STANDARD

ANSI/AMCA Standard 300-24

Reverberation Room Methods of Sound Testing of Fans

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ANSI Accredited Standards Developer

Air Movement and Control Association International

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Reverberation Room Methods of Sound Testing of Fans

1. Purpose

This standard establishes a method of determining the sound power levels of a fan. It was originally developed in response to the need for a reliable and accurate method of determining the sound power levels of fan equipment.

2. Scope

This standard applies to fans of all types and sizes. It is limited to the determination of airborne sound emission for the specified setups. Vibration is not measured, nor is the sensitivity of airborne sound emission to vibration effects determined.

The size of a fan that can be tested in accordance with this standard is limited only by the practical aspects of the test setups. Dimensional limitations, fan under test dimensions, and air performance will control the test room size, power and mounting requirements for the fan under test.

The test setup requirements in this standard establish the laboratory conditions necessary for a successful test. Rarely will it be possible to meet these requirements in a field situation. This standard is not intended for field measurements.

3. Normative References

The following documents are referred to in the text such that some or all of their content is normative. For dated references, the edition cited applies. For undated references, the latest edition, including any amendments, applies.

AHRI Standard 250, *Performance and Calibration of Reference Sound Sources,* Air-Conditioning, Heating, and Refrigeration Institute, Arlington, VA USA.

ANSI/AHRI Standard 220-14, *Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment*, Air-Conditioning, Heating, and Refrigeration Institute, Arlington, VA USA.

ANSI/AMCA Standard 204-20, *Balance Quality and Vibration Levels for Fans*, Air Movement and Control Association International, Arlington Heights, IL USA.

ANSI/AMCA Standard 210-16/ASHRAE 51-16, *Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating,* Air Movement and Control Association International, Arlington Heights, IL USA.

ANSI/ASA S1.4-2014/Part 1/IEC 61672-1, *Electroacoustics – Sound Level Meters – Part 1: Specifications (a nationally adopted international standard)*, Acoustical Society of America, Melville, NY USA.

ANSI/ASA S1.6, *Preferred Frequencies and Filter Band Center Frequencies for Acoustical Measurements,* Acoustical Society of America, Melville, NY USA.

ANSI/ASA S1.11/Part 1/IEC 61260-1, *Electroacoustics – Octave-Band and Fractional-Octave-Band Filters – Part 1: Specifications (a nationally adopted international standard)*, Acoustical Society of America, Melville, NY USA.

ANSI/ASA S1.40, *Specifications and Verification Procedures for Sound Calibrators,* Acoustical Society of America, Melville, NY USA.

ANSI/ASA S12.51-2012/ISO 3741-2010 (R2017), *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for reverberation test rooms (a nationally adopted international standard)*, Acoustical Society of America, Melville, NY USA.

Cunefare, Kenneth, and Alexander Michaud. 2008. ASHRAE RP-1314, *Reflection of Airborne Noise at Duct Terminations*. ASHRAE Research Project published in ASHRAE Transactions Vol. 114, Part 2.

IEC 61260-1:1995, *Electroacoustics – Octave band and fractional-octave band filters*, Geneva, Switzerland

IEC 61672-1:2002, *Electroacoustics – Sound level meters – Part 1 Specifications*, Geneva, Switzerland

ISO 5801:2017, *Fans – Performance testing using standardized airways,* International Organization for Standardization, Geneva, Switzerland.

4. Definitions/Units of Measure/Symbols

4.1 Definitions

4.1.1 Blade passage frequency (BPF)
The frequency of fan impeller blades passing a single fixed object, per the following formula:

$$\frac{\text{Number of Blades} \times \text{Fan RPM}}{60}\,\text{Hz} \qquad \text{Eq. 4.1}$$

4.1.2 Air test chamber
An enclosure used to regulate airflow and often treated to absorb sound; it may also conform to air test chamber conditions given in ANSI/AMCA Standard 210.

4.1.3 Broadband sound
Sound that is random in nature with frequency components distributed over a broad frequency band.

4.1.4 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.

4.1.5 Decibel (dB)
A dimensionless unit of level in logarithmic terms for expressing the ratio of a power or power-like quantity to a similar reference quantity (see Sections 4.1.17 and 4.1.18).

4.1.6 Discrete frequency sound/tones
Sounds/tones that consist of one or more sound waves that are a sinusoidal function of time.

4.1.7 Ducted fan
A fan having a duct connected to either its inlet, its outlet or to both.

4.1.8 Duct end reflection
A phenomenon that occurs whenever sound is transmitted across an abrupt change in area, such as at the end of a duct in a room. When end reflection occurs, some of the sound entering the room is reflected back into the duct and does not escape into the room.

4.1.9 Frequency
The number of times in one second that a periodic function repeats itself.

4.1.10 Informative
A term that indicates that the referenced material is provided as advice to the reader but does not constitute a mandatory requirement.

4.1.11 Non-ducted fan
A fan without ducts connected to its inlet and outlet.

4.1.12 Normative
A term that indicates that the referenced material, if applied, constitutes a mandatory requirement.

4.1.13 Octave band
A band of sound covering a range of frequencies such that the highest frequency is twice the lowest, as defined in ANSI/ASA S1.11. Fan sound power levels are reported in eight standardized octave bands, shown in Table 5.1.

4.1.14 One-third octave band
A band of sound covering a range of frequencies in which the highest frequency is the cube root of two multiplied by the lowest frequency, as defined in ANSI/ASA S1.11. The fan industry measures sound power levels in 24 one-third octave bands as shown in Table 5.1.

4.1.15 Reverberation room
A reverberation room is a room designed to create a diffuse sound field. A diffuse sound field is one that consists of a superposition of sound waves traveling in all directions with equal probability. This characteristic ensures the average energy density is approximately the same at all points in the room.

4.1.16 Shall and should
The word “shall” is to be understood as mandatory; the word “should” is to be understood as advisory.

4.1.17 Sound power level, L_W
Ten times the logarithm (base 10) of the ratio of the sound power radiated by the source to a reference sound power, expressed in decibels (dB). The reference sound power used in this standard is 1 picowatt, pW.

4.1.18 Sound pressure level, L_p
Twenty times the logarithm (base 10) of the ratio of the sound pressure radiated by the source to a reference sound pressure, expressed in; decibels (dB). The reference sound pressure used in this standard is 20 μPa.

4.1.19 Unit under test
The fan whose sound power level is determined.

4.1.20 Wavelength
The distance between two points having the same phase in two consecutive cycles of a periodic wave, along a line in the direction of propagation. Wavelength (λ) is determined by frequency and the speed of sound in the air through which the wave propagates:

$$\lambda = c/f \qquad \text{Eq. 4.2}$$

Where:

$\lambda =$ wavelength, m (ft)
f= frequency, Hz
c = 343 m/s at 20°C (1125 ft/s at 68°F)

The value for *c* is acceptable for use in this standard within the limits of ± 5°C (9°F) for standard air.

4.1.21 Standard air
Air having a density of 1.2 kg/m^3 (0.075 lbm/ft^3). Standard air has a ratio of specific heats of 1.4 and a viscosity of 1.8185 × 10^{-3} Pa•s (1.222 × 10^{-5} lbm/ft-s). Air at 20°C (68°F), 50% relative humidity and 101.325 kPa (14.696 lbm/in.^{2}, 29.92 in. Hg) barometric pressure has these properties, approximately.

