configuration shall meet the requirements in Section 4.2 through 4.5 and 4.7.

4.2 *Equipment Configurations and Sound Components.* Only those Sound Components that apply to how the product is installed and used shall be included in the product sound rating. The appropriate sound component(s) shall be selected based on the product application.

4.2.1 *Equipment with Ducted Discharge(s) and Ducted Inlet(s).* The following sound component Sound Power Levels can be determined for this configuration:

4.2.1.1 Ducted discharge
4.2.1.2 Ducted inlet
4.2.1.3 Casing radiated

4.2.2 *Equipment with Ducted Discharge(s) and Free Inlet(s).* The following sound component Sound Power Levels can be determined for this configuration:

4.2.2.1 Ducted discharge
4.2.2.2 Optional free inlet
4.2.2.3 Optional free inlet combined with casing radiated This Sound Component shall not be derived from separate free inlet and casing radiated sound tests.

4.2.3 *Equipment with Ducted Inlet(s) and Free Discharge(s).* The following sound component Sound Power Levels can be determined for this configuration:

4.2.3.1 Ducted inlet

4.2.3.2 Optional free discharge

4.2.3.3 *Free Discharge Combined with Casing Radiated*. This Sound Component shall not be derived from separate free discharge and casing radiated sound tests.

4.3 *Method of Test.*

4.3.1 *General*. All sound tests shall be conducted using either the ANSI/AHRI Standard 220 reverberation room Comparison Method or the ANSI/AHRI Standard 230 sound intensity method. The specific test set-up will depend on the product Sound Components being tested. The tests can be divided into two basic types: ducted sound component tests and non-ducted sound component tests. For ducted sound component tests, the sound component of interest is ducted into the test space with an Acoustic Test Duct. For non-ducted sound component tests, the unit may either be located in the test space with the untested Sound Components being ducted out, or the unit is located adjacent to the test space without an Acoustic Test Duct.

4.3.2 *Ducted Sound Components* For ducted discharge and ducted inlet Sound Components tested in accordance with this standard, a Duct End Correction (as computed in Section 5.2.1 of this standard) shall be added to each One-third Octave Band. The addition of the Duct End Correction provides the user with the sound power that would be transmitted into an acoustically, non-reflective duct system.

Products having multiple ducted discharges or multiple ducted inlets on a common face that are meant by the manufacturer to join into a common duct shall be tested at the same time. A Duct End Correction of only one of the ducts shall be made. However, if products have multiple ducted inlets or discharges on a common face or different faces, and are not joined into a common duct, each shall be tested separately. Duct End Corrections shall be made for each of the ducts.
An airflow control device, such as an orifice end plate, shall not be placed in the Acoustic Test Duct. However, airflow control devices can be part of other test ducts or plenum not related to the Sound Component under test.

Although a straight Acoustic Test Duct is preferred for ducted sound component tests, an Acoustic Test Duct Elbow may be used to accommodate test facility and unit set-up limitations. If an Acoustic Test Duct Elbow is employed, Acoustic Test Duct Elbow Corrections (E_2) shall be added to the sound data to account for attenuation of the Acoustic Test Duct Elbow using Appendix C.

4.3.3 *Test Unit Airflow Measurements.* All test airflow measurements shall be made in accordance with either ANSI/AMCA Standard 210/ASHRAE Standard 51 or ASHRAE Standard 37.

4.4 *Test Set-up Configurations.*

4.4.1 *Ducted Discharge Tests.* For this test the unit discharge is ducted into a test space using an Acoustic Test Duct. When using a reverberation room, sound measurements of the ducted discharge component shall be conducted using ANSI/AHRI Standard 220. When using Sound Intensity, sound of the ducted discharge component shall be determined using ANSI/AHRI Standard 230. Test configurations are conceptually shown (and not to scale) in Figure 3 or 4. For either reverberation room or sound intensity tests, a Duct End Correction (and Acoustic Test Duct Elbow Correction if needed) shall be added to the Sound Power Level to account for the acoustic energy that is prevented from entering the test space by the impedance mismatch created by the termination of the Acoustic Test Duct. For ducted discharge tests, it is recommended that the Acoustic Test Duct be three effective duct diameters in length, but shall not be less than 1m. However, duct lengths up to five effective duct diameters are permissible if needed for set-up or airflow performance measurement considerations.

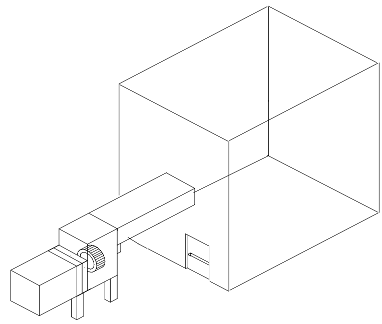

Figure 3. Concept Reverberation Room Ducted Discharge Test Set-up

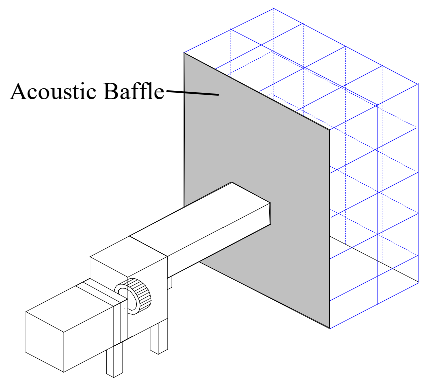

Figure 4. Concept Sound Intensity Ducted Discharge Test Set-up

4.4.2 *Ducted Inlet Test.* For this test, the unit inlet is ducted into a test space using an Acoustic Test Duct. When using a reverberation room, sound measurements of the ducted inlet component shall be conducted using ANSI/AHRI Standard 220. When using Sound Intensity, sound of the ducted inlet component shall be determined using ANSI/AHRI Standard 230. Test configurations are conceptually shown (and not to scale) in Figure 5 or 6. For either reverberation room or sound intensity tests, a Duct End Correction (and Acoustic Test Duct Elbow Correction if needed) shall be added to the Sound Power Level to account for the acoustic energy that is prevented from entering the test space by the impedance mismatch created by the termination of the Acoustic Test Duct. For ducted inlet tests, it is recommended that the Acoustic Test Duct be one effective duct diameter in length, but shall not be less than 1m. However, duct lengths up to five effective duct diameters are permissible if needed for set-up or airflow performance measurements.

