

ANSI/AMCA Standard 320-08

Laboratory Methods of Sound Testing of Fans Using Sound Intensity

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**AIR MOVEMENT AND CONTROL
ASSOCIATION INTERNATIONAL, INC.**

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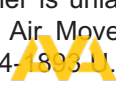
Laboratory Method of Sound Testing of Fans Using Sound Intensity



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Foreword

This standard was developed in response to the need for an accurate and reliable method of determining the sound power level of fan equipment without special acoustical facilities such as anechoic, hemi-anechoic, or reverberant rooms. It allows for smaller and larger fans to be tested than was possible previously in the AMCA laboratory using ANSI/AMCA 300 Reverberant Room Method for Sound Testing of Fans. This standard combines the established fan installation and operation procedures of ANSI/AMCA 300 with the method of sound power determination using sound intensity measurements in ANSI S12.12 American National Standard Engineering Method for the Determination of Sound Power Levels of Noise Sources Using Sound Intensity.

Since sound power levels are considered to be independent of the acoustical environment around the fan, a good comparison may be made between two or more fans proposed for any specific air performance condition. Moreover, these values establish an accurate base for estimating the acoustical outcome of the fan installation in terms of sound pressure levels. A successful estimate of sound pressure levels requires extensive information on the fan and the environment in which it is to be located.

It is often advantageous for the equipment user to employ acoustical consultation to ensure that all factors which affect the final sound pressure levels are considered. More detailed information on the complexity of this situation may be found in other documents available elsewhere.

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Laboratory Method of Sound Testing of Fans Using Sound Intensity

1. Scope

This standard is intended to apply to fans of all types and sizes. This standard is limited to the determination of airborne sound emission for the specified setups. Vibration is not measured, and the sensitivity of airborne sound emission to vibration effects is not determined.

The size of a fan which can be tested in accordance with this standard is limited only by the practical aspects of the test setup.

This standard establishes a method of determining the octave band sound power levels of a fan. The method is reproducible when all requirements of the method are met.

In this standard, sound power levels are determined using sound intensity measurements on a measurement surface that encloses the sound source. Guidelines are provided on suitable test environment acoustical characteristics, the measurement surface, and the number of intensity measurements. Test setups are designated generally to represent the physical orientation of fans as installed following ANSI/AMCA 210, and used also in ANSI/AMCA 300.

2. Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI/AMCA 210-99/ ANSI/ASHRAE 51-99 *American National Standard Laboratory Method of Testing Fans for Aerodynamic Performance Rating*, Air Movement and Control Association International, Inc., 30 W. University Drive, Arlington Heights, IL, 60004-1893 U.S.A.

ANSI/AMCA 300-05 *American National Standard Reverberant Room Method for Sound Testing of Fans*, Air Movement and Control Association International, Inc., 30 W. University Drive, Arlington Heights, IL 60004-1893 U.S.A.

ANSI S1.6-1984 (R1990) *American National Standard Preferred Frequencies, Frequency Levels, and Band Numbers for Acoustical Measurements*, Acoustical Society of America, 120 Wall Street, 32nd Floor, New York, 10005-3993 U.S.A.
(AMCA 1108-84-A0)

ANSI S1.11-1986, *American National Standard Specification for Octave-Band and Fractional-Octave Band Analog and Digital Filters*, Acoustical Society of America, 120 Wall Street, 32nd Floor, New York, 10005-3993 U.S.A.
(AMCA 1727-86-A0)

ANSI S1.13-1995, *Measurement of Sound Pressure Levels in Air*, Acoustical Society of America, 120 Wall Street, 32nd Floor, New York, 10005-3993 U.S.A.

