AHRI Standard 260-2024 (SI/I-P)

Sound Rating of Ducted Air Moving and Conditioning Equipment

AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE

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IMPORTANT

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ICS Code: 17.140.01

Note:

This standard supersedes AHRI Standard 260-2017 (I-P) and AHRI Standard 261-2017 (SI).

Intent

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

Review and Amendment

This standard is subject to review and amendment as technology advances.

2024 Edition

This edition of AHRI Standard 260 (SI/I-P), *Sound Rating of Ducted Air Moving and Conditioning Equipment*, was prepared by the Airside Standards Technical Committee. The standard was approved by the Standards Committee on 11 December 2024.

Origin and Development of AHRI Standard 260

ARI 260-2001 was published as a new standard in 2001

Addendum 1 was published to replace Equation 5 in Section 5.3.1 in August 2002

Revised in 2011 to update Hertz *octave band* requirement, align sound power determination with AHRI 220 and ISO 9614, align duct end correction determination with ASHRAE Technical Report 1314, align acoustic test elbow corrections method, and was approved as an American National Standard (ANS) on 27 April 2012

In 2012, AHRI 261-2012 (SI) was published as a new standard that that was partitioned from AHRI Standard 260-2012 (I-P) and both were approved as an ANS on 26 June 2013

AHRI 260-2017 (I-P) and AHRI 261-2017 (SI) revised sound power determination to align with AHRI 230 if *sound intensity* is used, and revised sound rating predictions for untested fan operating points

Summary of Changes

AHRI 260-2024 (SI/I-P) contains the following updates to the previous edition:

- Combined AHRI 260 (I-P) and AHRI 261 (SI) to use joint units.
- The SI units used correspond to what is used internationally, not necessarily a direct conversion from I-P units.
- Updated language to clarify that the standard covers variable speed units, not just fixed speed.
- Updated figures to be more clear and align nomenclature to the body text.

Committee Personnel

Airside Standards Technical Committee

Company/Organization	Participant	Voting Role
Voting Organizations		
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	Roger Howard	Primary
	Randy Zimmerman	Alternate
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Swegon	Karl Peterman	Nonvoting
Maria Woodbury		AHRI Staff Liaison

Airside Standards Technical Committee Scope:

The Airside STC is responsible for development and maintenance of standards and guidelines related to sound and vibration of equipment whose primary function is to move or condition air, or both.

Out of scope for this STC are standards whose primary purpose is not sound and vibration performance, or that are common to both airside and water/refrigeration.

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These lists represent the membership at the time the Standards Technical Committee and Standards Committee were balloted on the final text of this edition. Since that time, changes in the membership may have occurred. Membership on these groups shall not in and of itself constitute an endorsement by the group's members or their employers of any document developed by the group on which the member serves.

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SOUND RATING OF DUCTED AIR MOVING AND CONDITIONING EQUIPMENT

Section 1. Purpose

1.1 Purpose

This standard establishes definitions, requirements for acquiring sound data, sound level calculations, equipment sound ratings, and conformance conditions for factory-assembled ducted air moving and conditioning equipment.

1.2 Rationale

Ducted equipment presents unique challenges when providing sound ratings because 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 define the sound coming from 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 the applied configuration of the ducted air-conditioning equipment, free discharge (or free inlet) combined with the casing radiated *sound component* can be required. All *sound components* are acoustically described/rated by utilizing a *mapped sound rating* approach that references a product's fan operating map, supply fan map, or return/exhaust fan 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 inlet/discharge plena) and other *sound sources* (such as the refrigeration circuit and return and exhaust fans) to the *base unit mapped sound rating*. Thus, a *mapped sound rating* can be developed for a given product configuration and each of the *sound components* defining the sound for any product operating condition.

Figure 1 presents an example of a product application showing the relationship between the product *sound components* and the application sound paths. Figure 2 presents an example of a vertically ducted product depicting the contribution of product *sound sources* on *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 Hz to 8000 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 Hz to 10,000 Hz.

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 application sound paths shown in

Figure 1: 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.

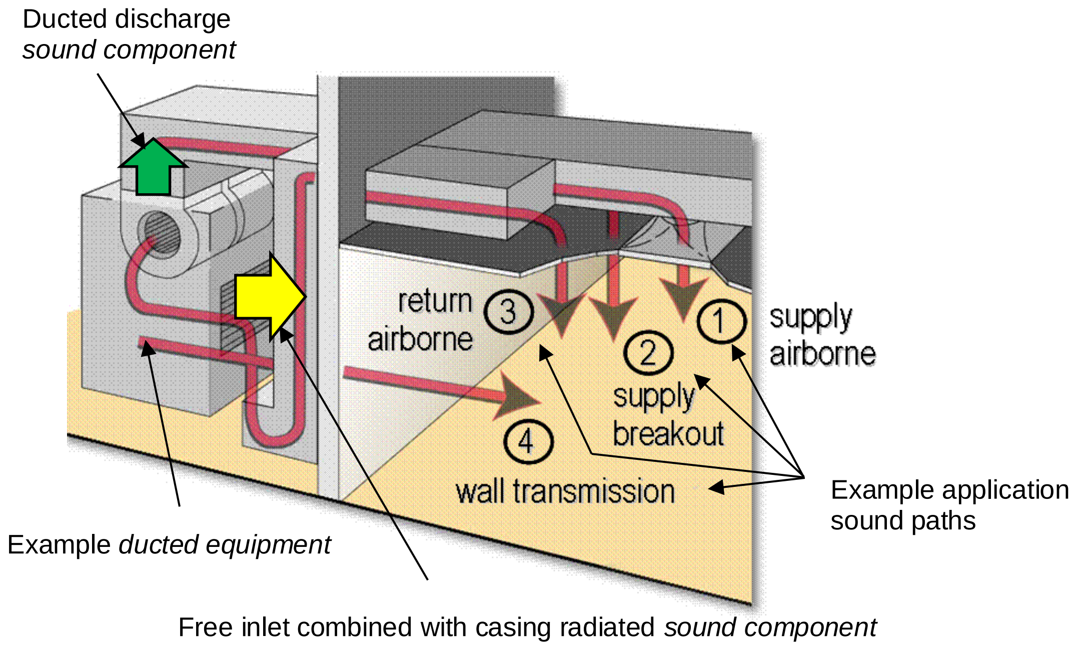

Figure 1 Example of a Ducted Product Application (Informative)

Figure 2 shows a vertical ducted unit with *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 is 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 are included. For the ducted inlet *sound component*, the sound from the inlet side of the return and inlet side of the supply fan are included.