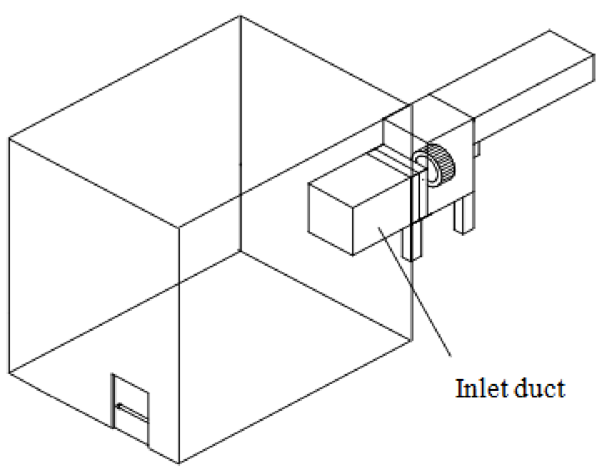

Figure 5. Concept Reverberation Room Ducted Inlet Test Set-up

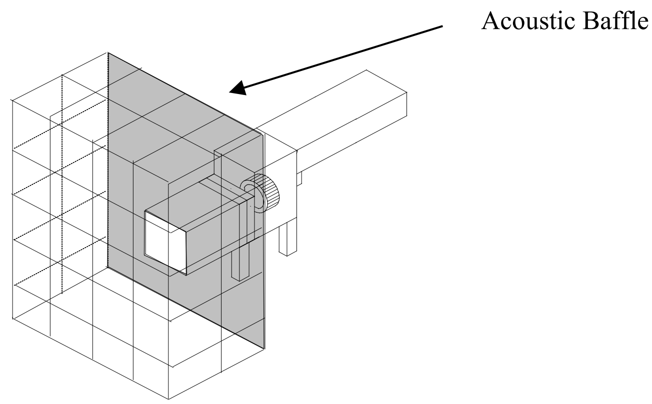

Figure 6. Concept Sound Intensity Ducted Inlet Test Set-up

4.4.3 *Casing Radiated Test.* The casing of the unit shall be in the test space with both the inlet and the discharge ducted out of the test space. For reverberation room tests, the sound shall be measured using ANSI/AHRI Standard 220. For Sound Intensity, the sound shall be determined in accordance with ANSI/AHRI Standard 230. The test configurations are conceptually shown (and not to scale) in Figures 7 and 8. A duct with high transmission loss walls to minimize breakout into the test space per Section 4.6.1.3 shall be used.

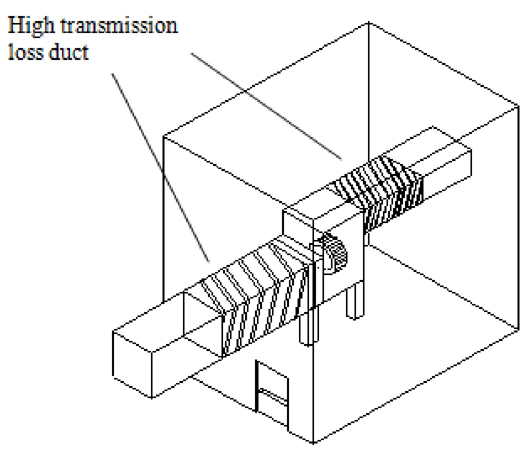

Figure 7. Concept Reverberation Room Casing Radiated Test Set-up

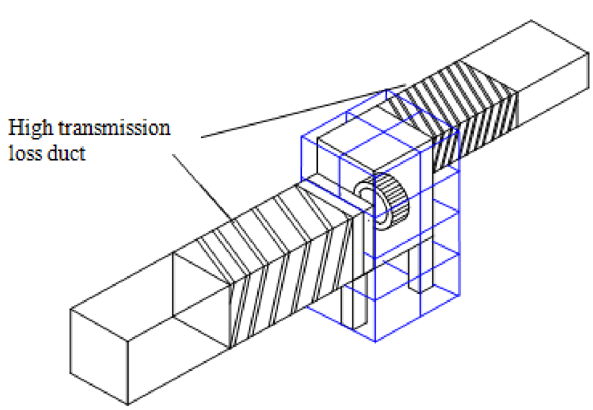

Figure 8. Concept Sound Intensity Casing Radiated Test Set-up

4.4.4 *Free Discharge or (Free Inlet) Combined with Casing Radiated Test.* For this test, the unit discharge (or the inlet) is ducted out of the test space. The sound component of the free discharge (or inlet) combined with casing radiated sound shall be measured using ANSI/AHRI Standard 220 when using a reverberation room and ANSI/AHRI Standard 230 when using Sound Intensity. The test configurations are conceptually shown (and not to scale) in Figures 9 and 10. A duct with high transmission loss walls to minimize breakout into the test space per Section 4.5.1.3 shall be used.

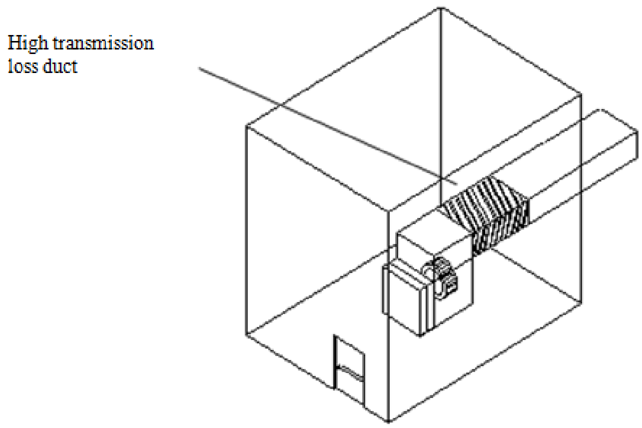

Figure 9. Concept Reverberation Room Free Discharge (or Inlet) Combined with Casing Radiated Test Set-up

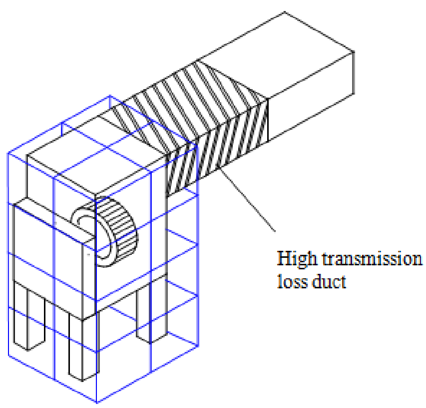

Figure 10. Concept Sound Intensity Free Discharge (or Inlet) Combined with Casing Radiated Test Set-up

4.4.5 *Free Discharge or Free Inlet Test.* For this test, the free discharge or free inlet of the unit shall be directly connected to the test space with the minimum amount of duct. The sound component of the free discharge (or inlet) shall be measured using ANSI/AHRI Standard 220 when using a reverberation room and ANSI/AHRI Standard 230 when using Sound Intensity. The test configurations are conceptually shown (and not to scale) in Figures 11 and 12. In Figure 12, the diagram on the left is typical for low air velocity and figure on right typical for high air velocity.

