STANDARD

ANSI/AMCA Standard 301-22

Methods for Calculating Fan Sound Ratings from Laboratory Test Data

An American National Standard
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ANSI Accredited Standards Developer

Air Movement and Control Association International

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Methods for Calculating Fan Sound Ratings from Laboratory Test Data

Methods for Calculating Fan Sound Ratings from Laboratory Test Data

1. Purpose

This document establishes standard methods for calculating fan sound ratings from laboratory test data.

2. Scope

This standard applies to any fan, if a test standard exists to measure its fan sound power levels.

3. References

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

ANSI S3.4-1980 (ASA 37-1980) (R2003), American National Standard Procedure for the Computation of Loudness of Noise, Acoustical Society of America, Melville, NY, USA.

ANSI/AMCA Standard 99-16, Standards Handbook, Air Movement and Control Association International Inc., Arlington Heights, IL, USA.

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

ANSI/AMCA Standard 300-14, Reverberant Room Method for Sound Testing of Fans, Air Movement and Control Association International Inc., Arlington Heights, IL, USA.

ANSI/AMCA Standard 320-13, Laboratory Methods of Sound Testing of Fans Using Sound Intensity, Air Movement and Control Association International Inc., Arlington Heights, IL, USA.

ANSI/ASA S1.42-2020, Design Response of Weighting Networks for Acoustical Measurements, Acoustical Society of America, Melville, NY, USA.

ISO 5136:2003(E), Acoustics — Determination of sound power radiated into a duct by fans and other air-moving devices — In-duct method, International Organization for Standardization, Geneva, Switzerland.

4. Definitions, Symbols and Subscripts

4.1 Definitions

For the purposes of this standard, the definitions given in ANSI/AMCA Standard 99, ANSI/AMCA Standard 210 and ANSI/AMCA Standard 300 apply.

4.2 Units of measure

The primary units used in this standard are The International System of Units, also known as Le Systéme International d'Unités (SI), with inch-pound (I-P) units given as the secondary reference.

4.3 Symbols and subscripts

See Table 1 for the symbols and subscripts used in this standard.

Table 1 — Symbols and Subscripts

Symbols	Description	SI Units	I-P Units
B	Slope of extrapolated line for reduced frequencies (frequencies greater than those tested)	dimensionless	
D	Impeller diameter	mm	in.
F	Frequency	Hz	Hz
f_{bp}	Frequency, blade pass	Hz	Hz
K	System resistance parameter	Pa/(m^3/s)^2	(in. wg)/cfm^2
K_D	System resistance normalized for impeller diameter	[Pa/(m^3/s)^2]mm^4	[(in. wg)/cfm^2]in^4
L_p	Sound pressure level (re 2.0 × 10^{-5} Pa, 0.0002 μbar)	dB	dB
L_W	Sound power level (re 1.0 × 10^{-12} W, 1 picowatt)	dB	dB
L_WA	Sound power level, A-weighted (re 1.0 × 10^{-12} W)	dBA	dBA
L_{WG}	Generalized sound power level (re 1.0 × 10^{-12} W)	dB	dB
L_{Wi}	Sound power level at the inlet (re 1.0 × 10^{-12} W)	dB	dB
L_{WK}	Specific sound power level (re 1.0 × 10^{-12} W)	dB	dB
L_{Wmi}	Measured sound power level from the inlet	dB	dB
L_{Wmo}	Measured sound power level from the outlet	dB	dB
L_{Wo}	Sound power level at the outlet (re 1.0 × 10^{-12} W)	dB	dB
$L_{Wo}A$	Sound power level at the outlet, A-weighted	dBA	dBA
$L_{W,fw}$	Sound power level of full-width fan	dB	dB
$L_{W,pw}$	Sound power level of partial-width fan	dB	dB
N	Fan rotational speed	rpm	rpm
P_s	Fan static pressure	Pa	in. wg
$P_{s,max}$	Maximum fan static pressure	Pa	in. wg
P_t	Fan total pressure	Pa	in. wg
$P_{t,max}$	Maximum fan total pressure	Pa	in. wg
Q	Fan airflow rate	m^3/s	cfm
Q_{fw}	Volume flow rate of full-width fan	m^3/s	cfm
Q_{max}	Maximum fan airflow rate	m^3/s	cfm
Q_{pw}	Volume flow rate of partial-width fan	m^3/s	cfm
S	Sones (hemispherical or spherical)	sone	sone
s_i	Octave band loudness index	sone	sone
s_m	Maximum octave band loudness index	sone	sone
X	Reduced frequency	dimensionless	
ρ	Test density	kg/m^3	lbm/ft^3