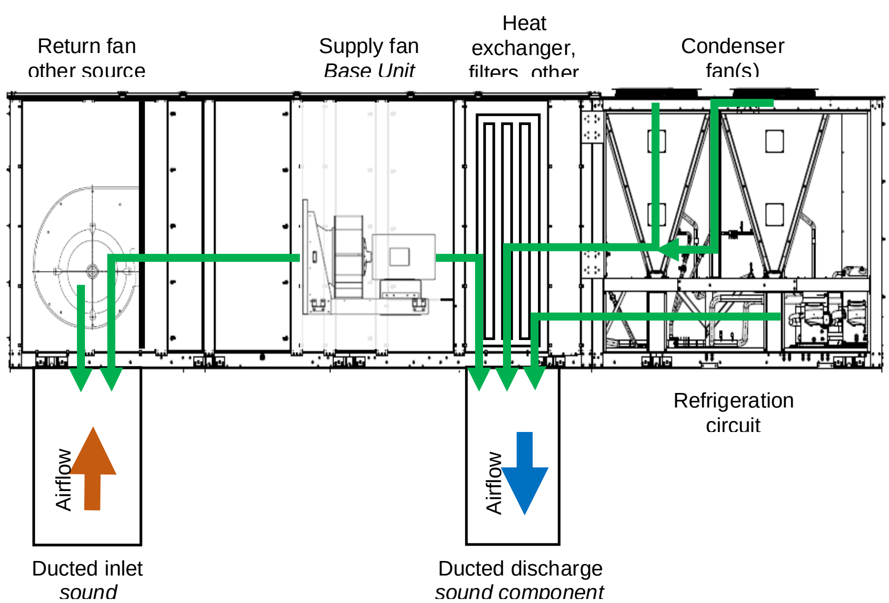

Figure 2 Example Relationship Between Sound Components and Sound Sources (Informative)

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 product *sound components* across the operating range. *Mapped sound ratings* reported are *octave band sound power levels* from 63 Hz to 8000 Hz. In addition to the stated *octave band mapped sound ratings*, this standard can be used to provide *one-third octave band mapped sound ratings* from 50 Hz to 10,000 Hz.

2.2 Exclusions.

This standard does not apply to the following AHRI classes of equipment:

1) Outdoor heat rejection sections of equipment addressed in AHRI 270 and AHRI 370
2) Non-ducted equipment addressed in AHRI 300 and AHRI 350
3) Terminal equipment addressed in AHRI 880 (I-P) and AHRI 881 (SI)
4) Ductless fan coil units addressed in AHRI 440 (I-P)
5) Active chilled beams addressed in AHRI 1240 (I-P) and AHRI 1241 (SI)

Section 3. Definitions

All terms in this document shall follow the standard industry definitions in the ASHRAE Terminology website unless otherwise defined in this section. For acoustic-related terms, refer to the ASA Standard Term Database.

3.1 Expression of Provisions

Terms that provide clear distinctions between requirements, recommendations, permissions, options, and capabilities.

3.1.1 "Can" or "cannot"

Express an option or capability.

3.1.2 "May"

Signifies a permission expressed by the document.

3.1.3 "Must"

Indication of unavoidable situations and does not mean that an external constraint referred to is a requirement of the document.

3.1.4 "Shall" or "shall not"

Indication of mandatory requirements to strictly conform to the standard and where deviation is not permitted.

3.1.5 "Should" or "should not"

An expression of alternatives rather than requirements. In the negative form, an alternative is the expression of potential choices or courses of action that is not preferred but not prohibited.

3.2 Standard Specific Definitions

3.2.1 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.

3.2.2 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.

3.2.3 Acoustic Test Duct Elbow

An elbow that can be added to the *acoustic test duct* to facilitate testing.

3.2.4 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* (see Appendix C).

3.2.5 Appurtenance

An addition to a *base unit* for purposes including air modulation, heat transfer, control, isolation, safety, and static pressure regain. Examples include:

- Coil(s)
- Electric heater(s)
- Air filter(s)
- Damper(s)
- Moisture eliminator(s)
- Fan-motor drive(s)
- Gas heat exchanger(s)
- Inlet or discharge plena
- Air mixing device(s)
- Flow straightener(s)
- Modulation device(s) in the fan inlet/discharge
- Application duct geometry(s) (such as duct elbow configurations)
- Alternate unit casing construction(s) (such as double walled, lined, perforated face)

3.2.6 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, and can include a source of heating or cooling.

3.2.7 Comparison Method

A method of determining *sound power level* by comparing the average sound pressure level produced in the room to an *RSS* 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.

3.2.8 Ducted Equipment

Heating, ventilating, and air-conditioning equipment having one or more supply fans that employ ductwork to convey the conditioned air to or from the selected space, or both, and can have combinations of discharges and inlets as follows:

1) Ducted discharge(s) and ducted inlet(s)
2) Ducted discharge(s) with free inlet(s)
3) Ducted inlet(s) with free discharge(s)

This equipment can be ducted in horizontal and vertical configurations, and can incorporate multiple inlets and outlets.