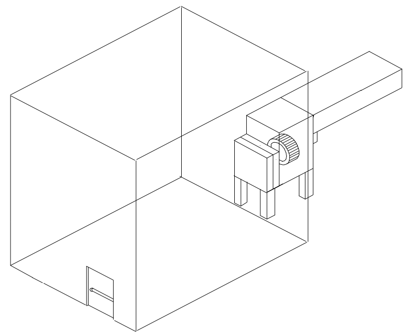

Figure 11. Concept Reverberation Room Free Discharge (or Inlet) Test Set-up

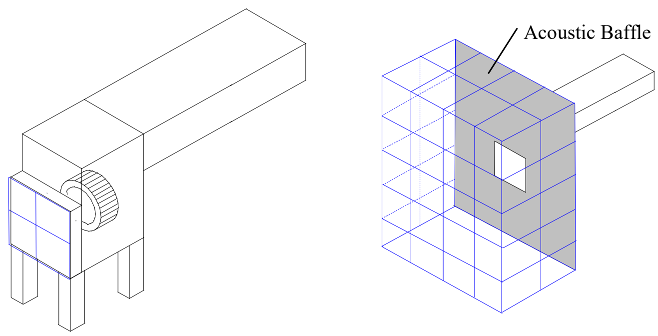

Figure 12. Concept Sound Intensity Free Discharge (or Inlet) Test Set-up

4.5 *General Test Set-up (Reverberation Room and Sound Intensity).* Equipment configurations described in Sections 4.5.1 through 4.5.4 are applicable for both reverberation room testing per ANSI/AHRI Standard 220 and for testing employing the sound intensity method per ANSI/AHRI Standard 230.

4.5.1 *Ductwork Required for Testing*. Ductwork attached to the unit under test may influence the sound measured, thus care shall be taken in the attachment and treatment of all ductwork.

4.5.1.1 *Ductwork Size.* Ductwork shall be sized to match the manufacturer's recommended supply or return opening and shall maintain constant duct dimensions. If the manufacturer does not define the supply or return opening, it is recommended that the Acoustic Test Duct be sized for a maximum velocity of 10 m/s. The ratio of the longer to the shorter sides of the rectangular duct cross-section shall not exceed four unless this is not possible due to the manufacturer's specifications.

4.5.1.2 *Ductwork Connection.* Ductwork should be connected to the unit under test using a flexible gasket or connector. All flexible duct connections shall be maintained to retain flexibility and to contain the sound within the duct. The length of the flexible connection shall not contribute to the transmission loss of the ductwork.

4.5.1.3 *Construction of Test Ductwork.* The test duct wall transmission loss characteristics required vary with the type of rating test being conducted (casing radiated being the most stringent), the surface area of test duct in the test space, and the relative sound levels in the test duct versus the test unit radiation level into the test space. For this reason, it is difficult to quantify the wall transmission loss characteristics. However, experience conducting tests with typical products has shown that the following duct construction methods provide reasonable results. It should also be noted that when testing products with low sound emissions, test set up diagnostic tests may need to be conducted to confirm that adequate test duct wall transmission loss characteristics exist.

The Acoustic Test Duct shall have walls with high transmission loss construction and shall not have internal absorptive lining. The test ductwork shall be any of the following:

4.5.1.3.1 A minimum of 1.2 mm thick sheet metal stiffened by a minimum of 19 mm thickness gypsum board attached by sheet metal screws on 152 mm centers and bonded to the exterior of the duct

4.5.1.3.2 Round sheet metal or PVC duct with a minimum of 4.88 kg/m^2 limp exterior acoustical barrier

4.5.1.3.3 A minimum of 19 mm plywood. For high aspect ratio ducts, it may also be necessary to stiffen the 19 mm plywood.

4.5.1.3.4 Other configurations may be used if shown by test to provide equivalent transmission loss, and other acoustic characteristics, when compared to the above construction methods.

4.5.2 *Static Pressure Taps.* Static pressure taps shall be in accordance with either ANSI/AMCA Standard 210/ASHRAE Standard 51 or ASHRAE Standard 37.

4.5.3 *Acoustic Test Ducts and Acoustic Duct Elbow.* For testing of ducted discharge or inlet, straight Acoustic Test Ducts are recommended. However, the standard allows for the use of an Acoustic Test Duct Elbow due to facility or set-up limitations. The use of an Acoustic Test Duct Elbow, its description, and the corrections applied shall be stated in the test report. If elbows are needed, the corrections given in Appendix C shall be used. The Acoustic Test Duct shall meet the construction requirements from Section 4.5.1.3.

4.5.4 *High Transmission Loss Duct Construction*. A special duct construction that limits the contribution of duct radiated sound to the component sound shall be used as illustrated in Figures 7 through 10. Acoustical duct lagging or thicker/ higher density duct walls are typically required. Sound Intensity can be used to determine the relative contribution of the duct radiation to the unit radiation. Alternatively, successive iterations of sound power measurements can be conducted with additional lagging to determine the adequacy of the ducts. No adjustments to the component sound power are allowed for contamination from duct radiation.

4.5.5 *Acoustic Baffle*. A barrier shall be constructed to terminate the duct and extend beyond the sound intensity measurement surface as defined in ANSI/AHRI Standard 230 Section 7.1. A typical construction would be 19 mm ply-wood with stiffeners.

4.6 *Test Instrumentation and Facilities (Reverberation Rooms).* This section defines the instrumentation and reverberation room to be used for sound power testing.

4.6.1 *Reverberation Room Instrumentation.* The reverberation room instrumentation shall meet or exceed the requirements as stated in ANSI/AHRI Standard 220.

4.6.2 *Reverberation Room Qualification.* The reverberation room used in testing shall be qualified, and shall meet the qualification requirements, as specified in ANSI/AHRI Standard 220 for the One-third Octave Bands from 50 Hz to 10,000 Hz.