Subscript	Description
C	Converted or desired variable (e.g., X_c, N_c, D_c, Q_c, etc.)
R, ref	Reference values

5. Calculation of Sound Power Ratings

5.1 General

Fan-generated sound has a variety of sources. These include aerodynamic and mechanical vibration as well as electrical sources that determine the fan's overall acoustic performance. Sound power level is the established metric for quantifying fan-generated sound. Test standards, such as ANSI/AMCA Standard 300, ANSI/AMCA Standard 320 and ISO 5136 describe procedures to test and measure sound power of a fan.

It is desirable to report fan sound power levels across the entire fan performance envelope. However, practical limitations of test laboratory capability and large data requirements often limit the number of tested sizes, speeds and points of operation. Fan laws for fan sound performance are not as reliable as the familiar fan laws for fan aerodynamic performance, nor are they universally accepted. It is for this reason that sound power ratings are calculated largely by interpolation of available data. This section describes methods for calculating the sound power ratings from base tests.

The basic building blocks for these calculations are the sound power data for a given fan operating at a constant speed. Sound power spectra, in the form of one-third octave or full octave band data, shall be available for at least three points over the usable portion of the air performance curve. Each of these spectra are referred to as "determinations." Determinations are used to calculate sound power levels at other rating points.

The base test determinations are chosen on either side of the rated point of operation. The preferable quantity used as the basis for interpolating the point of operation over most of the fan curve is the system resistance parameter, but pressure also is acceptable over the relatively straight rise on the right side of the curve. Airflow is acceptable over much of the curve and is the only option if interpolation is to extend close to shut off. (See Annex A for further discussion and illustrations.) When both the diameter and speed are changed, a diameter-independent variable shall be used (see Table 2).

Table 2 — Quantities, Variables and Diameter-Independent Variables

Quantity	Variable	Diameter-Independent Variable
Airflow	Q	% Q_{max}
Pressure	P	% P_{max}
System resistance parameter	$K = \left(\frac{P}{Q^2}\right)$	$K_D = \left(\frac{P}{Q^2}\right) D^4$

Note: P can be either fan static (P_s) or fan total pressure (P_t).

Base test data may not be available at the extreme points of operation, e.g., wide open delivery, where sound power levels are usually highest. If the required point of operation is outside the range of determinations tested, extrapolation can be used toward wide open delivery, but only if the resulting sound power level (L_W) is equal to or higher than the value calculated from the nearest determination. If the extrapolation result for any of the sound power levels is below that of the nearest determination, the value from the nearest determination shall be used. Extrapolation is not allowed towards shut off past the last base test point.

Sound determinations may be available at multiple speeds and fan sizes. These additional data, especially at multiple speeds, can greatly enhance the accuracy of the methods described in the following procedure. Calculation of sound power levels from these data to other rating points follow several different procedures depending on the extent of available sound power data. The procedures involve applying fan scaling laws and a variety of interpolation techniques.

To improve the accuracy of the sound power prediction, calculations shall be performed using one-third octave band data as opposed to full octave band data, when available.

5.2 Reduction of sound power data to reference values

Traditional sound power scaling methods begin with normalizing or reducing sound power spectra to reference values at reduced frequencies. This is done to conserve computational resources that in the past involved graphical layouts, slide rule calculations or relatively slow electronic computations. Modern computers effectively have eliminated the need to convert sound power to reference values. However, for historical consistency, the reduction to reference values is described in this standard.

It is evident from equations 5.1 and 5.14 (or equations 5.2 and 5.15) that the sound power levels at rated speeds and sizes can be converted directly from the test speed and size data without first being reduced to reference values. However, it shall be noted that a conversion to reduced band frequencies is required because blade pass frequency changes with speed. This adjustment is necessary due to the presence of a tone at the blade pass frequency. (Sections 5.2.3 and 5.2.4)

One of two reduction methods can be used. The first, called the generalized sound power method (see Section 5.2.1), reduces sound power data to a reference speed and diameter. The second, called the specific sound power method (see Section 5.2.2), reduces the sound power to unit flow rate and unit fan total pressure. The aerodynamic fan laws can be used to show that the two methods produce the same results.