3.2.9 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*.

3.2.10 Effective Diameter (D_e)

The diameter of a circular duct equal in area to a specific *acoustic test duct*.

3.2.11 Mapped Sound Rating

Equipment sound ratings that are based upon a series of tests performed across the range of operating conditions that can be determined 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 5. 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).

3.2.12 Octave Band

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

3.2.13 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.

3.2.14 Published Rating

A statement of the assigned values of those performance characteristics, under stated *rating conditions*, where a unit can be chosen to fit the application. These values apply to all units of the same nominal size and type (identification) produced by the same manufacturer. This includes the rating of all performance characteristics shown on the unit or published in specifications, advertising, or other literature controlled by the manufacturer, at stated *rating conditions*.

3.2.14.1 Application Rating

A rating based on tests performed at *rating conditions* other than *standard rating conditions.*

3.2.14.2 Standard Rating

A rating based on tests performed at *standard rating conditions*.

3.2.15 Rating Conditions

Any set of operating conditions where a single level of performance results and causes only that level of performance to occur.

3.2.15.1 Standard Rating Condition

Rating conditions used as the basis of comparison for performance characteristics.

3.2.16 Reference Sound Source (RSS)

A portable, aerodynamic *sound source* that produces a known stable broadband sound power output.

3.2.17 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.

3.2.18 Sound Components

The product sound that can be independently defined to describe a product's contribution to sound paths in an application.

3.2.19 Sound Intensity

The average sound power transmitted through a unit area.

3.2.20 Sound Power Level

The acoustic energy emitted from a source expressed in decibels.

3.2.21 Sound Sources

Any phenomenon occurring within the unit under test that contributes to the product sound.

Section 4. Test Requirements

4.1 General

This standard incorporates a reverberation room *comparison method* or a *sound intensity* method, or both, to obtain the *sound power levels* of the *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 the equipment
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)

The sound generated by all *sound sources* shall be 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 AHRI 220. The reverberation room method of qualification, sound power calculation method, and facility requirements shall be in accordance with AHRI 220. The method of test and test configurations shall be as defined in Section 4.2 through Section 4.6.

When using the *sound intensity* method, *sound power levels* shall be determined using AHRI 230. The performance verification using an *RSS* measurement method and sound power calculation method shall be in accordance with AHRI 230. The method of test and test configuration shall meet the requirements in Section 4.2 through Section 4.5 and Section 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:

- Ducted discharge
- Ducted inlet
- 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:

- Ducted discharge.
- Optional free inlet.
- 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:

- Ducted inlet.
- Optional free discharge.
- Optional 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 AHRI 220 reverberation room *comparison method* or the AHRI 230 *sound intensity* method. The specific test set-up depends 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 can either be located in the test space with the untested *sound components* being ducted out, or 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 4.10.1) shall be added to each *one-third octave band*. The addition of the *duct end correction* provides the user with the sound power 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.

Note: Although a straight *acoustic test duct* should be used for ducted *sound component* tests, an *acoustic test duct elbow* can 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 AMCA 210/ASHRAE 51 or ASHRAE 37.

4.4 Test Set-up Configurations

4.4.1 Ducted Discharge Test

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 AHRI 220. When using *sound intensity*, the sound of the ducted discharge component shall be determined using AHRI 230. Test configurations are conceptually shown (and not to scale) in Figure 3 and Figure 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*. The *acoustic test duct* length shall not be less than 1 m (3 ft) and not greater than five *effective duct diameters* as determined by Equation 2.

Note: For ducted discharge tests, the *acoustic test duct* should be three *effective duct diameters* in length. The intent is to establish a consistent acoustic environment for ducted connections.

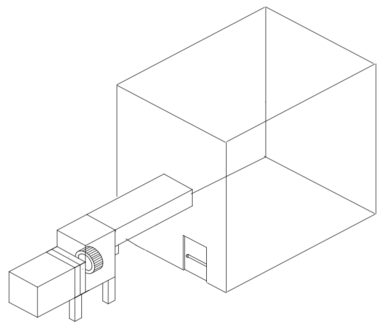

Figure 3 Concept Reverberation Room Ducted Discharge Test Set-up

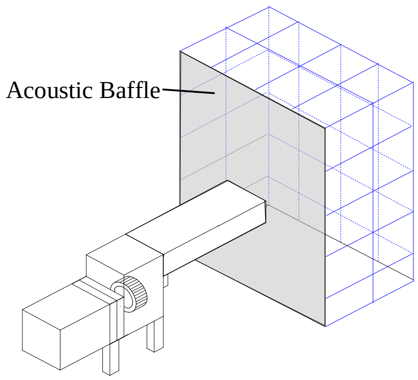

Figure 4 Concept Sound Intensity Ducted Discharge Test Set-up

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 AHRI 220. When using *sound intensity*, the sound of the ducted inlet component shall be determined using AHRI 230. Test configurations are conceptually shown (and not to scale) in Figure 5 and Figure 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*. The *acoustic test duct* length shall not be less than 1 m (3 ft) and not greater than five *effective duct diameters* as determined by Equation 2.

Note: For ducted inlet tests, the *acoustic test duct* should be one *effective duct diameter* in length. The intent is to establish a consistent acoustic environment for ducted connections.