4.2 Symbols and subscripts

Table 4.1 — Symbols and Subscripts

Symbol	Description	SI Unit	I-P Unit
A_{min}	Minimum distance to reverberant field	m	ft
a	Rectangular duct width	m	ft
b	Rectangular duct height	m	ft
c	Speed of sound	m/s	ft/s
D	Duct diameter	m	ft
D_e	Equivalent diameter	m	ft
E_o	End reflection factor at duct outlet	dB	dB
E_i	End reflection factor at duct inlet	dB	dB
f	Frequency	Hz	Hz
L_p	Sound pressure level, re 20 μPa (0.0002 μbar)	dB	dB
L_{pc}	Corrected fan sound pressure level	dB	dB
L_{pb}	Sound pressure level of room background measured over the normal microphone path	dB	dB
L_{pk}	Fan casing sound pressure rating	dB	dB
L_{ps}	Room space and time averaged sound pressure level	dB	dB
L_{pm}	Sound pressure level of fan + room background measured over the normal microphone path	dB	dB
L_{pq}	Sound pressure level of the RSS, corrected	dB	dB
L_{pqm}	Sound pressure level of RSS + room background measured over the normal microphone path	dB	dB
L_W	Sound power level re 1 picowatt (1.0×10^{-12} W)	dB	dB
L_{W1}, L_{W2}, L_{W3}	One-third octave sound power level	dB	dB
L_{Wk}	Sound power radiated through the fan casing	dB	dB
L_{Wi}	Sound power level transmitted to inlet duct from fan	dB	dB
L_{Wmi}	Sound power level measured at the open inlet of the fan	dB	dB
L_{Wmo}	Sound power level measured at the open outlet of the fan	dB	dB
L_{Wmt}	Sound power level measured at the open inlet and outlet of the fan	dB	dB
L_{Wo}	Sound power level transmitted to the outlet duct from fan	dB	dB
L_{Wr}	Sound power level of RSS	dB	dB
n	One-third octave band of interest (used as a subscript)	—	
n	Number of discrete frequencies in one-third octave band	—	
n_{RSS}	Number of RSS locations	—	
p	Sound pressure	Pa	bar

p_{ref}	Sound pressure reference level, 20 μPa (0.0002 μbar)	Pa	bar
P_s	Fan static pressure	Pa	in. wg
P_t	Fan total pressure	Pa	in. wg
s	Standard deviation	dB	dB
W	Sound power (in watts)	W	W
W_{ref}	Reference sound power (1 picowatt)	W	W
γ	Wavelength	m	ft

5. Instruments/Methods of Measurement

5.1 Sound measurement instrumentation

The sound level measurement instrumentation shall meet the requirements of ANSI S1.4.

5.2 Microphone system

A diffuse field microphone shall be used. The microphone system (transducer and any associated components and cable) shall meet the requirements for use in a Type 1 precision sound level meter, according to ANSI S1.4. A microphone with a nominal diameter of 13 mm (0.5 in.) is recommended.

5.3 Frequency analyzer and weighting system

A one-third octave band filter is required and shall meet the Order 3 Type 3-D requirements of ANSI/ASA S1.11.

5.4 Data recording equipment

This standard does not attempt to set limitations on data recording equipment other than to record and retain one-third octave band data. Considerations include long-term stability, ease of use and the method of averaging the sound pressure signal. Modern integrating-type analyzers that comply with IEC 804 are recommended.

Table 5.1 — Standardized Octave and One-Third Bands (From ANSI/ASA S1.6)

Octave Bands

Center frequency *f*, Hz	63	125	250	500	1000	2000	4000	8000

One-Third Octave Bands

Center freq. *f*, Hz	50	63	80	100	125	160	200	250	315	400	500	630

Center freq. *f*, Hz	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000

5.5 Reference sound source

The reference sound source (RSS) is used to define the relationship between the sound power level and sound pressure level in the reverberation room, near the unit under test.

The reference sound source should comply with the requirements of ANSI/AHRI Standard 250. The RSS shall produce steady broadband sound over at least the frequency range from 50 Hz to 10,000 Hz. While ANSI/AHRI Standard 250 allows RSS calibration over a limited frequency range, this standard requires calibration over the entire range.

5.6 Test method

The test method is based on an RSS comparison for the determination of sound power.

Application of the test method requires that the fan under test be set in position in a test room that is qualified according to the requirements of Section 6.1.

Once the test room has been qualified, the background sound pressure levels are recorded, then the sound pressure levels are recorded while the RSS operates. The fan is then operated, without the RSS in operation, at various performance points of interest for the given test speed, and the sound pressure levels are recorded. Since the sound power levels of the RSS are known, the comparison method is used to determine the sound power levels of the fan for each operating point.

Current ANSI and ASA documents on sound testing, facilities and equipment are useful references. See Section 4.

5.7 Accuracy of results

Accuracy of test results is addressed in Annex C and depends upon several variables, including the room qualification and the type of test setup utilized.

6. Equipment/Setups

6.1 Reverberation room

An enclosure meeting the requirements of Annex A is mandatory for the purposes of this standard. An enclosure meeting the requirements of Annex B is recommended for broad-band sound testing and is mandatory for the purpose of investigating pure tones and narrow bands.

6.2 Setup categories

A number of specific fan test setups are allowed. The test setups are determined by the airflow direction and the particular mounting arrangement of the fan under test. The test setups fall into two general categories.

The first category is for a free-standing unit that would be placed entirely in the test room (see Figure 10.1). Results of this arrangement yield total sound power L_{Wmt} of the fan under test, non-ducted.

The second category includes those fans that would be tested on a chamber or two-room system where only the inlet or outlet terminate in the test room (see Figures 10.2 and 10.3). These arrangements result in the determination of inlet (L_{Wi}) or outlet (L_{Wo}) sound power. Section 6.6 discusses the limitations that must be imposed on the test room for determining the position of the fan under test and the location of the microphone. The choice of test setup for a specific test will depend on the way the fan is expected to be applied in the field.

6.3 Aerodynamic performance

An aerodynamic performance test is necessary to determine the point of operation of a fan under test. The test shall be performed in accordance with ANSI/AMCA Standard 210 or other fan aerodynamic performance test standard having a demonstrated accuracy equivalent to ANSI/AMCA Standard 210.

6.4 Mounting methods

The method of mounting the fan under test and connecting it to a non-integral driver or an airflow test facility is not specified. Any conventional method may be used, including vibration isolation devices and short flexible connectors. Other than these, sound and vibration absorptive material may not be incorporated in the fan under test unless it is a standard part of the fan. Ducts shall be of metal or other rigid, dense, non-absorptive material and have no exposed sound absorption material on the interior or exterior surfaces.

The driving motor and drive, when not an integral part of the fan under test, may be damped or enclosed in any manner that does not expose sound absorption material to the test room. When a driving motor and drive are an integral part of the fan under test, they may not be treated in any manner, and normal belt tensions, bearings and lubricants shall be used. When a fan and its drive are both in the reverberation room, the test results may contain sound contributions from flanking paths as well as mechanical and/or electrical sound from the drive system.

6.5 Duct length

On a chamber or two-room setup, the length of duct shall be consistent with the practice acceptable per ANSI/AMCA Standard 210 that is necessary to accurately establish the point of operation.

The length of duct shown in Figures 10.2 and 10.3 is consistent with the procedures of ANSI/AMCA Standard 210. Care must be exercised to ensure that no duct resonances exist in close proximity to specific frequencies of interest such as the blade passage frequency.

6.6 Microphone locations

When using the comparison method, the minimum distance between the sound source and the nearest microphone position may also be calculated from:

$$A_{min} = C_2 10^{(L_{Wr}-L_{pq})/20} \qquad \text{Eq. 6.1}$$

Where:

A_{min} = the minimum distance between the sound source and the microphone, m (ft)

C_2 = 0.4 for bands between 50-80 Hz and 6300 to 10k Hz, and 0.8 for bands between 100-5k Hz.

$(L_{Wr} - L_{pq})$ = the maximum value for any one-third octave band.

If the test room and test setup have been qualified in accordance with Annex A, the continuous microphone traverse used for the qualification shall also be used for the sound pressure measurements. If a microphone array is used for the qualification, the same array arrangement shall be used for the sound pressure measurements.

An array of six or more microphones may be used in place of a microphone on a rotating boom. The array shall meet the requirements of ANSI/ASA S12.51-2012/ISO 3741-2010 (R2017).

The microphone traverse or array shall meet the following requirements:

1. No point on the traverse or array shall be any closer than A_{min} from the sound source
2. No point on the traverse or array shall be any closer than 1.0 m (3.333 ft) to any surface of the test room
3. No point on the traverse or array shall at any time be closer than 0.5 m (1.67 ft) to any surface of a rotating diffuser
4. The microphone traverse or array should not lie in any plane within 10° of a room surface
5. The microphone shall swing or move on a normal path of an arc or straight line with a minimum distance of 3 m (10 ft) between the extreme points of travel
6. The maximum air velocity over the microphone shall be 1 m/s (200 fpm)
7. Room volume is not specified in this standard, but the room must be large enough in volume that the volume of the test fan and associated ductwork does not exceed 1% of the room volume
8. Neither the RSS nor the fan shall be within 300 mm (1 ft) of any room centerline

6.7 Calibration of system

Before each sound power determination, the following calibration checks shall be performed. A calibration check shall be made of the entire measurement system at one or more frequencies within the frequency range of interest. An acoustical calibrator conforming to ANSI/ASA S1.40and with an accuracy of ± 0.5 dB shall be used for this purpose. In conformance with ANSI/ASA S1.40,the calibrator shall be checked at least once every year to verify that its output has not changed. In addition, an electrical calibration of the instrumentation over the entire frequency range of interest shall be performed at intervals according to the instrument manufacturer’s recommendation.