Using either of these approaches, the first step is to reduce the available sound power data to reference values. All subsequent calculations will begin with these values.

5.2.1 Generalized sound power

The generalized sound power for each frequency band shall be calculated using the following:

$$L_{WG} = L_W - 50\log\left(\frac{N}{N_R}\right) - 70\log\left(\frac{D}{D_R}\right) \qquad \text{Eq. 5.1}$$

Where:

N = Test fan speed
D = Test fan impeller diameter

The reference values N_R and D_R can be any value but traditionally have been 1,000 rpm and 508 mm (20 in.), respectively.

5.2.2 Specific sound power

The specific sound power for each frequency band shall be calculated using the following:

$$L_{WK} = L_W - 10\log\left(\frac{Q}{Q_R}\right) - 20\log\left(\frac{P_t}{P_{tR}}\right) \qquad \text{Eq. 5.2}$$

Where:

Q = Test fan flow rate
P_t = Test fan total pressure

The reference values for flow rate (Q_R) and fan total pressure (P_{tR}) can be any value, but traditionally, have been noted in I-P units, or 0.000472 m^3/s (1 cfm) and 249 Pa (1 in. wg), respectively.

5.2.3 Reduced frequency

In addition to reducing sound power values, slowing fan speed reduces band frequencies. The reduced frequency for each band shall be calculated using the following:

$$X = 10\log\left(\frac{f}{N}\right) + 20 \qquad \text{Eq. 5.3}$$

Where:

f = Band center frequency
N = Test fan speed
See Table 3 for center frequencies.

Reduced sound power data often is required outside the range of tested frequencies. To cover this range, the reduced sound power spectrum is extended on either end (see Figure 1). For reduced frequencies lower than those tested, the reduced sound power at the lowest reduced frequency shall be used. For reduced frequencies greater than those tested, the reduced sound power levels shall be extrapolated along a line passing through the highest frequency point. The slope of this line, *b*, is established by the two highest full octave bands or, through linear regression of the six highest one-third octave bands.

For full octaves:

$$b = \frac{(L_{WK,G_8} - L_{WK,G_7})}{(X_8 - X_7)} \qquad \text{Eq. 5.4}$$

For one-third octaves:

$$b = \frac{\sum_{i=19}^{24}\left((X_i - \bar{X})\left(L_{WK,G_i} - \overline{L_{WK,G}}\right)\right)}{\sum_{i=19}^{24}(X_i - \bar{X})^2} \qquad \text{Eq. 5.5}$$

These calculations are repeated for each sound power determination to form the reduced sound power and reduced frequencies. Subsequent calculations to other points of rating will use these reduced sound power spectra. Therefore, it may be desirable to store or publish these reduced sound power spectra instead of the original sound power levels.

5.2.4 Conversion of reduced spectra to rated speed

The reduced sound power spectra from the base tests at each of the required determinations are converted to the rated values of X_c for each band.

$$X_c = 10\log\left(\frac{f}{N_c}\right) + 20 \qquad \text{Eq. 5.6}$$

Where:

f = Band center frequency
N_c = Rated fan speed

The reduced values of L_{WGc} or L_{WKc} corresponding to the new value of X_c are either read off a graph (see Figure 2) or simply interpolated from the reduced values obtained through Section 5.2.

Because fan sound often includes a tone at the blade pass frequency (f_{bp}), a correction shall be made to account for the tone's full value. The blade pass frequency is calculated using the following formula:

$$f_{bp}(Hz) = \frac{Number\ of\ blades \times N}{60} \qquad \text{Eq. 5.7}$$

In the frequency band that features the rated fan's blade pass frequency, the reduced sound power level (L_{WGc} or L_{WKc}) is compared with the value (L_{WG} or L_{WK}) of the base test blade pass frequency. If the value of the original blade pass frequency is higher, the higher value is used (see Figure 2).

5.3 Calculation of reduced sound power at a new point of operation

Calculation of the sound power at a new point of rating begins with the reduced sound power and reduced frequency data.

The methods described here consider several basic scenarios:

1. Reduced sound power calculated from determinations obtained at a single speed.
2. Reduced sound power calculated at a speed bounded by two tested speeds.
3. Reduced sound power calculated from tests of a smaller diameter fan.