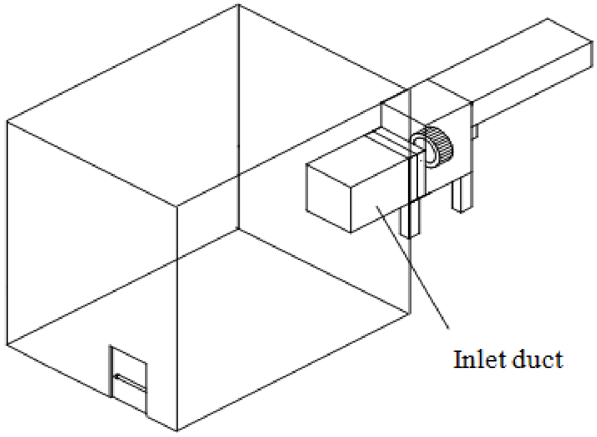

Figure 5 Concept Reverberation Room Ducted Inlet Test Set-up

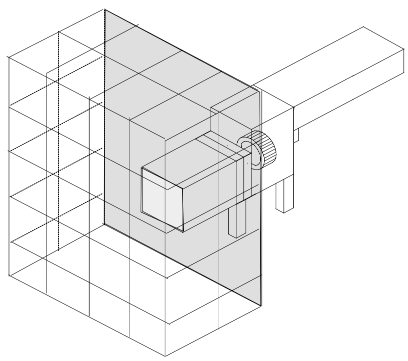

Figure 6 Concept Sound Intensity Ducted Inlet Test Set-up

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 AHRI 220. For *sound intensity*, the sound shall be determined in accordance with AHRI 230. The test configurations are conceptually shown (and not to scale) in Figure 7 and Figure 8. A duct with high transmission loss walls to minimize breakout into the test space in accordance with Section 4.5.1.3 shall be used.

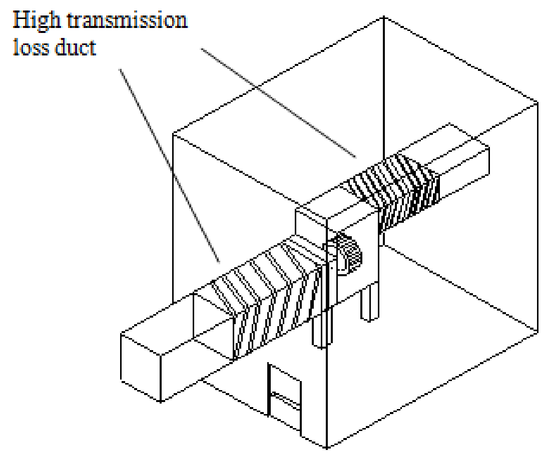

Figure 7 Concept Reverberation Room Casing Radiated Test Set-up

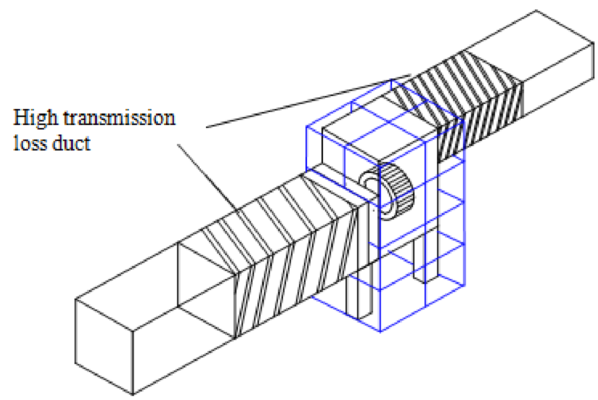

Figure 8 Concept Sound Intensity Casing Radiated Test Set-up

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 AHRI 220 when using a reverberation room and AHRI 230 when using *sound intensity*. The test configurations are conceptually shown (and not to scale) in Figure 9 and Figure 10. A duct with high transmission loss walls to minimize breakout into the test space in accordance with Section 4.5.1.3 shall be used.

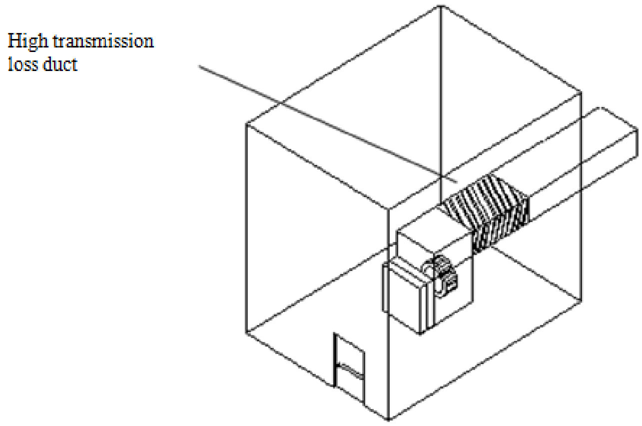

Figure 9 Concept Reverberation Room Free Discharge (or Inlet) Combined with Casing Radiated Test Set-up

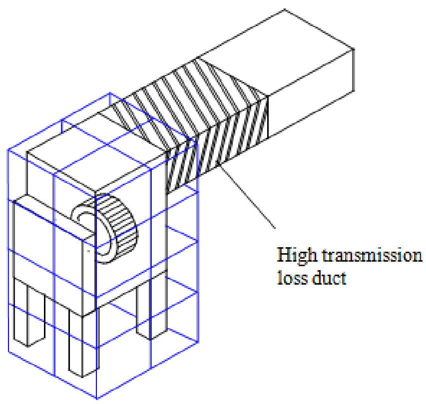

Figure 10 Concept Sound Intensity Free Discharge (or Inlet) Combined with Casing Radiated Test Set-up

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 a minimum amount of duct. The *sound component* of the free discharge (or inlet) shall be measured using AHRI 220 when using a reverberation room and AHRI 230 when using *sound intensity*. The test configurations are conceptually shown (and not to scale) in Figure 11 and Figure 12. In Figure 12, the diagram on the left shows a low air velocity test set-up and the diagram on the right shows a high air velocity test set-up.