The microphone and its associated cable shall be chosen so that their sensitivity does not change by more than 0.2 dB over the temperature range encountered during the measurement. If the microphone is moved, care shall be exercised to avoid introducing acoustical or electrical noise (for example, from gears, flexing cables or sliding contacts) that could interfere with measurement.

The instrumentation system, including the microphones and cables, shall meet the requirements of IEC 61672-1:2002, class 1, and the filters shall meet the requirements of IEC 61260-1:1995, class 1.

6.8 Equations

The type of fan and its test setup determine the calculations required to obtain the sound power levels (L_{Wmt}, L_{Wi}, L_{Wmi}, L_{Wo}, L_{Wmo}) of the fan under test. Equations for each test setup are included under the specific arrangement along with any qualifying statements or limitations. Also included are any assumptions that were made regarding these specific setups. End reflection factors (E_i) and (E_o), when required, shall be calculated from Annex E, using the appropriate duct size.

It cannot be assumed that the inlet and outlet sound powers are always equal. Therefore, total sound power levels shall not be used to derive inlet or outlet sound power levels.

7. Test Procedure

7.1 Observations

7.1.1 Point of operation

Although the acoustical measurements necessary to determine sound power are the same for all types of fans, the non-acoustical measurements necessary to determine the aerodynamic point of operation differ. This standard provides different test setups for the testing of various fan types. Regardless of the test setup, the point of operation shall be determined. If the sound test setup also conforms to one of the test setups in ANSI/AMCA Standard 210, then the point of operation can be established with sufficient accuracy. If the sound test setup does not conform to one of the test setups in ANSI/AMCA Standard 210, steps must be taken to ensure that the fan rotational speed is known within ± 1% and the point of operation can be established within ± 5% along a system curve.

7.1.2 Sound pressure levels

7.1.2.1 Sound pressure levels: background (L_{pb})

Background sound pressure levels are those measured in the test room with the test fan under test and the RSS off. The background noise includes all noise sources not directly associated with fan sound. Examples of background noise sources include noise due to the motion of the microphone and noise due to other external sources. Efforts should be made to keep the background noise level at a minimum. For a test or set of determinations at various operation points of the fan under test, background sound pressure levels need to be observed once. The background sound pressure shall be measured and recorded in one-third octave bands.

7.1.2.2 Sound pressure levels: RSS (L_{pqm})

RSS sound pressure levels are those measured in the test room with the RSS operating and the fan under test off. RSS sound pressure levels include background sound pressure levels. For a test or set of determinations at various points of fan under test operation, RSS sound pressure levels need to be observed once. The RSS sound pressure level shall be measured and recorded in one-third octave bands.

7.1.2.3 Sound pressure levels: fan (L_{pm})

Fan sound pressure levels are those measured in the test room with the fan under test operating and the RSS off. Fan sound pressure levels include background sound pressure levels. Fan sound pressure levels must be observed for each operating point. The fan sound pressure levels shall be measured and recorded in one-third octave bands.

Note: The observations above are valid only when taken in a room that is qualified per the procedures defined in Annex A or B.

7.1.3 Test conditions

The test conditions shall, as nearly as possible, be the same for all sound pressure level measurements. Operation of the microphone traverse or array and any rotating vanes shall be the same for all measurements. Although strongly discouraged, if it is necessary for operators to be present in the test room, they shall be away from the fan under test and remain in the same position during the test. Readings shall be a time-weighted average over an integral number of microphone swings. The time span used shall be sufficient to provide a stable value and shall be a minimum of 30 seconds for frequency bands equal to or less than 160 Hz and 15 seconds for frequency bands equal to or greater than 200 Hz.

7.2 Information to be recorded

As applicable, the following information shall be compiled and recorded for all observations made in accordance with this standard.

7.2.1 Fan under test

1. Description of the fan under test
    a. Manufacturer
    b. Model
    c. Nominal size
    d. Impeller diameter, mm (in.)
    e. Number of impeller blades
    f. Blade angle setting (adjustable or variable pitch fans only)
    g. Number of stator vanes
    h. Inlet area, m^2 (ft^2)
    i. Outlet area, m^2 (ft^2)
2. Operating conditions
    a. Fan rotational speed, rev/min
    b. Fan airflow rate, m^3/s (ft^3/min)
    c. Fan static pressure or total pressure at actual test conditions, Pa (in. wg)
    d. Fan air density, kg/m^3 (lbm/ft^3)
3. Mounting conditions
    a. Test figure per this standard
    b. Test installation type
    c. A sketch showing the test room setup, including the dimensional locations of the fan under test and points or path of acoustical measurements

7.2.2 Test environment

1. Barometric pressure, kPa (in. Hg)
2. Ambient dry-bulb temperature, °C (°F)
3. Ambient wet-bulb temperature, °C (°F)
4. Fan inlet dry-bulb temperature, °C (°F)
5. Static pressure at the fan inlet, Pa (in. wg)

7.2.3 Laboratory and instruments

1. Laboratory name
2. Laboratory location
3. Technician(s) conducting test
4. List of test equipment used, with calibration information
5. Scope of room qualification. Data shall indicate the room is qualified for one-third octaves and, in the case of discrete frequency testing, the one-third octaves for which the qualification applies

7.2.4 Acoustical data

1. Background sound pressure levels L_{pb}
2. RSS sound pressure levels L_{pqm}
3. RSS calibrated L_{W} and date last calibrated

4. Background corrections for the RSS
5. Fan sound pressure levels L_{pm}
6. Background corrections for the fan
7. Unweighted fan sound power levels L_{Wmi} or L_{Wmo}
8. End reflection correction data
    a. End reflection correction values E_i or E_o
    b. Duct length
    c. Flush or free-space termination of the duct into the test room
    d. Orifice plate inside diameter, m (ft)
9. Test date

8. Calculations

Installation type and setup affect the calculations. See Section 6.8 in addition to sections 8.1 and 8 .2. Calculations shall be done in one-third octave bands.

8.1 Background correction

The observed RSS or fan under test sound pressure levels include both the sound source and background noise. The effect of background noise level is termed background correction and must be subtracted from the observed sound pressure level. Background correction values depend on the difference between the observed sound pressure levels and the background noise levels.

8.1.1 Background correction of observed RSS sound pressure level

When the difference between the observed RSS sound pressure level (L_{pqm}) and the measured background sound pressure (L_{pb}) is less than 6 dB in any given one-third octave band, the sound power of the test subject cannot be accurately determined in that band. If this condition exists, the test needs to be suspended and the source of the background sound issue needs to be identified and corrected/reduced to provide at least a 6 dB separation between the observed RSS sound pressure and the background sound pressure in all bands of interest. If the difference between the observed RSS sound pressure (L_{pqm}) and the background sound pressure (L_{pb}) in every band of interest is greater or equal to 6 dB, the observed RSS sound pressure in each band is to be corrected for the background sound level with the following formula:

$$L_{pq} = 10\log_{10}\left(10^{\left(\frac{L_{pqm}}{10}\right)} - 10^{\left(\frac{L_{pb}}{10}\right)}\right) \quad \text{Eq. 8.1}$$

Note that if the difference in measured sound pressure of the RSS is greater than 15 dB above the level of the background sound pressure, it generally is not necessary to run the correction.