Various forms of interpolation and extrapolation are performed on each value of the reduced sound power spectrum. First, the reduced sound power spectra are calculated for the rated values of X_c as in Section 5.2.4. This step accounts for the shift in frequency content with fan speed. Next, these reduced sound spectra for surrounding determinations are interpolated to match the required point of operation. If test data exists for tip speeds above and below the rated fan tip speed, the spectra are interpolated again based on tip speed. When the final reduced sound spectrum is established, the reduced values are converted back to sound power levels.

5.3.1 Base sound data at a single speed

Sound power from determinations obtained at a single base speed, N_1, to a new speed, N_c, are depicted in Figure 3. The base test determinations on either side of the required point of operation are identified in Figure 3 as points A and B. The sound power spectra at these two points are the basis for the calculation of sound power levels at the rated values of Q_c and P_c.

The reduced spectra, L_{WGc} or L_{WKc}, for the converted values of X_c at determinations A and B are interpolated based on the system resistance parameter, airflow or pressure. The interpolation based on the system resistance parameter K_D is shown below and in Figure 4. Please refer to Section 5.1 to select the basis of interpolation. This interpolation is repeated for each value in the spectra:

$$L_{WGc} = L_{WGc,A} + \frac{K_{Dc} - K_{D,A}}{K_{D,B} - K_{D,A}}\left(L_{WGc,B} - L_{WGc,A}\right) \qquad \text{Eq. 5.8}$$

or

$$L_{WKc} = L_{WKc,A} + \frac{K_{Dc} - K_{D,A}}{K_{D,B} - K_{D,A}}\left(L_{WKc,B} - L_{WKc,A}\right) \qquad \text{Eq. 5.9}$$

If the required point of operation, K_{Dc}, falls outside the tested determinations, extrapolation can be used from the two nearest determinations, but only if the resulting sound power level, L_W, is equal to or higher than the value calculated from the nearest determination. If the resulting sound power level, L_W, is lower, use only the value resulting from the nearest determination. This applies for each value of the spectrum individually.

Once the reduced sound power spectrum is established, the rated sound power levels can be calculated as in Section 5.4.

5.3.2 Base sound data at multiple speeds

Sound power from determinations obtained at multiple base speeds, N_1 and N_2, to an intermediate speed, N_c, is depicted in Figure 5. The base test determinations on either side of the required point of operation are identified in Figure 5 as points A, B, D and E. The reduced spectra at each of these points, as determined in Section 5.2.4, are the basis for the calculation of sound power levels at the rated values of Q_c and P_c.

The reduced spectra, L_{WGc} or L_{WKc}, for the converted values of X_c at determinations A and B are interpolated based on the system resistance parameter, airflow or pressure. The same procedure is repeated for determinations D and E. The two resulting spectra can be thought of as two separate estimates of the rated fan's reduced sound power, one from N_1 and one from N_2. These two spectra then are interpolated based on speed to arrive at the final calculated reduced sound power:

$$L_{WGc} = L_{WGc,N1} + \frac{N_c - N_1}{N_2 - N_1}\left(L_{WGc,N2} - L_{WGc,N1}\right) \qquad \text{Eq. 5.10}$$

or

$$L_{WKc} = L_{WKc,N1} + \frac{N_c - N_1}{N_2 - N_1}\left(L_{WKc,N2} - L_{WKc,N1}\right) \qquad \text{Eq. 5.11}$$

If the rated speed is higher than all tested speeds, only the estimate from the highest tested speed is used. If the rated speed is below the lowest tested speed, extrapolation can be used, but only if the result is greater than or equal to the reduced sound power level (L_{WG} or L_{WK}).

5.3.3 Base sound data at a smaller diameter

Sound power levels from a smaller fan diameter, D_1, can be rated to a larger diameter, D_c. If the rated tip speed is between two adjacent base test tip speeds, the two base tests shall be used for interpolation. This is shown in the following:

$$D_1 \le D_c$$

and

$$D_1 N_1 \le D_c N_c \le D_1 N_2$$

Note: Interpolation between speeds shall use a common base test size.

If the tip speed for the rated fan is above the tip speed for all base tests, the base test with the highest tip speed shall be used alone.