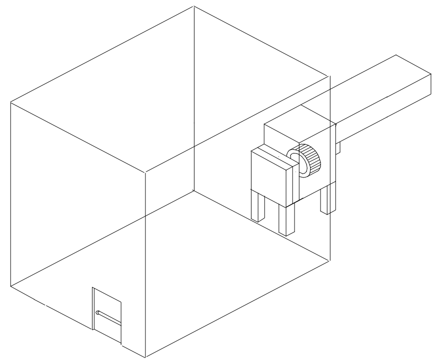

Figure 11 Concept Reverberation Room Free Discharge (or Inlet) Test Set-up

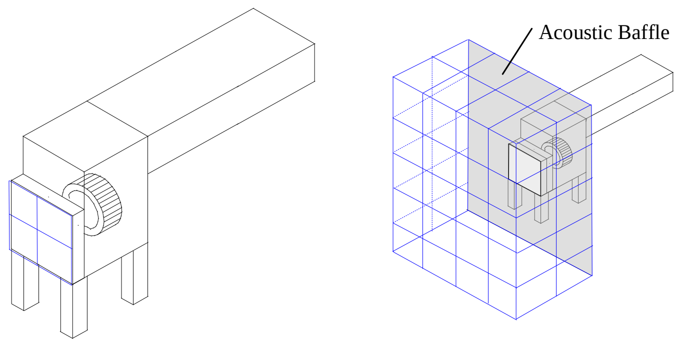

Figure 12 Concept Sound Intensity Free Discharge (or Inlet) Test Set-up

4.5 General Test Set-up (Reverberation Room and Sound Intensity)

Equipment configurations described in Section 4.5.1 through Section 4.5.4 are applicable for both reverberation room testing in accordance with AHRI 220 and for testing employing the *sound intensity* method in accordance with AHRI 230.

4.5.1 Ductwork Required for Testing

Ductwork attached to the unit under test can influence the sound measured, therefore the following requirements shall be met:

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.

Note: If the manufacturer does not define the supply or return opening, the *acoustic test duct* should be sized for a maximum velocity of 9.1 m/s (1800 ft/min).

The ratio of the longer to the shorter sides of the rectangular duct cross-section shall not exceed four unless this cannot be achieved due to the manufacturer's specifications.

4.5.1.2 Ductwork Connection

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.

Note: Ductwork should be connected to the unit under test using a flexible gasket or connector.

4.5.1.3 Construction of Test Ductwork

The required test duct wall transmission loss characteristics vary with the type of rating test being conducted (casing radiated being the most stringent *sound component*), 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, quantifying the wall transmission loss characteristics is difficult. However, experience conducting tests has shown that the following duct construction methods provide high transmission loss results. When testing products with low sound emissions, diagnostic tests can be conducted to confirm the test duct wall transmission loss characteristics.

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:

1) A minimum of 1.2 mm (18 gauge) thick sheet metal stiffened by a minimum of 15 mm (5/8 in) thickness gypsum board attached by sheet metal screws on 152 mm (6 in) centers and bonded to the exterior of the duct.
2) Round sheet metal or PVC duct with a minimum of 4.88 kg/m^2 (1.0 lb/ft^2) limp exterior acoustical barrier.
3) A minimum of 18 mm (3/4 in) plywood. The plywood can be stiffened to maintain the rigidity of the duct.
4) Other configurations can be used if shown by test to provide the same or greater transmission loss and other acoustic characteristics, when compared to the above three construction methods.

4.5.2 Static Pressure Taps

Static pressure taps shall be in accordance with either AMCA 210/ASHRAE 51 or ASHRAE 37.

4.5.3 Acoustic Test Ducts and Acoustic Test Duct Elbow

This 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*, the description, and the corrections applied shall be recorded. 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.

Note: For testing of ducted discharge or inlet, straight *acoustic test ducts* should be used.

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 Figure 7 through Figure 10. Acoustical duct lagging or thicker/ higher density duct walls can be 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. Adjustments to the component sound power shall not be made for contamination from duct radiation.

4.5.5 Acoustic Baffle

An *acoustic baffle* shall be constructed to terminate the duct and extend beyond the *sound intensity* measurement surface as defined in AHRI 230. Construction can be 18 mm (3/4 in) plywood with stiffeners.

4.6 Test Instrumentation and Facilities for the Reverberation Room Method

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 AHRI 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 AHRI 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.

Note: For sound test measurements made within a reverberation room, the airflow of the test unit, m^3/minute (cfm), should not numerically exceed the room volume, m^3 (ft^3).

4.6.4 Use of Windscreen

During testing, a windscreen can 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 Hz to 4000 Hz or + 1.5 dB for frequencies from 4000 Hz to 10,000 Hz. Sound measurements shall not be made with air velocities over the microphone exceeding 2 m/s (400 ft/min).

4.7 Test Instrumentation and Facilities for the Sound Intensity Method

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 AHRI 230.

4.7.2 Verification with an RSS

Performance verification with an *RSS*, as stated in AHRI 230, shall be conducted to verify the performance of the instrumentation system and the test operator. Verification shall be repeated in accordance with the requirements in AHRI 230.

4.7.3 Size of Sound Source Under Test

The size and shape of the *sound source* under test are unrestricted and serve to define the measurement surface. Information for selection of the measurement surface is provided in AHRI 230.

4.7.4 Time Averaging

Minimum averaging time is stated in AHRI 230.

4.7.5 Use of Windscreen

During testing, a windscreen can 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 Hz to 4000 Hz or + 1.5 dB for frequencies from 4000 Hz to 10,000 Hz. *Sound intensity* measurements in airflow shall meet the requirements in AHRI 230.

4.8 Test Method Measurement Reproducibility

For the reverberation room *comparison method*, Table 1 represents the uncertainty that can result from using AHRI 220 and an *RSS* calibrated in accordance with AHRI 250. For the *sound 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 AHRI 230. The standard deviations in Table 1 do not account for variations of sound power caused by changes in operating conditions.