8.1.2 Background correction of observed test subject sound pressure level

When the difference between the observed test subject sound pressure level (L_{pm}) and the measured background sound pressure (L_{pb}) is less than 6 dB in any given one-third octave band, the sound power of the test subject cannot be accurately determined in that band. If this condition exists in any, one-third octave band, then the corrected sound pressure in that band (L_{pq}) shall be reported as 1.3 dB less than the measured sound pressure level (L_{pm}) and the data point clearly marked as an upper boundary level. If the difference between the observed test subject sound pressure level (L_{pm}) and the measured background sound pressure (L_{pb}) in a one-third octave band is greater or equal to 6 dB, then the corrected test sound pressure level in that one-third octave band (L_{pq}) is to be corrected for the background sound level with the following formula:

$$L_{pc} = 10\log_{10}\left(10^{\left(\frac{L_{pm}}{10}\right)} - 10^{\left(\frac{L_{pb}}{10}\right)}\right) \quad \text{Eq. 8.2}$$

Note that if difference in measured sound pressure of the test subject is greater than 15 dB above the level of the background sound pressure, it generally is not necessary to run the correction.

8.2 Sound power level (L_W)

A sound power level is calculated using equations given in Section 10. The equations vary with product type and test setup. The sound power level of an octave band is calculated from one-third octave band values by using the formula:

$$L_w = 10\log_{10}\left(10^{\left(\frac{L_{W1}}{10}\right)} + 10^{\left(\frac{L_{W2}}{10}\right)} + 10^{\left(\frac{L_{W3}}{10}\right)}\right) \qquad \text{Eq. 8.3}$$

Where L_{W1}, L_{W2} and L_{W3} are one-third octave sound power level values.

9. Results and Report

Test results are presented as the sound power level, in dB, in each of the eight full octave bands for each fan test speed and point of operation. Full octave bands are given in Table 5.1. Optionally, the underlying one-third octave band sound power levels may be reported also. The report shall also include data defined in Sections 9.1 through 9.3. This standard does not require that discrete frequency content (pure tones) be identified. However, a laboratory equipped with suitable instrumentation is encouraged to investigate and report pure tones separately.

9.1 Fan under test

1. Description of the fan under test
    a. Manufacturer
    b. Model
    c. Nominal size
    d. Impeller diameter, mm (in.)
    e. Number of impeller blades
    f. Blade angle setting (adjustable or variable pitch fans only)
2. Operating conditions
    a. Aerodynamic performance test standard
    b. Fan rotational speed, rpm
    c. Fan airflow rate, m^3/s (ft^3/min)
    d. Fan static pressure or total pressure at actual test conditions, Pa (in. wg)
    e. Fan air density, kg/m^3 (lbm/ft^3)
    f. Air velocity near the microphone path, m/s (fpm)
3. Mounting conditions
    a. Test figure per this standard
    b. Installation type

9.2 Laboratory and Instruments

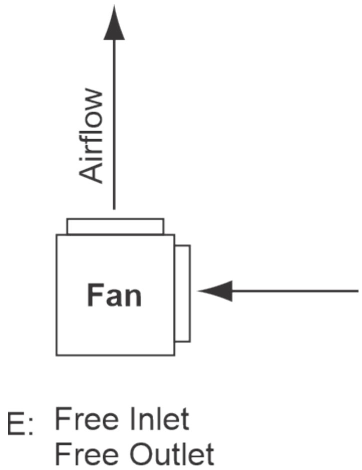
1. Laboratory name
2. Laboratory location

9.3 Acoustical data

1. Unweighted fan sound power levels in each band shall be reported to not more than one decimal place
2. Test date
3. Background sound pressure level in each reported band
4. Background correction for the RSS for each reported band

5. RSS sound pressure level in each reported band
6. Background correction for fan under test in each reported band
7. Fan under test sound pressure level in each reported band

10. Figures



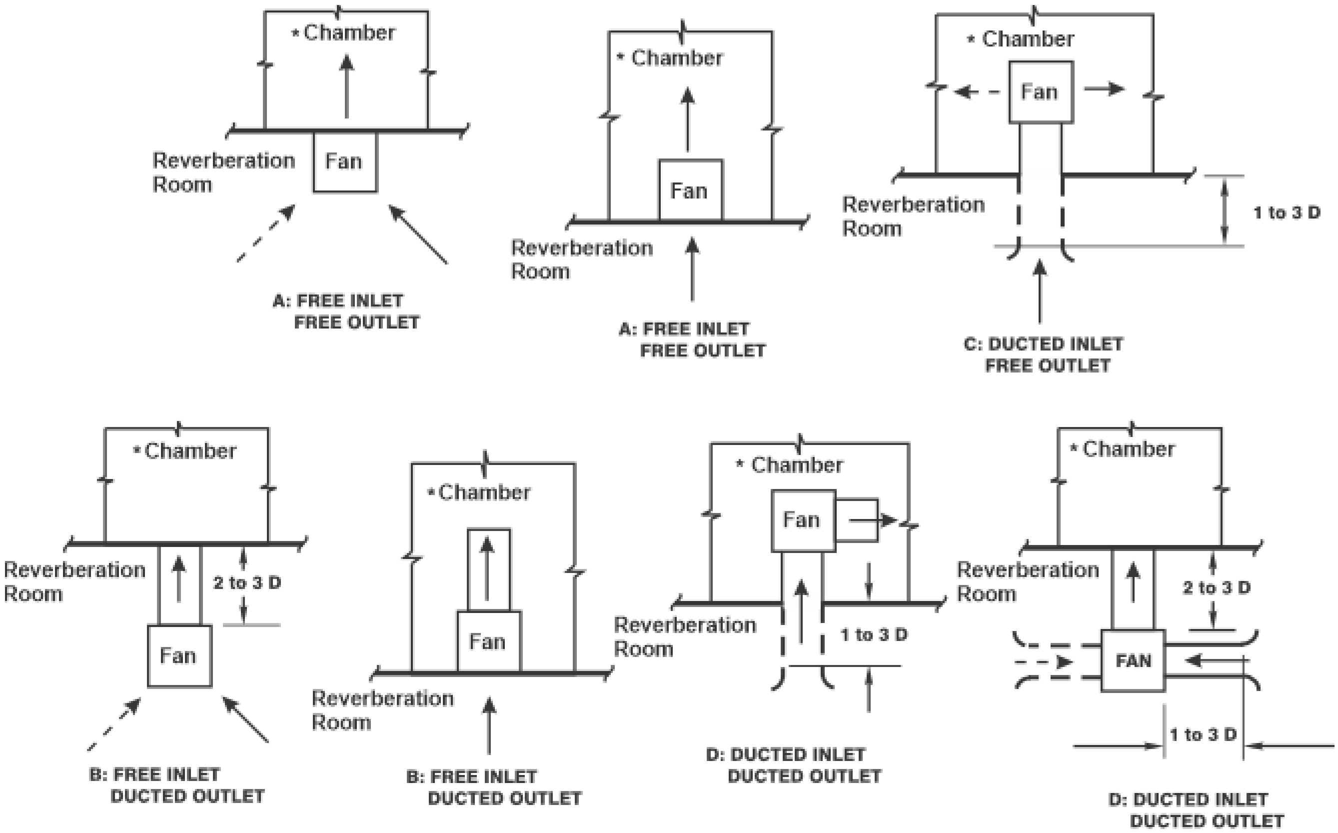
Sound Power Calculations

Installation type	L_W equation	
E: Free inlet, free outlet	$L_{Wmt} = L_{pc} + (L_{Wr} - L_{pq})$	Eq. 10.1

This test procedure and the above calculations are based on the following assumptions:

1. Directivity from the fan is averaged by the reverberation room and the microphone location allows the microphone to sense total averaged sound pressure levels.
2. The BV-3 level of vibration (as defined in ANSI/AMCA Standard 204) should be achieved on the fan bearing that is adjacent to the driving shaft.
3. Installation type E is similar to installation type A, but without any partition between the inlet and outlet.
4. The entire fan shall be in the reverberation room.