ANSI S12.5-1990 *American National Standard Requirements for the Performance and Calibration of Reference Sound Sources*, Acoustical Society of America, 120 Wall Street, 32nd Floor, New York, 10005-3993 U.S.A.
(AMCA 1863-90-A0)

ANSI S12.12-1992 *American National Standard Engineering Method for the Determination of Sound Power Levels of Noise Sources Using Sound Intensity*, Acoustical Society of America, 120 Wall Street, 32nd Floor, New York, 10005-3993 U.S.A.
(AMCA 1850-92-A0)

ANSI S1.40-1984 (R1990), *American National Standard Specification for Acoustical Calibrators*, Acoustical Society of America, 120 Wall Street, 32nd Floor, New York, 10005-3993 U.S.A.
(AMCA 1895-84-A0)

ANSI/IEEE SI 10-1997 *Standard for Use of the International System of Units (SI): The Modern Metric System*, Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, N.J., 08854-4141 USA

3. Definitions / Units of Measure / Symbols

The acoustical definitions and symbols used in this standard are taken from appropriate ANSI standards whenever possible; some have been expanded to fit the specific needs of this standard. The non-acoustical terms and units used are defined in ANSI/AMCA 210, and are consistent with those used in ANSI/AMCA 300.

3.1 Definitions

3.1.1 Blade passage frequency (BPF). The frequency of fan impeller blades passing a single fixed object, calculated by the following formula.

$$BPF = \frac{\text{Number of Blades} \times \text{Fan RPM}}{60} \text{ Hz}$$

3.1.2 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 3.1.12, 3.1.13, and 3.1.14).

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

3.1.4 End reflection. A phenomenon which 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 at the end of a duct in a room, some of the sound is reflected back into the duct and does not escape into the room.

3.1.5 Frequency range of interest. For general purposes, the frequency range of interest includes the octave bands with mid-band frequencies from 63 Hz to 8000 Hz; i.e., from the lower cut-off of the 63 Hz band to the upper cut-off of the 8000 Hz band.

3.1.6 Informative. A term which indicates that the reference or annex is provided as advice to the user of this standard.

3.1.7 Nonducted fan. A fan without ducts connected to its inlet and outlet.

3.1.8 Normative. A term which indicates that the reference or annex contains requirements which are mandatory in order to comply with this standard.

3.1.9 Octave band. The interval between any two frequencies having a frequency ratio of two. The fan industry reports sound power levels in eight standardized octave bands which are shown in Table 1A and Table 1B.

3.1.10 Reference point of fan equipment. The position that is used to define and locate the measurement surface relative to the fan equipment under test (see Figures 1, 2, 3 and 4). For fan inlet (or

Table 1A - ANSI S1.11 Octave Bands

ANSI S1.11 band number	18	21	24	27	30	33	36	39
Nominal midband frequency (Hz)	63	125	250	500	1000	2000	4000	8000

Table 1B - ANSI S1.11 One-Third Octave Bands

ANSI S1.11 band number	17	18	19	20	21	2	23	24	25	26	27	28
Nominal midband frequency (Hz)	50	63	80	100	125	160	200	250	315	400	500	630
ANSI S1.11 band number	29	30	31	32	33	34	35	36	37	38	39	40
Nominal midband frequency (Hz)	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000

Table 2 - Symbols

Unless otherwise noted, subscript numbers refer to the AMCA Octave Band Number. The non-acoustical terms and units used are defined in ANSI/AMCA 210 and IEEE/ASTM SI 10-1997.