Note: *Sound power levels* obtained from either reverberation room or intensity measurements made in conformance with this standard have standard deviations that are equal to or less than those in Table 1.

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 4000	400 to 5000	1.5
8000	6300 to 10,000	3.0

4.9 Information to be Recorded

The following shall be compiled and recorded for measurements that are made in accordance with the requirements of this standard to document the ducted sound power ratings provided by this standard:

- Description of unit under test and descriptive photograph
- *One-third octave band sound power levels* with *duct end corrections* included (if applicable), dB
- *One-third octave band duct end corrections*, dB, and description of how duct was terminated in the test space
- Duct internal height, width, and length dimensions, m (in)
- Duct material and thickness, m (in)
- *Acoustic test duct elbow octave band* correction (if used), dB
- *Acoustic test duct elbow* internal height and width dimensions, length, and location of the elbow in the duct (if used), m (in)
- Description of thermal conditions during test
- Airflow, m^3/s (cfm); duct static pressure, kPa (in H_2O); fan speed, RPM; fan motor, kW (BHP), for each test point
- *Sound component* measured
- Test date
- Test method used

4.9.1 Unit Under Test

The description of the *base unit* shall include the following information to clearly identify the unit under test:

- Fan type, model, manufacturer and size
- Cabinet wall construction and size
- Motor manufacturer and size
- Operating conditions (fan speed, (RPM); airflow, m^3/s (cfm); fan static pressure, kPa (in H_2O); and air density, kg/m^3 (lb/ft^3)
- Installation/mounting details
- Description of *appurtenances*
- Description of other *sound sources*

4.9.2 Thermal Conditions During Test

The following ambient conditions in the test facility during the test shall be recorded:

- Air temperature, ºC (ºF)
- Relative humidity, %
- Barometric pressure, kPa (in Hg)

4.9.3 Instrumentation

The manufacturer, model, and serial number for all equipment used for measurements including the RSS shall be recorded.

4.10 Determination of Component One-third Octave Band Sound Power Levels

The measured *one-third octave band* sound pressure level data acquired in a reverberation room shall be converted to *one-third octave band sound power levels* using the calculation procedures in Section 6 of AHRI 220. For *sound intensity* measurements, *sound power levels* are directly determined from the measurements in AHRI 230. Adjustments for the *duct end correction* for the nth *one-third octave band* ($E_{1(n)}$) as outlined in Section 4.10.1 and Section 4.10.2, or the *acoustic test duct elbow correction* for the nth *one-third octave band* ($E_{2(n)}$) as outlined in Section 4.10.3, or both, shall be added to the calculated *one-third octave band sound power levels* using Equation 1.

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

Where:

$E_{1(n)}$ = *Duct end correction* for the nth *one-third octave band* for either a duct terminating flush with a wall or terminating free in space (see Section 4.10.1 and Section 4.10.2). If a test duct is not used for this component, then $E_{1(n)} = 0$

$E_{2(n)}$ = *Acoustic test duct elbow correction* for the nth *one-third octave band* (see Section 4.10.3). If a test elbow is not used for this component, then $E_{2(n)} = 0$

$L'_{w(n)}$ = Test unit component *sound power level*, dB, for the nth *one-third octave band* adjusted for the *duct end correction* and the *acoustic test duct elbow correction*, if required

$L_{w(n)}$ = Test unit component *sound power level*, dB, for the nth *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*

4.10.1 Calculation of the 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* provides the user with the sound power transmitted into a non-reflecting duct system.

For a ducted discharge or ducted inlet test, the value for the *duct end correction* depends on the duct termination in the test space. If an *acoustic test duct* terminating flush, or less than three *effective diameters*, see Equation 2, from any acoustically reflective surface, then Equation 3 shall be used to calculate the *duct end correction*. If an *acoustic test duct* terminating into the free space, greater than three *effective diameters* from any reflective surface, then 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 (ft^2)

D_e = *Effective diameter*, m (ft)

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.

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

Where:

C_o = Speed of sound in air, m/s (ft/s)

D_e = *Effective diameter* (as shown in Equation 2), m (ft)

$E_{1(n)}$ = *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*. Research (ASHRAE RP-1314) has shown that free duct termination effects are not fully exhibited for duct lengths shorter than three *effective diameters*.

4.10.2 Duct End Correction Limit

When using the equations for *duct end corrections* in Section 4.10.1, 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 diameters*. This can overstate the *sound power levels* at low frequencies for such small products.

For this reason, information shall 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.

4.10.3 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. The *acoustic test duct elbow corrections* shall be obtained from Appendix C.

4.11 Determination of Component Octave Band Sound Power Levels

One-third octave band sound power levels determined for product *sound components* (ducted discharge, ducted inlet, casing radiated and free inlet combined with casing radiated) defined in Section 4.10 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:

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

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*

4.12 Individual Unit Tests

Individual *ducted equipment* can be tested at specific operating conditions, and the results recorded according to procedures in this standard. These tests can be conducted to check published sound ratings for individual units at application specific operating conditions. The results for individual sound tests shall be recorded 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 5. Rating Requirements

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 *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 end corrections* that are employed in the ducted component cases.

5.2 Mapped Sound Ratings

The *mapped sound rating* for the specific configuration of the *ducted equipment* shall be published or provided in a selection program including all the applicable *sound components*. The *mapped sound rating* for each *sound component* shall be derived from the addition of *appurtenance* effects and other *sound sources* to the *base unit* for each unit configuration.

5.3 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* provides a total acoustic description of the equipment based on the full range of operating conditions as defined by the manufacturer.

5.3.1 Base Unit Supply Fan Rating

The number of speed curves and test points along each speed curve of the supply fan in the *base unit* shall be evaluated to confirm 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* can be 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.