Depicted in Figure 6, sound power from determinations generally is obtained at multiple base tip speeds, D_1N_1 and D_1N_2, and is rated to an intermediate tip speed, D_cN_c. The base test determinations on either side of the required point of operation are identified in Figure 6 as points A, B, D and E. The reduced spectra at each of these points, as determined in Section 5.2.4, are the basis for calculating sound power levels at the rated values of Q_c and P_c.

The reduced spectra, L_{WGc} or L_{WKc}, for the converted values of X_c at determinations A and B are interpolated based on the system resistance parameter, airflow or pressure as noted in Section 5.3.1. The same procedure is repeated for determinations D and E. The two resulting spectra then are interpolated based on tip speed to arrive at a final estimate of the reduced sound power.

$$L_{WGc} = L_{WGc,N1} + \frac{N_c D_c - N_1 D_1}{N_2 D_1 - N_1 D_1}\left(L_{WGc,N2} - L_{WGc,N1}\right) \qquad \text{Eq. 5.12}$$

or

$$L_{WKc} = L_{WKc,N1} + \frac{N_c D_c - N_1 D_1}{N_2 D_1 - N_1 D_1}\left(L_{WKc,N2} - L_{WKc,N1}\right) \qquad \text{Eq. 5.13}$$

If the rated tip speed is higher than all tested tip speeds, only the estimate from the highest tested tip speed is used. If the rated tip speed is below the lowest tested tip speed, extrapolation can be used, but only if the result is a higher reduced sound power level.

5.4 Conversion of reduced sound spectrum to sound power

The result of Section 5.3 is a spectrum of the reduced sound power levels rated to the required diameter, speed and point of operation. The final reduced sound power values are converted to sound power levels at the required operating point for each frequency band using the following:

$$L_{Wc} = L_{WGc} + 50\log\left(\frac{N_c}{N_R}\right) + 70\log\left(\frac{D_c}{D_R}\right) \qquad \text{Eq. 5.14}$$

or

$$L_{Wc} = L_{WKc} + 10\log\left(\frac{Q_c}{Q_{cR}}\right) + 20\log\left(\frac{P_{tc}}{P_{tcR}}\right) \qquad \text{Eq. 5.15}$$

5.5 Effect of air density

Sound power levels can be adjusted for density as follows:

$$L_{Wref} = L_w + 20\log\left(\frac{\rho ref}{\rho}\right) \qquad \text{Eq. 5.16}$$

Where:

ρ = Test density
ρref = Reference density
L_W = Sound power level calculated from test data
L_{Wref} = Sound power level at reference density

The formula above can be used for laboratory ambient air temperatures from 0-60°C (32-140°F) or when ρ_{ref}/ρ is less than 1.14. If the magnitude of the correction is equal to or greater than 3 dB, the correction should be used with caution. If a correction to any sound pressure values is needed, the correction is 10 times the logarithm rather than 20 times:

$$L_{Pref} = L_P + 10\log\left(\frac{\rho ref}{\rho}\right) \qquad \text{Eq. 5.17}$$

6. Method of Calculating Sound Ratings in *L_WA*, Sound Power Levels A-Weighted

The A-weighted sound power level shall be calculated using the following procedures:

For each octave or one-third octave band, use the Table 3 values to determine the L_WA value for each band and adjust the sound power levels.

A single number L_WA value is calculated with logarithmic addition of the L_WA values for each octave band.

$$L_WA = 10\log\left(10^{L_WA_1/10} + 10^{L_WA_2/10} + \cdots + 10^{L_WA_n/10}\right) \qquad \text{Eq. 6.1}$$

Where:

n = 8 for calculations using full octave bands
n = 24 for calculations using one-third octave bands

7. Method of Calculating Sound Ratings in Sones

7.1 Sone

One sone is, by definition, the loudness of a sound with a frequency of 1,000 Hz and a sound pressure of 0.02 microbar (40 dB).

7.1.1 Hemispherical sones

The hemispherical sone used to rate fans is based on the sound pressure level at a distance of 1.52 m (5 ft) from the acoustic center of the fan in a hemispherical free field.