<u>Symbol</u>	<u>Description</u>	<u>SI Unit</u>	<u>IP Unit</u>
A_n	Area of n^{th} segment	m^2	ft^2
c	Speed of sound	m/s	ft/sec
d	Characteristic acoustic source dimension	m	ft
D	Duct diameter	m	ft
E_i	Duct inlet end correction	dB	dB
E_o	Duct outlet end correction	dB	dB
E_w	Adjustment to sound power level for duct end correction(s)	dB	dB
f	Frequency	Hz	Hz
I	Sound intensity	W/m^2	*
I	Sound intensity I at measurement location n	W/m^2	*
I_n	Surface average sound intensity	W/m^2	*
I_{ref}	Reference intensity, 1 pW/m^2 ($1.0 \times 10^{-12} \text{ W/m}^2$)	--	--
l	Measurement surface characteristic dimension (length)	m	ft
L_l	Sound intensity level (re. 1 pW/m^2)	dB	dB
$\overline{L}_l$	Surface average sound intensity level	dB	dB
L_{lf}	Fan sound intensity level	dB	dB
$\overline{L}_{\text{lf}}$	Surface average fan sound intensity level	dB	dB
L_{iq}	RSS sound intensity level	dB	dB
$\overline{L}_{\text{iq}}$	Surface average RSS sound intensity level	dB	dB
L_p	Sound pressure level (re. $20 \mu\text{Pa}$)	dB	dB
$\overline{L}_{\text{pb}}$	Background sound pressure level	dB	dB
$\overline{L}_{\text{pb}}$	Surface average background sound pressure level	dB	dB
L_{pbn}	$\overline{L}_{\text{pb}}$ at measurement location n	dB	dB
L_W	Sound power level (re. 1 pW)	dB	dB
L_{Wi}	Fan inlet sound power level (ducted inlet)	dB	dB
L_{Wm}	Fan total sound power level (non-ducted fan)	dB	dB
L_{Wmi}	Fan inlet sound power level (non-ducted inlet)	dB	dB
L_{Wmo}	Fan outlet sound power level (non-ducted outlet)	dB	dB
L_{Wo}	Fan outlet sound power level (ducted outlet)	dB	dB
L_{Wq}	RSS calibration sound power level	dB	dB
p	Sound pressure	Pa	*
p_{ref}	Reference sound pressure, $20 \mu\text{Pa}$ ($2.0 \times 10^{-5} \text{ Pa}$)	--	--
P_s	Fan static pressure	Pa	in. wg
P_t	Fan total pressure	Pa	in. wg
Q	Fan airflow rate	m^3/s	cfm
r	Measurement surface characteristic dimension (radius)	m	ft
R_W	Sound power level reference source adjustment	dB	dB
S	Surface area of measurement surface	m^2	ft^2
S_{ref}	Reference area, 1 m^2	--	--
W	Sound power	W	*
W_{ref}	Reference sound power, 1 pW (1.0×10^{-12})	--	--
δ_{WN}	Convergence index (with N measurement locations)	dB	dB
z	Measurement surface characteristic dimension (height above reflecting plane)	m	ft

* I-P units not used



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outlet) sound power testing of equipment with a single inlet (or single outlet), the reference point is the center of that inlet (or outlet). For fan total sound power testing of equipment with a single inlet and a single outlet, the reference point is the midpoint of the line that joins the centers of the inlet and the outlet. Generally, the reference point is the centroid of the centers of all inlets and outlets that contribute to the sound power level being determined.

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

3.1.12 Sound intensity level, L_I , in decibels. Ten times the logarithm (base 10) of the ratio of absolute value (magnitude) of the sound intensity, I , to the reference intensity, I_{ref} .

$$L_I = 10 \log_{10} \left(\frac{|I|}{I_{\text{ref}}} \right) \text{ dB}$$

3.1.13 Sound power level, L_W , in decibels. Ten times the logarithm (base 10) of the ratio of the sound power W to the reference power W_{ref} .

$$L_W = 10 \log_{10} \left(\frac{W}{W_{\text{ref}}} \right) \text{ dB}$$

3.1.14 Sound pressure level, L_p , in decibels. Ten times the logarithm (base 10) of the square of the ratio of the sound pressure, p , to the reference pressure, p_{ref} . Unless otherwise stated, the sound pressure, p , is the root-mean-square (rms) pressure.

$$L_p = 10 \log_{10} \left(\frac{p}{p_{\text{ref}}} \right)^2 \text{ dB}$$

3.2 Symbols

See Table 2 (page 3).

4. Instruments and Methods of Test

4.1 Sound pressure microphones

Pressure-sensing microphones shall comply with the requirements of ANSI S12.12.

4.2 Sound intensity probes

The sound intensity probe shall consist of two pressure-sensing microphones, and comply with the requirements of ANSI S12.12.

Note: To cover the entire frequency range of interest, it may be necessary to use more than one probe or microphone spacing.

4.3 Frequency analyzer

An octave band or one-third octave band filter set shall meet or exceed the Order 3, Type 1-D, requirements of ANSI S1.11.

4.4 Reference sound source (RSS)

The reference sound source should comply with the requirements of ANSI S12.5.

4.4.1 The RSS shall be a small, modified, direct-driven centrifugal fan having maximum overall dimensions of 610 mm (2 ft) or less.