Figure 10.1 — Fan Total Sound Testing



Sound Power Calculations

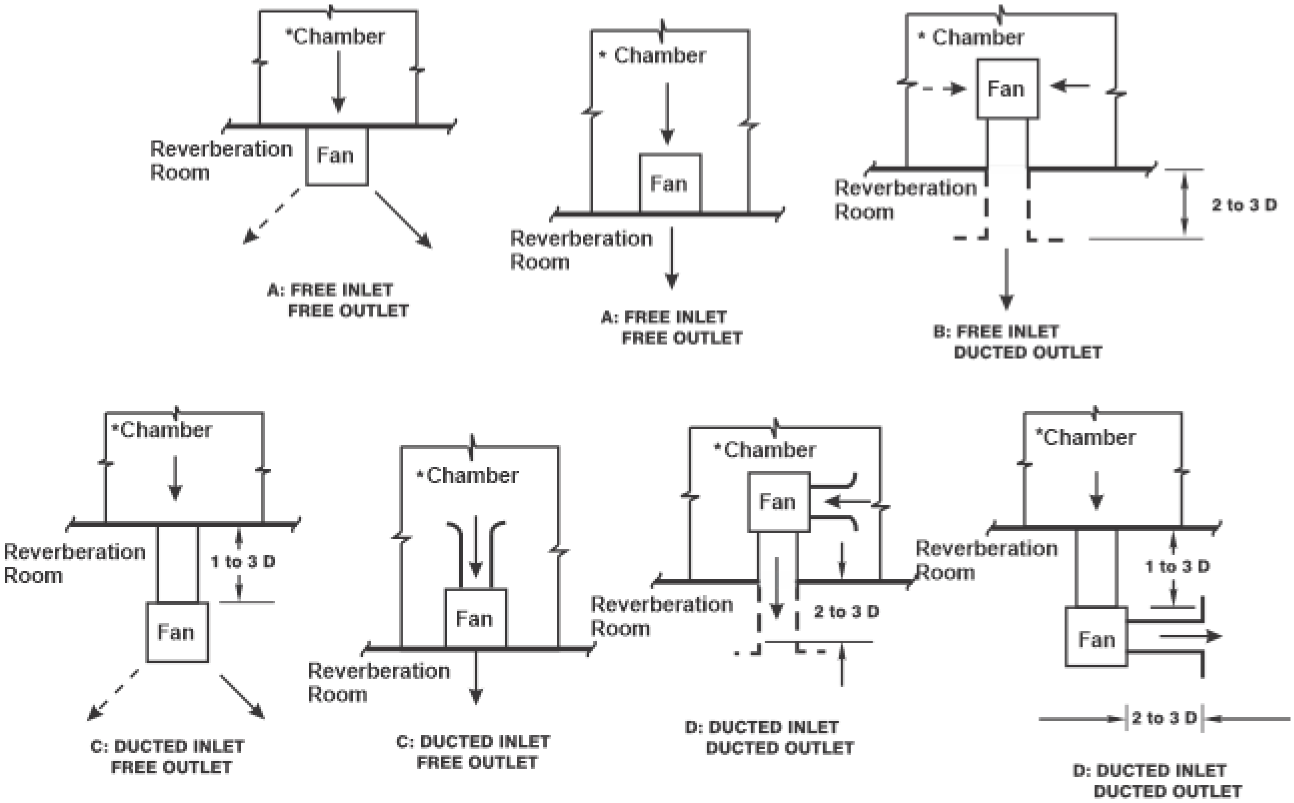
Installation Type	L_W Equations	
A or B: Free inlet	$L_{Wmi} = L_{pc} + (L_{Wr} - L_{pq})$	Eq. 10.2
C or D: Ducted inlet	$L_{Wi} = L_{pc} + (L_{Wr} - L_{pq}) + E_i$	Eq. 10.3

This test procedure and the above calculations are based on the following assumptions:

1. Acoustical energy in an outlet duct that terminates in a second room or air test chamber does not contribute to fan test sound pressure levels. This requires adequate transmission loss between adjoining rooms and the addition of absorptive material within an air test chamber to absorb this energy.
2. Adequate absorption takes place at the discharge of a duct in a second room or chamber so that any energy passing down that duct is adequately attenuated.
3. Directivity from the fan is averaged by the reverberation room and the microphone location allows the microphone to sense total averaged sound pressure levels.
4. Duct construction is such that the transmission loss through the duct wall is large enough to eliminate any addition to measured room sound pressure levels.
5. The BV-3 level of vibration (See ANSI/AMCA Standard 204) should be achieved on the fan bearing that is adjacent to the driving shaft.
6. Inlet orifices to control the operating point are not permitted unless integral to the fan.
7. When the fan is in the reverberation room, the sound power determined will include any fan casing noise.

*An air test chamber is not required, but if used it may require acoustical treatment.

Figure 10.2 — Fan Inlet Sound Testing



Sound Power Calculations

Installation Type	L_W Equations	
A or C: Free outlet	$L_{Wmo} = L_{pc} + (L_{Wr} - L_{pq})$	Eq. 10.4
B or D: Ducted outlet	$L_{Wo} = L_{pc} + (L_{Wr} - L_{pq}) + E_o$	Eq. 10.5

This test procedure and the above calculations are based on the following assumptions:

1. Acoustical energy in an inlet duct that terminates in a second room or air test chamber does not contribute to fan test sound pressure levels. This requires adequate transmission loss between adjoining rooms and the addition of absorptive material within a chamber to absorb this energy.
2. Adequate absorption takes place at the inlet of a duct in a second room or air test chamber so that any energy passing down that duct is adequately attenuated.
3. Directivity from the fan is averaged by the reverberation room and the microphone location allows the microphone to sense total averaged sound pressure levels.
4. Duct construction is such that the transmission loss through the duct wall is large enough to eliminate any addition to measured room sound pressure levels.
5. The BV-3 level of vibration (see ANSI/AMCA Standard 204) should be achieved on the fan bearing that is adjacent to the driving shaft.
6. Outlet orifices to control the operating point are not permitted unless integral to the fan.
7. See note #7 from Figure 10.2.

*An air test chamber is not required, but if used it may require acoustical treatment.

Figure 10.3 — Fan Outlet Sound Testing

Annex A
Broadband Room Qualification: One-Third Octave (Normative)

A.1 General

This annex covers the procedures for a broad-band qualification of a test room for one-third octave bands. If pure-tone qualification is required, refer to Annex B.

A.2 Instruments and equipment

The instruments and microphone traverse/array shall be the same as those used during the actual testing of a fan. The instruments shall conform to the requirements given in sections 5.1, 5.2, 5.3 and 5.4. The microphone traverse/array shall conform to the requirements of Section 6.6. The test procedure given in this annex requires the use of a RSS having the characteristics specified in Section 5.5.

A.3 Test procedure

Eight or more measurements shall be made of the reverberant field sound pressure levels in the room, each with the RSS placed at a different location within the room, under the following conditions:

- Each location for the RSS shall be selected on the floor and shall not be closer than 1 m (3 ft) from a wall and not closer to any microphone than permitted by equation A_{min} (Section 6.6). The distance between any two RSS locations shall be greater than 0.9 m (3 ft). No source location shall lie within ± 300 mm (1 ft) of a room centerline. The RSS locations shall be in the general vicinity of the locations intended for the fan under test as seen in a plan view of the test room.
- With the RSS at each of the eight (or more) above locations, determine the average sound pressure levels in accordance with the procedures of Section 7.
- The microphone traverse/array, sound diffuser (if any), instruments and observation times shall be identical to those to be used for a fan under test.

A.4 Computation procedure

For each frequency band for which the test room is to be qualified, the standard deviation *s*, in dB, shall be computed using the formula:

$$s = \sqrt{\frac{1}{n_{RSS}-1}\sum_{j=1}^{n_{RSS}}\left(\left(L_{pq}\right)_j - \overline{L_{pq}}\right)^2} \qquad \text{Eq. A.1}$$

Where:

$\left(L_{pq}\right)_j$ = the sound pressure level in dB averaged over all microphone positions when the RSS is in the j th location

$\overline{L_{pq}}$ = arithmetic mean of $(L_{pq})_j$ values in dB averaged over all RSS locations

n_{RSS} = number of RSS locations, a minimum of eight

A.5 Qualification

For each frequency band, the test room qualifies for the measurement of broad-band sound if the computed standard deviation *s*, in dB, does not exceed the limits given in Table A.1.