For each full octave or one-third octave band, convert the measured sound power levels from the inlet or outlet in decibels (re 1.0 × 10^{-12} W) to sound pressure level at a distance of 1.52 m (5 ft) from the acoustic center of the fan in a hemispherical free field using the following formula:

$$L_P = L_{Wmi} - 11.5 \quad \text{Eq. 7.1}$$

$$L_P = L_{Wmo} - 11.5 \quad \text{Eq. 7.2}$$

Note: These equations use sea level air properties given in ANSI/AMCA Standard 99: 15°C, 101.32 kPa and an acoustic impedance of 416.8489 Pa·s/m.

For full octave band calculations, find the loudness index for each full octave band sound pressure level in Table 4. Add the loudness indices and multiply the sum by 0.3. Add 0.7 times the highest *s* value to obtain the total loudness, *S*, in spherical sones:

$$S = 0.3\,(s_1 + s_2 + s_3 + \ldots + s_8) + 0.7s_m \quad \text{Eq. 7.3}$$

Where:

S = Hemispherical sones (or spherical sones in Section 7.1.2)
$s_{i(1-8)}$ = Octave band loudness index number
s_m = Highest octave band loudness index number

For one-third octave band calculations, find the loudness index for each one-third octave band sound pressure level in Table 5. Add the loudness indices and multiply the sum by 0.15. Add 0.85 times the highest *s* value to obtain the total loudness, *S*, in spherical sones:

$$S = 0.15\,(s_1 + s_2 + s_3 + \ldots + s_{24}) + 0.85s_m \quad \text{Eq. 7.4}$$

Where:

S = Hemispherical sones (or spherical sones in Section 7.1.2)
$s_{i(1-24)}$ = One-third octave band loudness index number
s_m = Highest one-third octave band loudness index number

7.1.2 Spherical sones

The spherical sone used to rate fans is based on the sound pressure level at a distance of 1.52 m (5 ft) from the acoustic center of the fan in a spherical free field.

For each full octave or one-third octave band, convert the measured sound power levels from the inlet or outlet in decibels (re 1.0 × 10^{-12} W) to sound pressure level at a distance of 1.52 m (5 ft) from the acoustic center of the fan in a spherical free field using the following formula:

$$L_P = L_{Wmi} - 14.65 \quad \text{Eq. 7.5}$$

$$L_P = L_{Wmo} - 14.65 \quad \text{Eq. 7.6}$$

Notes:

1. These equations are based on an acoustic impedance of 400 Pa·s/m.
2. The spherical sone calculation from full octave band or one-third octave band sound pressure values are performed in the same manner as described for hemispherical sones except that spherical L_P is substituted for hemispherical L_P.

Table 3 — Reference Frequencies and A-Weighting Corrections (ANSI/ASA S1.42)

Full Octave Bands				
AMCA Band	**Center Frequency *f* (Hz)**	**Upper Frequency *f* (Hz)**	**Lower Frequency *f* (Hz)**	**A-Weighting Adjustment (dB)**
1	63	90	45	-26.22
2	125	180	90	-16.19
3	250	355	180	-8.67
4	500	710	355	-3.25
5	1000	1400	710	0.00
6	2000	2800	1400	+1.20
7	4000	5600	2800	+0.96
8	8000	11200	5600	-1.15

One-Third Octave Bands				
AMCA Band	**Center Frequency f (Hz)**	**Upper Frequency f (Hz)**	**Lower Frequency f (Hz)**	**A-Weighting Adjustment (dB)**
1	50	56	45	-30.27
	63	71	56	-26.22
	80	90	71	-22.40
2	100	112	90	-19.14
	125	140	112	-16.19
	160	180	140	-13.24
3	200	224	180	-10.85
	250	280	224	-8.67
	315	355	280	-6.64
4	400	450	355	-4.77
	500	560	450	-3.25
	630	710	560	-1.91
5	800	900	710	-0.79
	1000	1120	900	0.00
	1250	1400	1120	+0.58

6	1600	1800	1400	+0.99
	2000	2240	1800	+1.20
	2500	2800	2240	+1.27
7	3150	3550	2800	+1.20
	4000	4500	3550	+0.96
	5000	5600	4500	+0.55
8	6300	7100	5600	-0.12
	8000	9000	7100	-1.15
	10000	11200	9000	-2.49