4.6.3 *Test Unit Size.* For reverberation room testing, the total volume of the test unit, including ductwork, shall not exceed 5 % of the volume of the reverberation room.

4.6.4 *Use of Windscreen.* During testing, a windscreen may be used on the microphone. The effect of the windscreen on the microphone response shall not be more than $\pm$ 1 dB for frequencies of 50 to 4,000 Hz or $\pm$ 1.5 dB for frequencies from 4,000 to 10,000 Hz. Sound measurements shall not be made with air velocities over the microphone exceeding 2 m/s.

4.6.5 *Airflow Limitation.* For sound test measurements made within a reverberation room, it is recommended that the airflow of the test unit, m^3/min, not numerically exceed the room volume, m^3.

4.7 *Test Instrumentation and Facilities (Sound Intensity).* This section defines the instrumentation and facilities to be used for sound power testing.

4.7.1 *Sound Intensity Instrumentation.* The sound intensity instrumentation shall meet or exceed the requirements as stated in ANSI/AHRI Standard 230 Section 6.

4.7.2 *Verification with a RSS.* Performance verification with a RSS, as stated in ANSI/AHRI Standard 230 Section 6.5, is required periodically to verify the performance of the instrumentation system and the test operator. Frequency of verification shall be done per requirements in ANSI/AHRI Standard 230 Section 6.5.

4.7.3 *Size of Noise Source.* The size and shape of the noise source are unrestricted and serve to define the measurement surface. Guidance for selection of the measurement surface is provided in ANSI/AHRI Standard 230 Section 7.1.

4.7.4 *Time Averaging.* Minimum averaging time is stated in ANSI/AHRI Standard 230 Section 4.3.

4.7.5 *Use of Windscreen.* During testing, a windscreen may be used on the microphone. The effect of the windscreen on the microphone response shall not be more than ± 1 dB for frequencies of 50 to 4,000 Hz or ± 1.5 dB for frequencies from 4,000 to 10,000 Hz. Sound intensity measurements in airflow shall meet the requirements in ANSI/AHRI Standard 230 Section 6.3.

4.8 *Test Method Measurement Reproducibility.* Sound Power Levels obtained from either reverberation room or intensity measurements made in conformance with this standard should result in measurement standard deviations which are equal to or less than those in Table 1. For the reverberation room Comparison Method this table represents the uncertainty that would result from using ANSI/AHRI Standard 220 and a RSS calibrated per ANSI/AHRI Standard 250. For the intensity method, the uncertainties in this table include uncertainty in the sound intensity measurement method due to the test environment, background noise levels and selection of measurement points or measurement surfaces as defined in ANSI/AHRI Standard 230. The standard deviations in Table 1 do not account for variations of sound power caused by changes in operating conditions.

Table 1. Reproducibility in the Determination of Ducted Equipment Sound Power Levels

Octave Band Center Frequency, Hz	One-third Octave Band Center Frequency, Hz	Maximum Standard Deviation of Reproducibility, dB
63	50 to 80	4.0
125	100 to 160	3.0
250	200 to 315	2.0
500 to 4,000	400 to 5,000	1.5
8,000	6,300 to 10,000	3.0

4.9 *Information to be Recorded.* The following shall be compiled and recorded for measurements that are made according to the requirements of this standard to document the ducted noise ratings provided by this standard:

4.9.1 Description of unit under test and descriptive photograph

4.9.2 One-third octave band Sound Power Levels with end corrections (if applicable) included, dB

4.9.3 One-third octave band Duct End Corrections, dB, and description of how duct was terminated in the test space

4.9.4 Duct internal height, width, and length dimensions, m

4.9.5 Acoustic test duct elbow octave band correction, dB (if used)

4.9.6 Acoustic test elbow duct internal height and width dimensions, length and location of the elbow in the duct, m (if used)

4.9.7 Description of thermal conditions during test

4.9.8 Airflow, m^3/s; duct static pressure, kPa; fan speed, rev/s; fan motor, BHP, for each test point

4.9.9 Sound component measured

4.9.10 Test date

4.9.11 Test method used

4.9.11.1 *Unit Under Test.* Description of Base Unit shall include the following information to clearly identify the unit under test:

4.9.11.1.1 Fan type, model, manufacturer and size,
4.9.11.1.2 Cabinet wall construction and size
4.9.11.1.3 Motor manufacturer and size
4.9.11.1.4 Operating conditions (fan speed, rev/s; airflow, m^3/s; fan static pressure, kPa; and air density, kg/m^3)
4.9.11.1.5 Installation/mounting details
4.9.11.1.6 Description of Appurtenances
4.9.11.1.7 Description of other Sound Sources

4.9.12 Thermal Conditions During Test

4.9.12.1 Air temperature, °C
4.9.12.2 Relative humidity, %
4.9.12.3 Barometric pressure, kPa

4.9.13 Instrumentation

4.9.13.1 The equipment used for the measurements, including name, type, serial number and manufacturer
4.9.13.2 Description (manufacturer, model and serial number) of RSS used

Section 5. Sound Level Calculations

5.1 *General.* This standard utilizes an octave band sound power level rating system based on one-third octave band sound level test data, determined by a reverberation room test method or sound intensity test method. Ducted Sound Components (ducted discharge or ducted inlet) shall include Acoustic Test Duct End Corrections and the effects of the Acoustic Test Duct Elbow (if used), for either a reverberation room or sound intensity test. The non-ducted Sound Components (casing radiated, free inlet combined with casing radiated and free components) do not have the duct correction considerations that are employed in the ducted component cases.