5.3.2 Appurtenance Effects to the Base Unit Rating

The number of test points along the supply fan speed curves shall be evaluated to confirm 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 the *appurtenance* can be described as a function of airflow velocity. For the *base unit*, the difference between adjacent test points shall not exceed 5 dB for any given *one-third octave band*.

Note: The supply fan and an appurtenance plenum can be tested as an assembly if these are supplied together in a product.

5.3.3 Mechanical Airflow Control Device

The effects of a mechanical airflow control device, for example, inlet guide vanes (excluding VFDs), 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.

5.3.4 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* shall be based on the test data specified in Appendix D. Additional operating conditions shall be evaluated to confirm 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 *sound sources* on the *mapped sound rating* of the *base unit* and the *base unit's appurtenances* can vary depending on the operational character and what controls the output of the other *sound source*. The effects of independent and the more difficult interdependent *sound sources* on the *base unit* are addressed in Appendix D.

5.3.4.1 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 are independent of the supply fan (see Appendix D). The sound due to refrigerant circuit related *sound sources* operating at non-standard conditions defined by the manufacturer can be provided as optional information.

5.3.4.2 Exhaust and Return Fans

Due to the potential interdependent effects of the exhaust and return fan *sound sources* with the supply fan, test points shall be evaluated in the manner specified in Appendix D.

5.3.4.3 Burners

The effects of the burner *sound source* shall be evaluated at the input rate and gas type specified on the nameplate.

5.3.5 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.

5.3.5.1 Sound Estimation for Untested Fan Operating Points

The manufacturer can estimate *sound power levels* and provide ratings for other supply fan (as well as return fan and exhaust fan) 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 5.3.5.2. The tested region is defined by the highest and lowest fan speeds, fan power limits, and system curves tested.

5.3.5.2 Application of Fan Laws for Untested Sizes and Speeds Outside of the Tested Region

Base unit fan sound power can 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 301 provides one method of scaling.

Fans and cabinets are proportional when the criteria of Appendix C of AHRI 431 are met with the following modifications. Fans shall have the same number of blades with the same geometries (including blade angle and blade shape). Scaling limits listed in this section supersede AHRI 430 and AHRI 431 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 proportional when:

- Impeller widths are proportional within ± 1.5%. Where applicable, the housing development radii and housing width are proportional within ± 1.5%.
- Fan housing outlet area or fan inlet area are proportional within ± 3%.

Fan cabinets are proportional when:

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

- The clearance between adjacent fans is proportional or greater.
- 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.
- 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.

5.3.5.3 Estimated Ratings for Untested Product Sizes or Appurtenances

Tested product data can be used to estimate the *sound power levels* and ratings of an untested size by interpolation of the same product line if all of the following conditions are met:

- Proportionality rules in Section 5.3.5.2 are followed
- The sizes of the two unit tested and used for interpolation shall not differ by more than the allowances in Section 5.3.5.2
- The manufacturer tests product sizes in a product line to assure an accurate method of prediction

5.4 Minimum Data Requirements for Published Sound Ratings

The following is a list of data required to document the sound ratings supplied in accordance with this standard:

- Unit configuration, *base unit*, *appurtenances*, and other *sound sources*
- *Octave band sound power levels*, dB
- *Acoustic test duct* internal height, width, and length dimensions, m (in)
- *Acoustic test duct elbow* internal height and width dimensions (if used) and location of the elbow in the *acoustic test duct*, m (in)
- Airflow, m^3/s (cfm); fan static pressure, kPa (in H_2O); fan speed, RPM; fan motor power, kW (BHP), for each test point
- Component under test as applicable: ducted discharge, ducted inlet, casing radiated, free discharge, free inlet, free inlet combined with casing radiated, or free discharge combined with casing radiated

5.5 Published Sound Power Ratings

All published sound power ratings shall be expressed in decibels rounded to the nearest whole decibel.

5.6 Verification of Published Sound Ratings

Any equipment selected at random and tested in a qualified laboratory in accordance with this standard shall have a sound rating not higher than the equipment's published sound rating when tested at the published operating point (airflow, fan static pressure, fan speed, and motor power).

5.7 Duct End Correction Documentation

If applicable, a statement shall be included that *duct end corrections* were applied to the ratings. The *duct end corrections* applied shall be provided upon request.

5.8 Acoustic Test Duct Elbow Correction Documentation

If applicable, a statement shall be included that duct elbow corrections were applied to the ratings. The duct elbow corrections applied shall be provided upon request.

Section 6. Minimum Data Requirements for Published Ratings

As a minimum, *published ratings* shall include all *standard ratings*. All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with AHRI Standard 260 (SI/I-P)". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 260 (SI/I-P)". *Application ratings* within the scope of the standard shall include a statement of the conditions under which the ratings apply.

Section 7. Conformance Conditions

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

This appendix lists all standards, handbooks, and other publications essential to the development and implementation of the standard. All references in this appendix are part of the standard.

A.1. AHRI Standard 210/240-2023 (2020), *Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment*, 2023, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A.2. AHRI Standard 220-2022 (SI), *Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment*, 2022, Air-conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A.3. AHRI Standard 230-2022 (SI), *Sound Intensity Testing Procedures for Determining Sound Power of HVAC Equipment*, 2022, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A.4. AHRI Standard 250-2022 (SI), *Performance and Calibration of Reference Sound Sources*, 2022, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A.5. AHRI Standard 340/360-2022 (I-P), *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, 2022, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A.6. AHRI Standard 430-2020 (I-P), *Performance Rating of Central Station Air-handling Unit Supply Fans*, 2020, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A.7. AHRI Standard 431-2020 (SI), *Performance Rating of Central Station Air-handling Unit Supply Fans*, 2020, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A.8. AHRI Standard 1230-2021 (I-P), *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-conditioning and Heat Pump Equipment*, 2021, Air-Conditioning, Heating, and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, USA.