Table A.1 — Maximum Allowable Standard Deviation *s*, (dB)

One-Third Octave Band Center Frequency (Hz)	**Maximum Allowable Standard Deviation (dB)** ***s***
50 to 80	3.0
100 to 160	1.5
200 to 630	1.0
800 to 2500	0.5
3150 to 10000	1.0

Annex B
Discrete Frequency Room Qualification: One-Third Octave Bands (Informative)

B.1 General

This annex covers the procedure for the qualification of a test room when sounds with tonal content are to be measured. Although qualification criteria are only presented for one-third octave bands of 100 Hz and above (Table B.2), it is recommended that the testing be performed starting with the 50 Hz one-third octave band (Table B.1) as qualification test results in a band are an indicator of the uncertainty of measurements taken in the room in the presence of tones in that band. The maximum one-third octave band to qualify will be no greater than 2500 Hz, but the required maximum frequency, as calculated per Annex B.3.1, will likely be lower. The qualification testing applies to a specific location in the test room and determines which of the one-third octave bands the test room location is qualified for. If a location or locations in a room are declared to be discrete frequency qualified per this annex, then the range of one-third octave bands qualified must be stated.

The discrete frequency qualification procedure in annex B follows the procedure in ANSI/AHRI Standard 220and Annex A.3 of ANSI/ASA S12.51-2012/ISO 3741-2010 (R2017). Recent research has shown that the loudspeaker qualification in a hemi-anechoic room can be eliminated from these standards and a nearfield microphone, located above the loudspeaker, can be added in the reverberation test to directly determine the room acoustic transfer function and the discrete frequency uncertainty. An alternate procedure based on this research is presented in Annex D of this standard.

B.2 Instruments and equipment

The instruments shall be as specified in Section 5 with the following substitutions/additions.

The sound source will consist of the following:

a. One or more loudspeaker(s), each having a sufficiently smooth frequency response within the range of frequencies to be qualified
b. A frequency generator, tunable to and meeting the tolerances given for the frequencies given in Table B.1 (a digital frequency synthesizer is recommended for ease of setting frequency)
c. A frequency counter accurate within ± 0.05 Hz over the pertinent frequency range
d. A power amplifier of suitable power and having an output impedance compatible with the loudspeaker(s)
e. A voltmeter capable of monitoring within ± 0.05% of the voltage across the loudspeaker(s) at all test frequencies

B.3 Test procedure

B.3.1 Maximum test frequency

The maximum test frequency required is 2500 Hz. If using a continuous microphone traverse, the maximum frequency is affected by the volume of the test room and the length of the traverse. In this case the maximum test frequency required is the larger of the results of equations B.1 and B.2.

Frequency Limit = 6000 / L	SI	Eq. B.1
Frequency Limit = 19685 / L	I-P	Eq. B.2
Frequency Limit = 5000 / $V^{1/3}$	SI	Eq. B.3
Frequency Limit = 176554 / $V^{1/3}$	I-P	Eq. B.4

L = Length of one complete microphone traverse, m or ft as appropriate
V = Volume of the reverberation room in m^3 or ft^3 as appropriate

Determine the one-third octave band containing the maximum test frequency from Table B.3. The one-third octave band containing the maximum test frequency shall be tested.

Qualification testing consists of two sections, the first being concerned with the near-field characteristics of the loudspeaker and the second with the test room itself. In both sections, measurements are made for each of the discrete frequencies associated with the one-third octave band being qualified (Table B.1). The same test equipment must be used for both sections of the qualification testing.

B.3.2 Loudspeaker qualification

The loudspeaker shall be located on the horizontal reflective surface of a hemi-anechoic field with the open cone facing up. A microphone with the diaphragm located horizontally over the center of the loudspeaker 10 to 20 mm (0.375 to 0.75 in.) above the plane of the loudspeaker rim. The input voltage to the loudspeaker must be sufficient to overcome background noise but must in no case be permitted to cause physical distortion of the loudspeaker components. The sound pressure levels for the discrete frequencies of a one-third octave band in Table B.1 are then measured. The loudspeaker is suitable only if the sound pressure levels at adjacent frequencies do not differ by more than 1 dB. This test determines the near-field characteristics of the loudspeaker and gives calibration sound pressure levels for the loudspeaker.

B.3.3 Room test

The loudspeaker shall be positioned in the room at the horizontal and vertical coordinates intended for the fan under test and placed with the open cone facing away from the nearest room surface. Using the same input voltage to the loudspeaker(s) as for the loudspeaker qualification, space and time averaged sound pressure levels, L_{ps}, are measured for the discrete frequencies of the one-third octave band.

B.4 Computation

The room test sound pressure level is then corrected to remove the effect of the loudspeaker's near-field characteristic by subtracting the loudspeaker qualification sound pressure level. The arithmetic mean for the room sound pressure level is then calculated, and the standard deviation *s* of the difference between the average sound pressure level and the arithmetic mean sound pressure level is determined by:

$$s = \sqrt{\frac{1}{(n-1)} \sum_{k=1}^{n} \left(\left(L_{ps}\right)_k - \overline{L_{ps}} \right)^2} \qquad \text{Eq. B.3}$$

Where:

$\left(L_{ps}\right)_k$ = the corrected sound pressure level, in dB, averaged over all microphone positions, of the kth discrete frequency

$\overline{L_{ps}}$ = the arithmetic mean of $(L_{ps})_k$ values averaged over all n test frequencies within the one-third octave band

n = the number of discrete frequencies within the one-third octave band

B.5 Discrete frequency uncertainty

A test room is accepted as qualified for pure-tone testing within a given one-third octave band if the standard deviation, *s,* in dB for that band does not exceed the values given in Table B.2. If a one-third octave band does not qualify, some modification to the microphone location, to the test position or to the room absorption will be required (AMCA #1901-85-A1: 1985).

Table B.1 — Test Frequencies for Alternative Qualification of Reverberation Room Facility for Measuring Sound Power Levels of Noise Sources Containing Significant Discrete Frequency Components (from ANSI/ASA S12.51-2012/ISO 3741-2010 [R2017])

Center Frequency of One-Third Band Octave Bands, Hz																	
50	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**	**800**	**1000**	**1250**	**1600**	**2000**	**2500**
—	—	—	—	—	147	—	—	--	361	—	—	—	—	—	1470	—	—
—	—	—	—	113	148	—	226	--	364	—	—	—	—	1130	1480	—	2260
—	56.4	71.2	—	114	149	—	228	--	367	__	564	712	—	1140	1490	—	2280
45.0	57.0	72.0	90	115	150	180	230	285	370	450	570	720	900	1150	1500	1800	2300
45.5	57.6	72.8	91	116	151	182	232	288	373	455	576	728	910	1160	1510	1820	2320
46.0	58.2	73.6	92	117	152	184	234	291	376	460	582	736	920	1170	1520	1840	2340
46.5	58.8	74.4	93	118	153	186	236	294	379	465	588	744	930	1180	1530	1860	2360
47.0	59.4	75.2	94	119	154	188	238	297	382	470	594	752	940	1190	1540	1880	2380
47.5	60.0	76.0	95	120	155	190	240	300	385	475	600	760	950	1200	1550	1900	2400
48.0	60.6	76.8	96	121	156	192	242	303	388	480	606	768	960	1210	1560	1920	2420
48.5	61.2	77.6	97	122	157	194	244	306	391	485	612	776	970	1220	1570	1940	2440
49.0	61.8	78.4	98	123	158	196	246	309	391	490	618	784	980	1230	1580	1960	2460
49.5	62.4	79.2	99	124	159	198	248	312	397	495	624	792	990	1240	1590	1980	2480
50.0	63.0	80.0	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500
50.5	63.6	80.8	101	126	161	202	252	318	403	505	636	808	1010	1260	1610	2020	2520
51.0	64.2	81.6	102	127	162	204	254	321	406	510	642	816	1020	1270	1620	2040	2540
51.5	64.8	82.4	103	128	163	206	256	324	409	515	648	824	1030	1280	1630	2060	2560
52.0	65.4	83.2	104	129	164	208	258	327	412	520	654	832	1040	1290	1640	2080	2580
52.5	66.0	84.0	105	130	165	210	260	330	415	525	660	840	1050	1300	1650	2100	2600
53.0	66.6	84.8	106	131	166	212	262	333	418	530	666	848	1060	1310	1660	2120	2620
53.5	67.2	85.6	107	132	167	214	264	336	421	535	672	856	1070	1320	1670	2140	2640
54.0	67.8	86.4	108	133	168	216	266	339	424	540	678	864	1080	1330	1680	2160	2660
54.5	68.4	87.2	109	134	169	218	268	342	427	545	684	872	1090	1340	1690	2180	2680
55.0	69.0	88.0	110	135	170	220	270	345	430	550	690	880	1100	1350	1700	2200	2700
55.5	69.6	88.8	111	136	171	222	272	348	433	555	696	888	1110	1360	1710	2220	2720
56.0	70.2	—	—	137	172	—	274	—	436	560	702	—	—	1370	1720	—	2740
—	—	—	—	138	173	—	276	—	439	—	—	—	—	1380	1730	—	2760
Increment, Hz			1	1	1	2	2	3	3	5	6	8	10	10	10	20	20
Tolerance of increment, Hz			± 0.3	± 0.3	± 0.3	± 0.5	± 0.5	± 1	± 1	± 1.5	± 2	± 3	± 3	± 5	± 5	± 5	± 5
Number of test frequencies, *n*			22	26	27	22	26	22	27	23	24	23	22	26	27	22	26