5.2 *Determination of Component One-third Octave Sound Power Levels.* The measured one-third octave band sound pressure level data acquired in a reverberation room in accordance with Section 4 shall be converted to one-third octave band Sound Power Levels using the calculation procedures in Section 6 of ANSI/AHRI Standard 220. For intensity measurements, Sound Power Levels are directly determined from the measurements in ANSI/AHRI Standard 230. Adjustments for the Duct End Correction for the n^{th} One-third octave Band ($E_{1(n)}$), as outlined in Sections 5.2.1 and 5.2.2, and/or the Acoustic Test Duct Elbow Correction for the n^{th} One-third Octave Band ($E_{2(n)}$) as outlined in Section 5.2.3 shall be added to the calculated one-third octave band Sound Power Levels using Equation 1.

$$L'_{w\,(n)} = L_{w(n)} + E_{1(n)} + E_{2(n)} \qquad 1$$

Where:

$E_{1(n)}$ = Acoustic Test Duct End Correction for the n^{th} One-third Octave Band for either a duct terminating flush with a wall or terminating free in space (see Sections 5.2.1 and 5.2.2). If no test duct is used for this component then $E_{1(n)} = 0$
$E_{2(n)}$ = Acoustic Test Duct Elbow Correction for the n^{th} One-third Octave Band (see Section 5.2.3). If no test elbow is used for this component then $E_{2(n)} = 0$
$L'_{w\,(n)}$ = Test unit component Sound Power Level, dB, for the n^{th} One-third Octave Band adjusted for the Acoustic Test Duct End Correction and the Acoustic Test Duct Elbow Correction, if required
$L_{w(n)}$ = Test unit component Sound Power Level, dB, for the n^{th} One-third Octave Band, determined by the reverberation room or sound intensity test methods
n = One-third Octave Band of interest in the Octave Band

5.2.1 *Calculation of the Acoustic Test Duct End Correction.* For ducted inlet or ducted discharge Sound Components tested in accordance with this standard, the Duct End Correction shall be added to each one-third octave band Sound Power Level. The addition of the Duct End Correction, to the tested Sound Power Levels will provide the user with the sound power that would be transmitted into a non-reflecting duct system.

For a ducted discharge or ducted inlet tests, the value for the Duct End Correction depends on the duct termination in the test space. For an Acoustic Test Duct terminating flush, or less than three Effective Diameters, see Equation 2, from any acoustically reflective surface, Equation 3 shall be used to calculate the Duct End Correction. For an Acoustic Test Duct terminating into the free space, greater than three Effective Diameters from any reflective surface, Equation 4 shall be used to calculate the Duct End Correction. These expressions shall be used to calculate the Duct End Correction (for either a flush or free termination) at the center frequencies of each One-third Octave Band or Octave Band.

$$D_e = \left(\frac{4 \cdot A}{\pi} \right)^{1/2} \quad (2)$$

Where:

A = Cross-sectional area of the duct, m^2
D_e = Effective Diameter, m

For a duct terminating flush or at a distance less than three Effective Diameters from the test space wall, Acoustic Baffle or termination surface use Equation 3:

$$E_{1(n)} = 10 \cdot \log_{10} \left[1 + \left(\frac{0.7 \cdot C_o}{\pi \cdot f \cdot D_e} \right)^2 \right] \quad (3)$$

For a duct terminating at a distance greater than or equal to three Effective Diameters from a test space wall, Acoustic Baffle or termination surface use Equation 4:

$$E_{1(n)} = 10 \cdot \log_{10} \left[1 + \left(\frac{C_o}{\pi \cdot f \cdot D_e} \right)^2 \right] \quad (4)$$

Where:

C_o = Speed of sound in air, m/s
D_e = Effective Diameter (as shown in Equation 2), m
$E_{1(n)}$ = Acoustic Test Duct End Correction for the n^{th} One-third Octave Band for a duct terminating flush
f = One-third Octave Band center frequency, Hz
n = One-third Octave Band of interest in the Octave Band

Note: Historically, the transition from flush to free space termination was defined as one Effective Diameter. Recent research (ASHRAE RP-1314, 2007) has shown that free duct termination effects are not fully exhibited for duct lengths shorter than three Effective Diameters.

5.2.2 *Acoustic Test Duct End Correction Limit.* When using the equations for Duct End Corrections in Section 5.2.1, if the calculated value for Duct End Corrections exceeds 14 dB, the value for $E_{1(n)}$ shall be limited to 14 dB.

Note: The calculated Duct End Corrections become numerically large for products with small effective duct diameters. This could overstate the Sound Power Levels at low frequencies for such small products. For this reason, sufficient information is to be presented with the sound rating data to allow users of this information to identify the value of $E_{1(n)}$ for a specific unit ducted component.

5.2.3 *Acoustic Test Duct Elbow Correction.* When using an Acoustic Test Duct Elbow (Section 4.5.3), Acoustic Test Duct Elbow Corrections for the n^th^ One-third Octave Band $E_{2(n)}$ shall be applied to the ducted Sound Power Levels as shown in Equation 1 in Section 5.2. The Acoustic Test Duct Elbow Corrections shall be obtained in Appendix C.

5.3 *Determination of Component Octave Band Sound Power Levels.* One-third octave band Sound Power Levels determined for the various product Sound Components (ducted discharge, ducted inlet, casing radiated and free inlet combined with casing radiated) defined in Section 5.1 shall be converted to octave band Sound Power Levels for sound rating Ducted Equipment using the method employed in Equation 5.

The three one-third octave band Sound Power Levels whose frequencies fall within each of the Octave Bands are summed as:

$$L'_{wo(m)} = 10 \log_{10} [\sum_{n=1}^{n=3} 10^{\left(\frac{L'_{w(n)}}{10}\right)}] \quad 5$$

Where:

$L'_{w(n)}$ = The end corrected Sound Power Level for the n^{th} One-third Octave Band from Equation 1, dB
$L'_{wo(m)}$ = Sound Power Level for the m^{th} Octave Band, dB
m = Octave Band of interest
n = One-third Octave Band of interest in the Octave Band

5.4 *Individual Unit Tests.* Individual ducted equipment may be tested at specific operating conditions, and the results reported according to procedures in Sections 4 and 5 of this standard. These tests are often conducted to check published sound ratings for individual units at application specific operating conditions. The results for individual sound tests shall be reported in octave band Sound Power Levels, or optional one-third octave band Sound Power Levels, together with the information listed in Section 4.9.

Section 6. Equipment Sound Ratings

6.1 *Mapped Sound Ratings*. The purpose of this standard is to establish a method of sound rating the indoor Sound Components of ducted equipment. The Mapped Sound Rating for the specific configuration of the Ducted Equipment shall be published, printed or provided in a selection program including all the applicable Sound Components. The Mapped Sound Rating for each sound component are to be derived from the addition of appurtenance effects and other Sound Sources to the Base Unit for each unit configuration.

6.2 *Combining Sound Sources and Appurtenances for Mapped Sound Ratings.* All Ducted Equipment is acoustically described by conducting a series of sound tests for the applicable equipment configuration Sound Components as described in Section 4.2. The sound data can then be used to define the sound rating for any product rating condition. Sound tests for each Sound Component are obtained by first mapping the supply fan in the Base Unit. The effects of Appurtenances and other Sound Sources are then added to the Mapped Sound Rating of the Base Unit to provide the acoustic description of a given sound component. The set of applicable Sound Components provide a total acoustic description of the equipment based on the full range of possible operating conditions as defined by the manufacturer.