Table 4 — Loudness Index for Full Octave Bands, *s*

Band Pressure Level, L_p (dB)	Full Octave Band (Hz)							
	63	125	250	500	1000	2000	4000	8000
6								-0.02
7								0.02
8								0.06
9							-0.02	0.10
10							0.02	0.14
11							0.06	0.18
12						-0.02	0.10	0.22
13						0.02	0.14	0.26
14						0.06	0.18	0.30
15					-0.02	0.10	0.22	0.35
16					0.02	0.14	0.26	0.40
17					0.06	0.18	0.30	0.45
18					0.10	0.22	0.35	0.50
19					0.14	0.26	0.40	0.55
20				-0.03	0.18	0.30	0.45	0.61
21				0.02	0.22	0.35	0.50	0.67
22				0.07	0.26	0.40	0.55	0.73
23				0.12	0.30	0.45	0.61	0.80
24				0.16	0.35	0.50	0.67	0.87
25				0.21	0.40	0.55	0.73	0.94

Band Pressure Level, L_p (dB)	Full Octave Band (Hz)							
	63	125	250	500	1000	2000	4000	8000
26			-0.03	0.26	0.45	0.61	0.80	1.02
27			0.02	0.31	0.50	0.67	0.87	1.10
28			0.07	0.37	0.55	0.73	0.94	1.18
29			0.12	0.43	0.61	0.80	1.02	1.27
30			0.16	0.49	0.67	0.87	1.10	1.35
31			0.21	0.55	0.73	0.94	1.18	1.44
32		-0.03	0.26	0.61	0.80	1.02	1.27	1.54
33		0.02	0.31	0.67	0.87	1.10	1.35	1.64
34		0.07	0.37	0.73	0.94	1.18	1.44	1.75
35		0.12	0.43	0.80	1.02	1.27	1.54	1.87
36		0.16	0.49	0.87	1.10	1.35	1.64	1.99
37		0.21	0.55	0.94	1.18	1.44	1.75	2.11
38	-0.03	0.26	0.62	1.02	1.27	1.54	1.87	2.24
39	0.02	0.31	0.69	1.10	1.35	1.64	1.99	2.38
40	0.07	0.37	0.77	1.18	1.44	1.75	2.11	2.53
41	0.12	0.43	0.85	1.27	1.54	1.87	2.24	2.68
42	0.16	0.49	0.94	1.35	1.64	1.99	2.38	2.84
43	0.21	0.55	1.04	1.44	1.75	2.11	2.53	3.0
44	0.26	0.62	1.13	1.54	1.87	2.24	2.68	3.2
45	0.31	0.69	1.23	1.64	1.99	2.38	2.84	3.4
46	0.37	0.77	1.33	1.75	2.11	2.53	3.0	3.6
47	0.43	0.85	1.44	1.87	2.24	2.68	3.2	3.8
48	0.49	0.94	1.56	1.99	2.38	2.84	3.4	4.1
49	0.55	1.04	1.68	2.11	2.53	3.0	3.6	4.3
50	0.62	1.13	1.82	2.24	2.68	3.2	3.8	4.6
51	0.69	1.23	1.96	2.38	2.84	3.4	4.1	4.9
52	0.77	1.33	2.11	2.53	3.0	3.6	4.3	5.2
53	0.85	1.44	2.24	2.68	3.2	3.8	4.6	5.5
54	0.94	1.56	2.38	2.84	3.4	4.1	4.9	5.8
55	1.04	1.68	2.53	3.0	3.6	4.3	5.2	6.2