A.9. 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; ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, USA.

A.10. ANSI/AMCA Standard 301-2022, *Methods for Calculating Fan Sound Ratings from Laboratory Test Data*, 2022, Air Movement and Control Association International, 30 West University Drive, Arlington Heights, IL 60004, USA.

A.11. ANSI/ASHRAE Standard 37-2009 (RA2019), *Methods of Testing for Rating Electrically Driven Unitary Air-conditioning and Heat Pump Equipment*, 2009, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, USA.

A.12. ASA Standard Terminology Database, ASA, Accessed May 20, 2022. https://asastandards.org/working-groups-portal/asa-standard-term-database/.

A.13. ASHRAE RP-1314, *Reflection of Airborne Noise at Duct Terminations*, 2008, ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092, USA.

A.14. ASHRAE Terminology. ASHRAE. Accessed May 20, 2022. https://www.ashrae.org/technicalresources/free-resources/ashrae-terminology.

A.15. Beranek, L.L. 1960, *Noise Reduction*, McGraw Hill, New York.

A.16. 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

This appendix lists standards, handbooks, and other publications not essential but that can provide useful information and background. References in this appendix are not part of the standard.

B.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.

B.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

C.1. Testing of Ducted Inlet or Ducted Discharge

Note: For testing of ducted inlet or ducted discharges, straight *acoustic test ducts* should be used.

An *acoustic test duct elbow* can be used when needed to facilitate testing. An example of a test elbow configuration is shown in Figure 13. 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*.

C.2. Insertion Loss Values for Unlined Acoustic Test Duct Elbows

Table 2 displays insertion loss values for unlined *acoustic test duct elbows* (Beranek 1960). An example of the application is shown in Table 3.

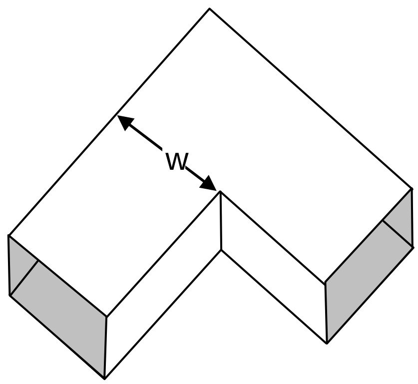

Figure 13 Insertion Loss of Unlined Acoustic Test Duct Elbows (Informative)

Table 2 Insertion Loss of Unlined Elbows

f·W	**Insertion Loss, dB**
< 48 (1.9)	0
≥ 48 (1.9) and < 96 (3.8)	1
≥ 96 (3.8) and < 190 (7.5	5
≥ 190 (7.5) and < 380 (15)	8
≥ 380 (15) and < 760 (30)	4
> 760 (30)	3

Note:

- *f* = center frequency, kHz
- *W* = width in the plane of bend, mm (in)

Table 3 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 (in)			
		500 (20)	750 (30)	1000 (40)	1250 (50)
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
10,000	10.000	3	3	3	3

APPENDIX D. EFFECTS OF OTHER SOURCES – NORMATIVE

D.1. Accounting for the Effects of Other Sound Sources

The degree of difficulty in accounting for the effects of other *sound sources* on the *mapped sound rating* of the *base unit* and the *base unit's appurtenances* can vary depending on the operational character and what controls the output of the other *sound source*. In the simplest of cases, the other *sound sources* can operate independently 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 *sound source*. However, in the case where the other source has an operating range that is interdependent, accounting for the effects on the supply fan *mapped sound rating* becomes more difficult. The effects of these more difficult sources on the *base unit* are addressed in Section D.2.

D.2. Independent Sound Sources

For the purpose of this standard, refrigerant circuit related *sound sources* are 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 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 less than the maximum standard deviations listed in Table 1 (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* greater than the maximum standard deviations listed in Table 1 at that operating 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*. The same contribution process shall be followed for any other independent *sound source*.

The *sound power level* for a refrigerant circuit related *sound source* can be difficult to obtain due to contamination from the supply fan *sound power level*. To help prevent supply fan contamination to the refrigerant circuit related *sound power level*, the supply fan can be operated at a quieter operating point or turned off while artificially maintaining operation of the refrigerant circuit. Refrigerant circuit operation can 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. The superheat can be adjusted to prevent liquid slugging of the compressor(s) and associated noise.

D.3. Interdependent Sound Sources

Return or exhaust fans are classified in this standard as interdependent *sound sources* because their operational range and thus acoustic source characteristics are not independent of the supply fan. The sound generated by return or exhaust fan, or both, in the return duct shall be determined as described in Section D.3.1 and Section D.3.2.

D.3.1. 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 in accordance with the requirements of Section 4 at fan operating points determined by the airflow and return duct static pressure.

D.3.2. 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 in accordance with the requirements 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, both fans can be tested at the same time to reach additional operational points in accordance with the manufacture's defined control scheme that cannot be reached testing the fans independently.

The return duct sound shall be the combination of the sound generated from the supply fan in the return duct and the sound 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

E.1. 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, and does not measure the effects of actual modulation. Supply fan testing shall be conducted with the modulation device fully open (for guide vanes fully open at 90°) across the entire supply fan operating range.

E.2. Modulation Device Modulation Effects

This test provides representative modulated system curves for the product with a mechanical modulation device. This test is defined for multiple percentages of modulation of a modulation device along the same system curve as defined for the insertion effect, and can be conducted for two additional system curves. 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. 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 device at specific degrees of closure. Additional tests shall be conducted at 1/4, 1/2, 3/4 and fully closed guide vane settings, applying the same system load line. Additional system lines can 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.