6.2.1 *Base Unit Supply Fan Rating.* Thenumber of speed curves and test points along each speed curve of the supply fan in the Base Unit shall be evaluated to ensure that the difference between adjacent test points does not exceed 5 dB for any given One-third Octave Band. At a minimum, the base unit supply fan shall be tested along the highest and lowest speed curves across the full operational range as specified by the manufacturer. This same approach shall be applied to characterizing the other source contributions of a return fan (see Appendix D). The rating of the Base Unit may be considered representative of the total unit operation sound if Appurtenance and other sound source effects are shown not to contribute to the Sound Components under test.

6.2.2 *Appurtenance Effects to the Base Unit Rating.* The number of test points along the supply fan speed curves shall be evaluated to ensure that the acoustical effect of the Appurtenance on the Base Unit is understood. The appurtenance effects upon the base unit ratings shall be obtained from test data as specified in Section 4. The objective of the test is to determine if the Appurtenance can be represented by an averaged acoustical effect or if it shall be described as a function of airflow velocity. As for the case of the Base Unit, the difference between adjacent test points shall not exceed 5 dB for any given One-third Octave Band.

Note: It may be desirable to test a supply fan and an appurtenance plenum as an assembly if they are supplied together in a product.

6.2.2.1 *Mechanical Airflow Control Device.* The effects of a mechanical airflow control device, for example, inlet guide vanes (excluding variable frequency drives) shall be defined as outlined in Appendix E.

Note: The mechanical airflow device is part of the product and not a separate control system for purposes of the test.

6.2.3 *Other Sound Source Effects on Base Unit Rating.* The effects of other Sound Sources shall be added to the combined results of the Base Unit and any appurtenance effects. The effects of the other Sound Sources are to be based on test data as specified in Appendix D. A sufficient number of operating conditions shall be evaluated to ensure that the acoustical effects of the other Sound Sources on the Base Unit and applicable Appurtenances are understood for each Sound Component being measured.

The degree of difficulty in accounting for the effects of other sources on the Mapped Sound Rating of the Base Unit and its Appurtenances can vary significantly depending on the operational character and what controls the output of the other source. In the simplest of cases, other sources may operate independent of the supply fan, be constant in their acoustical nature, or only have two states of operation; one being on and the other off. In this situation, the Mapped Sound Ratingsfor a given sound component can be developed and published for both with and without the operation effects of the other source. However, in the case where the other source has an operating range that is interdependent (such as with return and exhaust fans) it becomes more difficult to account for its effects on the supply fan Mapped Sound Rating. The effects of independent and the more difficult interdependent sources on the Base Unit are addressed in Appendix D.

6.2.3.1 *Refrigerant Circuit Sources.* Refrigerant circuit related Sound Sources are identified and defined only in reference to the thermal rating standard operation point for a given product and considered independent of the supply fan (see Appendix D). The sound due to refrigerant circuit related sources operating at non-standard conditions defined by the manufacturer may be provided as optional information.

6.2.3.2 *Exhaust and Return Fans.* Due to the potential interdependent effects of the exhaust and return fan Sound Sources with the supply fan, they shall be evaluated at a sufficient number of test points and in the manner as specified in Appendix D.

6.2.3.3 *Burners*. The effects of the burner Sound Source shall be evaluated at the input rate and gas type specified on the nameplate.

6.2.4 *Predicted Sound Ratings for Untested Fan Operating Points and Unit Sizes.* With certain restrictions, sound ratings can be predicted for untested fan operating points and unit sizes.

6.2.4.1 *Sound Estimation for Untested Fan Operating Points.* The manufacturer may estimate Sound Power Levels and provide ratings for other fan (typically the supply fan, however a similar process can be applied to return and exhaust fans) operating conditions using an appropriate algorithm that is based on the Sound Power Levels determined by testing over the base unit's operating range. However, Sound Power Levels and ratings shall not be estimated for a Base Unit operating at conditions outside the tested region except as allowed in Section 6.2.4.2. The tested region is defined by the highest and lowest fan speeds, fan power limits, and system curves tested.

6.2.4.2 *Application of Fan Laws for Untested Sizes and Speeds.* Base unit fan sound power may be scaled as a function of fan diameter or speed along a system curve by use of the fan laws to units with geometrically proportional cabinets and fans. Such scaling can only be applied to aerodynamically generated sound. The fan impeller diameter of the Base Unit to be calculated shall not be less than 80% or more than 120% of the fan impeller diameter of the test unit maintaining tested fan speed. If the diameter is unchanged, fan speed shall not be scaled to a value less than 80% of the lowest tested speed or more than 120% of the highest tested speed.

Note: AMCA Standard 301 provides one acceptable method of scaling.

Fans and cabinets are considered to be proportional when the criteria of AHRI Standard 431 (SI) Appendix C, Criteria for Proportionality are met with the following modifications. Fans shall have the same number of blades with similar geometries (e.g. blade angle and blade shape). Scaling limits listed in this section supersede AHRI Standard 431 (SI) when scaling fan sound power.

The basis for proportionality in every case shall be the respective impeller diameters. Linear dimensions shall be proportional to the diameter and areas shall be proportional to the square of the diameter.

Fans are considered to be proportional when:

6.2.4.2.1 Impeller widths are proportional within ± 1.5%. Where applicable the housing development radii, and housing width are proportional within ± 1.5%.

6.2.4.2.2 Fan housing outlet area or fan inlet area are proportional within ±3%.

Fan cabinets are considered to be proportional when:

6.2.4.2.3 The clearance between the cabinet and the nearest fan housing or fan wheel are proportional or greater.

6.2.4.2.4 The clearance between adjacent fans is proportional or greater.

6.2.4.2.5 The fan cabinet inlet and the fan cabinet outlet airflow cross sectional areas are not less than 92.5% of the respective geometrically proportionate values.

6.2.4.2.6 Arrangement and location of internal bearings and their supports, inlet vanes, motors and drives, shall result in net airflow areas not less than 92.5% of those derived from exact proportionality when located within 0.5 impeller diameter of the fan inlet.