4.4.2 The RSS shall produce steady, broadband sound over at least the frequency range from 50 Hz to 10,000 Hz. It shall comply in all respects with the performance requirements of ANSI S12.5 except for the spectral characteristics of the 50 Hz and 10,000 Hz one-third octave bands, where the sound power may deviate by up to 6 dB from the sound level of the adjacent one-third octave band. The sound power output shall be high enough so that the sound pressure and sound intensity levels shall be greater than the background noise levels. See Section 7.2.

4.4.3 The RSS shall be equipped with vibration isolators to minimize vibration transmission from the RSS into the structure of the room. The degree of isolation should be 20 dB or more. If metal springs are used as vibration isolators, rubber pads shall be used between the isolator and the structure of the room.

4.4.4 To ensure compliance with the stability requirements of ANSI S12.5, all operating parts of the RSS shall be rigidly and permanently attached. No rubbing or wearing parts shall be permitted (except lubricated bearings) and protection shall be provided against corrosion.

4.4.5 The RSS calibration shall consist of a determination of the sound power level radiated by the source when it is in operation on a reflecting plane with radiation into a free field above that plane. The calibration shall be in accordance with the requirements of ANSI S12.5, or as provided in Annex F. The maximum time interval since calibration shall not exceed that specified by the manufacturer, or three years, whichever is shorter.

Note: The RSS is used to qualify the performance of the sound intensity measurement system and

personnel, and to determine a sound power level adjustment for the specific site conditions. To be used for these purposes, the RSS must be of appropriate type, be calibrated accurately and be properly maintained.

4.5 Frequency response of instrumentation system

The frequency response of the instrumentation system shall be flat over the frequency range of interest within the tolerances given in Table 3, applied as outlined in ANSI S12.12.

Note 1: For sound intensity measurements, the use of two or more different configurations of the intensity probe, or different probes, may be required to cover the entire frequency range in conformance with Table 3.

Note 2: The useful frequency range for accurate sound intensity measurements is dependent upon the character of the sound field. Care shall be taken to verify that sound intensity measurements are accurate in the actual measurement environment.

Table 3 - Tolerances for the Instrumentation System

One-third Octave Band (Hz)	Tolerance (dB)
50-80	±1.5
100-4000	±1.0
5000-8000	±1.5
10,000	±2.0

4.6 Transducer and instrumentation system calibration checks

Before and after each series of sound power determination the following calibration checks shall be performed. A calibration check of the entire measuring system at one or more frequencies within the frequency range of interest shall be made for each microphone. An acoustical calibrator conforming to ANSI S1.40, and having an accuracy of ±0.5 dB or better, shall be used for this purpose. In conformance with ANSI 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 system over the entire frequency range of interest shall be performed periodically, at intervals as recommended by the manufacturer(s), but not more than two years.

In addition to the calibration check, the field check

procedure for sound intensity measurement specified by the manufacturer shall be performed. If no field check procedure is specified, the following procedure shall be performed:

The intensity probe shall be placed at the measurement surface, oriented normal to the surface, at a position where the noise is characteristic for the fan equipment under test. The sound intensity shall be measured. The intensity probe shall be rotated through 180 degrees and placed with its acoustical center in the same position as the initial measurement. The sound intensity shall be measured again. The intensity probe should be mounted on a stand or other mechanical device so that its acoustical center retains the same position when the probe is rotated. For the octave band with the highest level, the absolute difference between the two levels shall be less than the value in Table 4 for the measuring equipment to be acceptable. The two sound intensities shall be of opposite sign.

4.7 Performance verification

Periodically, the performance of the instrumentation system shall be verified by determining the sound power of a reference sound source using the procedures specified in ANSI S12.12. This verification shall be performed monthly by qualified personnel (see Section 6.2) or at the time of sound measurements if this occurs at intervals greater than one month apart.

The sound power level determined for the reference source shall differ from its calibrated value over the frequency range of interest by no more than the tolerance given in Table 5.

Table 4 - Tolerance for Difference in Sound Intensity Levels for Field Check

Octave Band (Hz)	Difference (dB)
63-125	1.5
250-4000	1.0
8000	1.5

Table 5 - Tolerance for Sound Power Level Determined for Reference Sound Source

Octave Band (Hz)	Tolerance (dB)
63	±5.0
125	±3.0
250-500	±2.0
1000-4000	±1.5
8000	±2.0