Table B.2 — Maximum Allowable Sample Standard Deviation, *s*

One-Third Octave Band Center Frequency (Hz)	Maximum Allowable Standard Deviation *s* (dB)
100 to 160	3.0
200 to 315	2.0
400 to 630	1.5
800 to 2500	1.0

Table B.3 — One-third Octave Band Frequency Range

Center Frequency, Hz	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500
Lower Band Limit, Hz	44.7	56.2	70.8	89.1	112	141	178	224	282	354	447	562	707	891	1122	1414	1778	2239
Upper Band Limit, Hz	56.2	70.8	89.1	112	141	178	224	282	354	447	562	707	891	1122	1414	1778	2239	2828

B.6 Determining upper frequency qualification limit

The upper frequency limit for qualification found in ANSI/AHRI Standard 220-14, clause 5.2.7 may be used to determine an upper frequency qualification limit.

Annex C
Reproducibility (Normative)

Measurements made according to this standard will result in interlaboratory reproducibility equal to or less than the standard deviations in Table C.1. This table includes uncertainty in the comparison measurement method due to the instrumentation, operator, reverberation room and background noise levels. Table C.1 does not account for variations of sound power caused by changes in operating conditions.

Table C.1 — Maximum Standard Deviations of Sound Power Level Reproducibility

One-third Octave Band Center Frequency, Hz	dB
50 - 80	4.0
100 - 160	3.0
200 - 315	2.0
400 - 5000	1.5
6300 - 10,000	3.0

Annex D
Room Qualification: In-situ Method for Discrete Frequency (Informative)

D.1 General

This annex covers an alternate procedure, rather than Annex B, that can be used for qualification of a test room. The procedure in Annex B shall be followed with the following exceptions and additions. The differences between the procedure in Annex B and Annex D are marginal considering expected tolerances and repeatability (Bauch 2018).

D.2 Instruments and equipment

The instruments to be used for the procedure in this section shall be as specified Section 5 with the following substitutions/additions. The sound source will consist of the following:

a. One or more loudspeaker, each having a sufficiently smooth frequency response within the range of frequencies to be qualified
b. A frequency generator, tunable to and meeting the tolerances given for the frequencies given in Table B.1 (a digital frequency synthesizer is recommended for ease of setting frequency)
c. A frequency counter accurate within ± 0.05 Hz over the pertinent frequency range
d. A power amplifier of suitable power and having an output impedance compatible with the loudspeaker(s)
e. A single microphone positioned 10 to 20 mm (0.375 to 0.75 in.) from the loudspeaker

D.3 Test procedure

D.3.1 Maximum test frequency

The maximum test frequency shall be determined according to Annex B.3.1.

D.3.2 Room test in-situ method

The loudspeaker shall be positioned in the room at the horizontal and vertical coordinates intended for the fan under test and placed so that the open cone faces away from the nearest room surface. A single microphone shall be positioned 10 - 20 mm (0.375 – 0.75 in.) above the plane of the loudspeaker rim and this near-field sound level shall be measured simultaneously with the room sound level. The room space and time averaged sound pressure levels L_{ps} are measured for the discrete frequencies of the one-third octave band.

D.3.3 Computation

The room standard deviation shall be calculated according to Annex B.4, except that the room test sound pressure level is then corrected to remove the effect of the loudspeaker's near-field characteristic by subtracting the room sound pressure level from the near-field sound pressure level. The resulting L_{ps} is the room acoustic transfer function. The levels are used in Eq. B.3 to calculate the standard deviation s of the room.

D.4 Discrete frequency uncertainty

A test room is accepted as qualified for pure-tone testing within a given one-third octave band if the standard deviation s in dB for that band does not exceed the values given in Table B.2. If a one-third octave band does not qualify, some modification to the microphone location and/or traverse, to the test position, or to the room absorption will be required; otherwise, the band(s) must be clearly called out as not qualified.

Annex E
Duct End Reflection Correction (Normative)

E.1 General

Conditions at the end of a test duct will prevent some of the sound energy from being transmitted into the test room. Therefore, the sound power measured in the room will be less than the true sound power in a duct and correction factors must be added to the calculated sound power determined in the test room to account for the end reflection.

End reflection corrections calculated in this annex are based on those observed for long, uniform ducts with abrupt terminations in the test space (reverberation room). These conditions rarely exist in fan test setups; however, the full calculated end reflection correction shall be used. Preliminary AMCA research into the effects on end reflection on standard ISO 5801 inlet cone indicate that there were no differences greater than the uncertainty of the test method between this and a straight duct. For measurements made using this configuration, standard end reflection corrections for the duct size shall be used.

Note: For large radius inlet bells, this approach may be conservative but is used for consistency.

For rectangular ducts, the equivalent duct diameter shall be used:

$$D_e = \sqrt{\frac{4ab}{\pi}} \qquad \text{Eq. E.1}$$

Where:

a = Rectangular duct width, m (ft)
b = Rectangular duct height, m (ft)
D_e = Equivalent diameter, m (ft)

E.2 Calculation of end reflection corrections

For ducted inlet or ducted discharge where the duct is on the measured side, the end reflection correction, E_i or E_o, shall be added to each one-third octave band sound power level.

The end reflection correction depends on the duct termination in the test space. The following equations shall be used to calculate end reflection corrections (for either a flush or free-space termination) at the center frequencies of each one-third octave band or full octave band.

The free-space equation shall be used when the termination is greater than three equivalent duct diameters and at least 0.5 wavelengths from any reflective surface. All other conditions shall use the flush termination equation.

For a duct terminating flush or at a distance less than three equivalent diameters from any test space surface (walls, floor and ceiling), use Eq. E.2:

$$E_{(n)} = 10\log_{10}\left[1 + \left(\frac{0.7 \times c}{\pi \times f \times D_e}\right)^2\right] \qquad \text{Eq. E.2}$$

For a duct terminating at a distance greater than or equal to three equivalent diameters from any test space surface, use Eq. E.3:

$$E_{(n)} = 10\log_{10}\left[1 + \left(\frac{c}{\pi \times f \times D_e}\right)^2\right] \qquad \text{Eq. E.3}$$

Where:

c	=	Speed of sound in air, m/s (ft/s)
D_e	=	Equivalent diameter, m (ft)
$E_{(n)}$	=	End reflection correction for the n^{th} one-third octave band
f	=	One-third octave band center frequency, Hz
n	=	One-third octave band of interest

Note: Historically, the transition from flush to free-space termination was defined as one equivalent diameter. Recent research (Cunefare and Michaud. ASHRAE RP-1314. 2008) has shown that free-space duct termination effects are not fully exhibited for duct lengths shorter than three equivalent diameters.

Figures E.1 and E.2 graphically depict the flush and free-space termination end corrections.