6.2.4.3 *Estimated Ratings for Untested Product Sizes or Appurtenances.* Tested product data may be used to estimate the Sound Power Levels and ratings of an untested size by interpolation of the same product line as long as:

6.2.4.3.1 Proportionality rules in Section 6.2.4.2 are followed

6.2.4.3.2 The two unit sizes tested and used for interpolation do not differ by more than the allowances in Section 6.2.4.2

6.2.4.3.3 The manufacturer tests a sufficient number of product sizes in a given product line to assure an accurate method of prediction

6.3 *Minimum Data Requirements for Published Sound Ratings.* The following is a list of data required to document the noise ratings supplied per this standard:

6.3.1 Unit configuration, Base Unit, Appurtenances and other sources

6.3.2 Octave band Sound Power Levels, dB

6.3.3 Acoustic test duct internal height, width and length dimensions, m

6.3.4 Acoustic test duct elbow internal height and width dimensions (if used) and location of the elbow in the Acoustic Test Duct, m

6.3.5 Fan speed, fan static pressure, airflow rate and fan motor power and appropriate units for each test point

6.3.6 Component under test as applicable ducted discharge, ducted inlet, casing radiated, free discharge or free inlet discharge combined with casing

6.4 *Published Sound Power Ratings.* All published sound power ratings shall be expressed in decibels rounded to the nearest whole decibel.

6.5 *Verification of Published Sound Ratings.* Any equipment selected at random and tested in a suitably qualified laboratory in accordance with this standard shall have a sound rating not higher than its published sound rating.

6.6 *Acoustic Test Duct End Correction Documentation*. If a component under test includes an end correction, a statement shall be included that an end correction was applied to the ratings. The end corrections applied shall be available upon request.

6.7 *Acoustic Test Duct Elbow Correction Documentation*. If a component under test includes an elbow correction, a statement shall be included that an elbow correction was applied to the ratings. The elbow corrections applied shall be available upon request.

Section 7. Conformance Conditions

7.1 *Conformance.* While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard's *Purpose* (Section 1) and *Scope* (Section 2) unless such product claims meet all of the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard shall not reference, state, or acknowledge the standard in any written, oral, or electronic communication.

APPENDIX A. REFERENCES – NORMATIVE

A1 Listed here are all standards, handbooks and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of the standard.

A1.1 AHRI Standard 340/360-2015, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, 2015, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.2 AHRI Standard 431 (SI)-2014, *Performance Rating of Central Station Air-handling Units*, 2014, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.3 AHRI Standard 1230-2014 with Addendum 1, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-conditioning and Heat Pump Equipment,* 2014, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.4 ANSI/AHRI Standard 210/240-2008 with Addenda 1 and 2, *Performance Rating of Unitary Air-Conditioning and Air Source Heat Pump Equipment,* 2008, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.5 ANSI/AHRI Standard 220-2014, *Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment*, 2014, Air-conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.6 ANSI/AHRI Standard 230-2013, *Sound Intensity Testing Procedures for Determining Sound Power of HVAC Equipment*, 2013, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.7 ANSI/AHRI Standard 250-2013, *Performance and Calibration of Reference Sound Sources*, 2008, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.8 ANSI/AMCA Standard 210/ASHRAE Standard 51-2016, *Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating*, 2016, Air Movement and Control Association International, 30 West University Drive Arlington Heights, IL 60004 U.S.A; American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.9 ANSI/AMCA Standard 301-2014, *Methods for Calculating Fan Sound Ratings from Laboratory Test Data,* 2014, Air Movement and Control Association International, 30 West University Drive, Arlington Heights, IL 60004, U.S.A.

A1.10 **ANSI/**ASHRAE Standard 37-2009, *Methods of Testing for Rating Unitary Air-conditioning and Heat Pump Equipment*, 2009, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.11 ASHRAE RP-1314, *Reflection of Airborne Noise at Duct Terminations*, 2008, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.12 *ASHRAE Terminology,* https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology, 2017, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.13 Beranek, L.L. 1960, *Noise Reduction*, McGraw Hill, New York.

A1.14 Title 10, *Code of Federal Regulations (CFR)*, Appendix AA to Subpart B of Part 430, U.S. National Archives and Records Administration, 8601 Adelphi Road, College Park, MD 20740-6001 or www.ecfr.gov.

APPENDIX B. REFERENCES – INFORMATIVE

B1 Listed here are standards, handbooks and other publications which may provide useful information and background but are not considered essential. References in this appendix are not considered part of the standard.

B1.1 ISO 9614-1:1993, *Acoustics – Determination of sound power levels of noise sources using sound intensity -- Part 1: Measurement at discrete points*, 1993, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

B1.2 ISO 9614-2:1996, Acoustics -- *Determination of sound power levels of noise sources using sound intensity - Part 2: Measurement by scanning*, 1996, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

APPENDIX C. ACOUSTIC TEST ELBOW CORRECTION (E_2) – NORMATIVE

C1 For testing of ducted inlet or ducted discharges, straight Acoustic Test Ducts are recommended. However, the standard does allow the use of an Acoustic Test Duct Elbow, when needed, to facilitate testing. An example of a test elbow configuration is shown in Figure C1. An Acoustic Test Duct Elbow Correction, shall be made (in addition to the test Duct End Correction) to the sound data to account for the presence of the Acoustic Test Duct Elbow.

Table C1 displays insertion loss values for unlined Acoustic Test Duct Elbows (Beranek 1960). An example of its application is shown in Table C2.

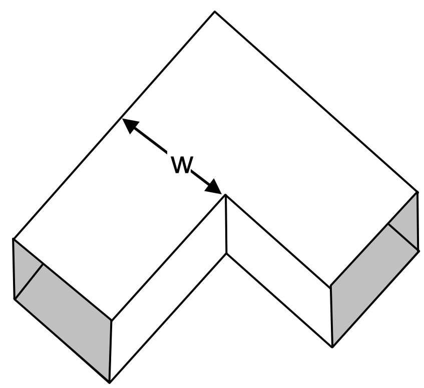

Figure C1. Insertion Loss of Unlined Acoustic Test Duct Elbows

Table C1. Insertion Loss of Unlined Elbows[1]	
	Insertion Loss, dB
fW < 48	0
48 ≤*fW* < 96	1
96 ≤ *fW* < 190	5
190 ≤ *fW* < 380	8
380 ≤ *fW* < 760	4
fW > 760	3
Note 1: *f* = center frequency, kHz, and *W* = width in the plane of bend, mm	

Table C2. Examples of Test Elbow Insertion Loss, dB

One-third Octave Band Frequencies, f (Hz)	One-third Octave Band Frequencies, f (kHz)	Duct Dimension, W, in Plane Of Bend , mm			
		500	750	1000	1250
50	0.050	0	0	1	1
63	0.063	0	0	1	1
80	0.080	0	1	1	5
100	0.100	1	1	5	5
125	0.125	1	1	5	5
160	0.160	1	5	5	8
200	0.200	5	5	8	8
250	0.250	5	5	8	8
315	0.315	5	8	8	4
400	0.400	8	8	4	4
500	0.500	8	8	4	4
630	0.630	8	4	4	3
800	0.800	4	4	3	3
1000	1.000	4	4	3	3
1250	1.250	4	3	3	3
1600	1.600	3	3	3	3
2000	2.000	3	3	3	3
2500	2.500	3	3	3	3
3150	3.150	3	3	3	3
4000	4.000	3	3	3	3
5000	5.000	3	3	3	3
6300	6.300	3	3	3	3
8000	8.000	3	3	3	3
10000	10.000	3	3	3	3

APPENDIX D. EFFECTS OF OTHER SOURCES - NORMATIVE

D1 The degree of difficulty in accounting for the effects of other sources on the Mapped Sound Rating of the Base Unit and its Appurtenances can vary significantly depending on the operational character and what controls the output of the other source. In the simplest of cases, the other source may operate independent of the supply fan, be constant in their acoustical nature, and only have two states of operation; one being on and the other off. In this situation, the Mapped Sound Ratings for a given Sound Component can be developed and published for both with and without the operation effects of the other source. However, in the case where the other source has an operating range that is interdependent it becomes more difficult to account for its effects on the supply fan Mapped Sound Rating. The effects of these more difficult sources on the Base Unit are addressed in Section D2.

D2 *Independent Sound Sources.* For the purpose of this standard, refrigerant circuit related Sound Sources are considered independent of the supply fan source and thus are identified and defined only in reference to the ISO thermal rating standard operation point for a given product. Other examples of independent Sound Sources are the airborne noise from variable frequency drive (VFD) ventilation fans, motor noise, gas burner combustion noise, and outdoor condenser fan noise. If a product is operated at the standard thermal rating conditions and the sound from the refrigerant circuit contributes 1 dB or less (in any One-third Octave Band) to the supply fan sound for a given sound component at that operating point, the supply fan (without the refrigerant circuit effects) can be used to describe the product at any other fan operating condition across the Mapped Sound Rating. If there is a contribution to the supply fan Sound Power Level at that point, the Sound Power Level of the refrigerant circuit sound source shall be defined and added to the supply fan Sound Power Level at all supply fan conditions for the given sound component. A similar contribution process is to be followed for any other independent sound source.

The Sound Power Level for a refrigerant circuit related sound source is typically difficult to obtain due to contamination from the supply fan Sound Power Level. To help avoid supply fan contamination to the refrigerant circuit related Sound Power Level, the supply fan may be operated at a quieter operating point or turned off while artificially maintaining operation of the refrigerant circuit. Refrigerant circuit operation may also be artificially maintained by approximating the standard thermal rating conditions. This approximation can be obtained by artificially controlling the refrigeration circuit to match the compressor inlet and discharge saturation temperatures (±3 K) that exist during a standard thermal rating test of the product. During refrigerant circuit operation, observe and record compressor inlet superheat. If necessary (and possible) adjust the superheat to avoid liquid slugging of the compressor(s) and associated noise.

D3 *Interdependent Sound Sources.* Return or exhaust fans are classified in this standard as interdependent other Sound Sources since their operational range and thus acoustic source characteristics are not independent of the supply fan. The noise generated by return and/or exhaust fan in the return duct shall be determined as follows:

D3.1 *Discrete Speed Fan or Multiple Discrete Speed Fan.* For a fan that is directly coupled to a motor shaft that has one or more speed taps, the Sound Power Level varies with fan speed. The fan speed depends on the discrete speed tap and the amount of speed slip between the stator and rotor fields. The speed slip increases as the load on the motor increases. This generates a Mapped Sound Rating that is a curve for each discrete fan speed.

The Sound Power Level in each One-third Octave Band shall be determined for each fan speed per the requirements of Section 4 at fan operating points determined by the airflow and return duct static pressure.

D3.2 *Variable Speed Fans.* For a return or exhaust fan that can run at an infinite number of speeds depending on variations in sheave sizes or variations in the electrical input signal to the motor, the Sound Power Level in each One-third Octave Band for each fan speed shall be determined per the requirements of Section 4.3.1 at fan operating points determined by the airflow and return duct static pressure. For products where a supply fan is always used in conjunction with a return or exhaust fan it may be advisable to test both fans at the same time to reach additional operational points per the manufacture's defined control scheme that could not be reached testing the fans independently.

D3.3 The return duct noise shall be the combination of the noise generated from the supply fan in the return duct and the noise generated by the return or exhaust fan in the return duct at the respective running conditions of each fan.

APPENDIX E. SUPPLY FAN MODULATION DEVICE EFFECTS – NORMATIVE

E1 *Modulation Device Insertion Effects.* This test identifies the acoustic effects of inserting a modulation device (such as inlet guide vanes at the fully open position) in the fan airflow. It does not measure the effects of actual modulation. Supply fan testing is conducted with the modulation device fully open (for guide vanes fully open at 90°) across the entire supply fan operating range.

E2 *Modulation Device Modulation Effects.* This test provides representative modulated system curves for the product with a mechanical modulation device. This test is defined for various percentages of modulation of a modulation device along the same system curve as defined for the insertion effect. It can be conducted for two additional system curves, if desired. Modulation device insertion effects shall first have been defined, at a minimum, along a single constant system curve. The initial point of the system curve shall be on the highest fan speed curve with the test point (static pressure and volumetric flow) being mid-way between stall and full open flow. Tests shall be conducted at this point with the modulation device fully open. Additional points along the system curve are obtained by operating the supply fan at other speeds defined in the original supply fan Mapped Sound Rating with the modulation devise a various degrees of closure. Additional tests are conducted at ¼, ½, ¾ and fully closed guide vane settings, applying the same system load line. Additional system lines may be tested, starting at a test point along the highest speed curve nearest the maximum efficiency point and at a more wide open point as defined by the manufacturer, if desired.