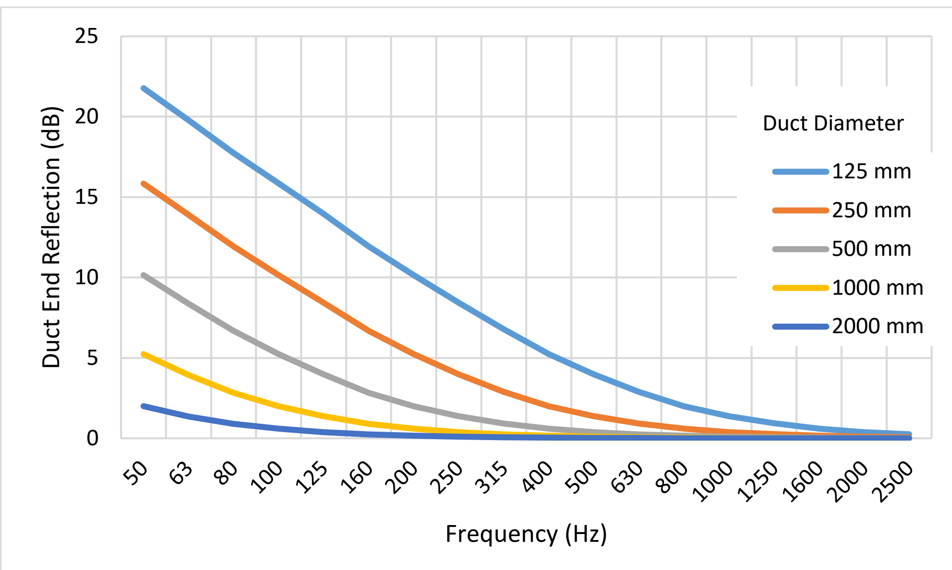


Figure E.1 — Flush Termination End Reflection Corrections (SI units)

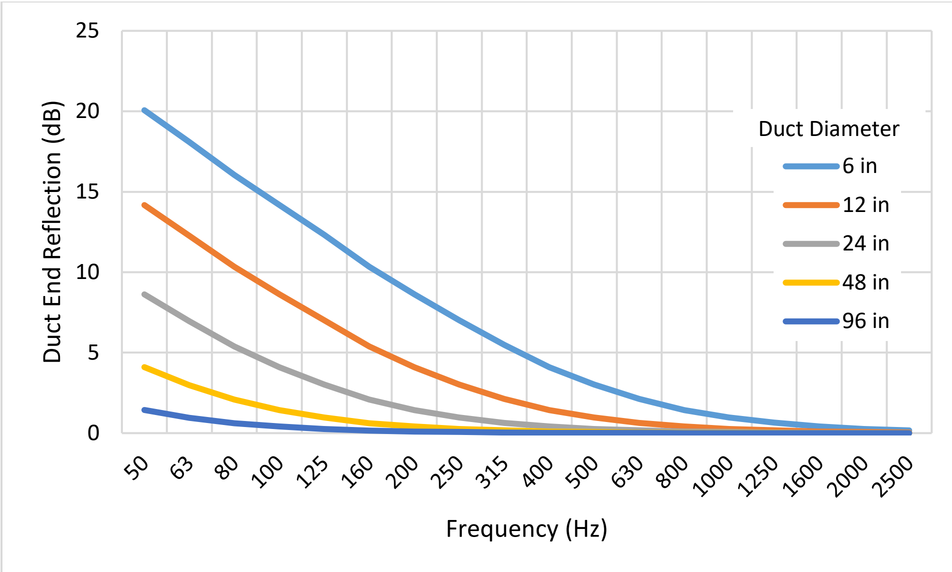


Figure E.1 — Flush Termination End Reflection Corrections (I-P units)

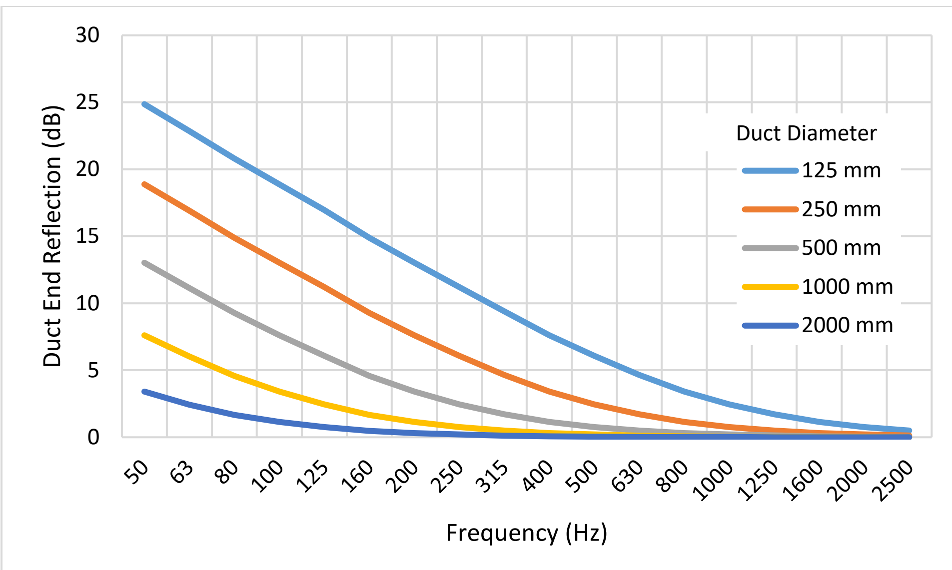


Figure E.2 — Free-Space Termination End Reflection Correction (SI units)

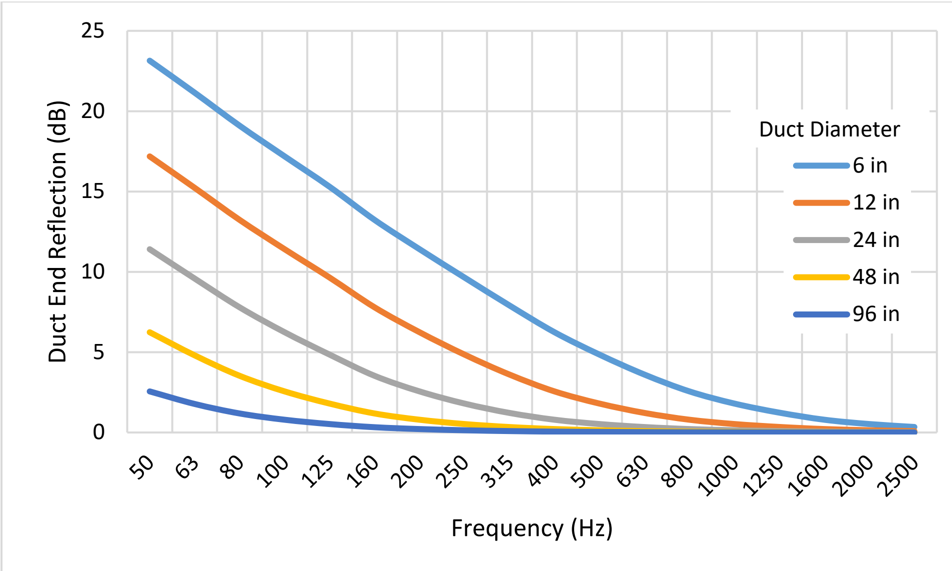


Figure E.2 — Free-Space Termination End Reflection Correction (I-P units)

Annex F
Radiation of Sound by Fan Casing (Informative)

F.1 General

The sound power radiated by a fan casing may be determined by the following method. Except as provided for below, all the requirements of this standard apply.

F.2 Instruments and equipment

Shall be as required in Section 5.

F.3 Setup and test

The fan inlet and fan outlet shall be ducted to termination points outside the test room. Ducts and connections should be constructed and secured such that the acoustic energy radiated through this equipment is no more than 10% of the total energy radiated by the fan casing into the test room. The test room sound pressure levels may be affected by sound radiating from the inlet and discharge ductwork connected to the fan under test, causing measured sound pressure levels to be somewhat higher than the true casing radiated sound pressure levels. This effect can be minimized by using internally lined round ductwork. No correction for duct-radiated sound power is allowed.

Note: If there is any doubt concerning the contribution of extraneous sound transmitted by ductwork, the importance of same can be checked by increasing the transmission loss of the ductwork.

F.4 Observations and calculations

Sound pressure levels L_{pq} and L_{pk} shall be observed as provided for in Section 7. The sound pressure levels L_{pq} and L_{pk} are observed and subject to the provisions for L_p in Section 7. For possible pure tones and additional testing, the results of the test of a fan casing are subject to the same requirements as the test of a fan.

$$L_{Wk} = L_{pk} + (L_{Wr} - L_{pq}) \text{ in each frequency band} \qquad \text{Eq. F.1}$$

Where:

L_{Wk} = sound power radiated through the fan casing and
L_{pk} = fan casing sound pressure level.
L_{wr} = reference sound source power level
L_{pq} = sound pressure level of the RSS, corrected

Annex G
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