Band Pressure Level, L_p (dB)	Full Octave Band (Hz)							
	63	125	250	500	1000	2000	4000	8000
56	1.13	1.82	2.68	3.2	3.8	4.6	5.5	6.6
57	1.23	1.96	2.84	3.4	4.1	4.9	5.8	7.0
58	1.33	2.11	3.0	3.6	4.3	5.2	6.2	7.4
59	1.44	2.27	3.2	3.8	4.6	5.5	6.6	7.8
60	1.56	2.44	3.4	4.1	4.9	5.8	7.0	8.3
61	1.68	2.61	3.6	4.3	5.2	6.2	7.4	8.8
62	1.82	2.81	3.8	4.6	5.5	6.6	7.8	9.3
63	1.96	3.0	4.1	4.9	5.8	7.0	8.3	9.9
64	2.11	3.2	4.3	5.2	6.2	7.4	8.8	10.5
65	2.27	3.5	4.6	5.5	6.6	7.8	9.3	11.1
66	2.44	3.7	4.9	5.8	7.0	8.3	9.9	11.8
67	2.61	4.0	5.2	6.2	7.4	8.8	10.5	12.6
68	2.81	4.3	5.5	6.6	7.8	9.3	11.1	13.5
69	3.00	4.7	5.8	7.0	8.3	9.9	11.8	14.4
70	3.20	5.0	6.2	7.4	8.8	10.5	12.6	15.3
71	3.5	5.4	6.6	7.8	9.3	11.1	13.5	16.4
72	3.7	5.8	7.0	8.3	9.9	11.8	14.4	17.5
73	4.0	6.2	7.4	8.8	10.5	12.6	15.3	18.7
74	4.3	6.6	7.8	9.3	11.1	13.5	16.4	20.0
75	4.7	7.0	8.3	9.9	11.8	14.4	17.5	21.4
76	5.0	7.4	8.8	10.5	12.6	15.3	18.7	23.0
77	5.4	7.8	9.3	11.1	13.5	16.4	20.0	24.7
78	5.8	8.3	9.9	11.8	14.4	17.5	21.4	26.5
79	6.2	8.8	10.5	12.6	15.3	18.7	23.0	28.5
80	6.7	9.3	11.1	13.5	16.4	20.0	24.7	30.5
81	7.2	9.9	11.8	14.4	17.5	21.4	26.5	33.0
82	7.7	10.5	12.6	15.3	18.7	23.0	28.5	35.3
83	8.2	11.1	13.5	16.4	20.0	24.7	30.5	38
84	8.8	11.8	14.4	17.5	21.4	26.5	33.0	41
85	9.4	12.6	15.3	18.7	23.0	28.5	35.3	44

Band Pressure Level, L_p (dB)	Full Octave Band (Hz)							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
86	10.0	13.5	16.4	20.0	24.7	30.5	38	48
87	10.8	14.4	17.5	21.4	26.5	33.0	41	52
88	11.7	15.3	18.7	23.0	28.5	35.3	44	56
89	12.6	16.4	20.0	24.7	30.5	38	48	61
90	13.6	17.5	21.4	26.5	33.0	41	52	66
91	14.7	18.7	23.0	28.5	35.3	44	56	71
92	16.0	20.0	24.7	30.5	38	48	61	77
93	17.3	21.4	26.5	33.0	41	52	66	83
94	18.7	23.0	28.5	35.3	44	56	71	90
95	20.0	24.7	30.5	38	48	61	77	97
96	21.4	26.5	33.0	41	52	66	83	105
97	23.0	28.5	35.3	44	56	71	90	113
98	24.7	30.5	38	48	61	77	97	121
99	26.5	33.0	41	52	66	83	105	130
100	28.5	35.3	44	56	71	90	113	139
101	30.5	38	48	61	77	97	121	149
102	33.0	41	52	66	83	105	130	160
103	35.3	44	56	71	90	113	139	171
104	38	48	61	77	97	121	149	184
105	41	52	66	83	105	130	160	197
106	44	56	71	90	113	139	171	211
107	48	61	77	97	121	149	184	226
108	52	66	83	105	130	160	197	242
109	56	71	90	113	139	171	211	260
110	61	77	97	121	149	184	226	278
111	66	83	105	130	160	197	242	298
112	71	90	113	139	171	211	260	320
113	77	97	121	149	184	226	278	
114	83	105	130	160	197	242	298	
115	90	113	139	171	211	260	320	

Band Pressure Level, L_p (dB)	Full Octave Band (Hz)							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
116	97	121	149	184	226	278		
117	105	130	160	197	242	298		
118	113	139	171	211	260	320		
119	121	149	184	226	278			
120	130	160	197	242	298			

Note: This table is based on ANSI S3.4-1980 (ASA 37-1980) (R2003) with modifications to extend indices to lower levels. That standard has been superseded by newer versions but, for the purposes of this standard, the 1980 version is being maintained.

Table 5 — Loudness Index for One-third Octave Bands, *s*

Band Pressure Level, L_P (dB)	One-third Octave Band (Hz)																							
	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
6																							-0.02	
7																						-0.02	0.02	
8																					-0.02	0.02	0.06	0.00
9																				-0.02	0.02	0.06	0.10	0.04
10																			-0.02	0.02	0.06	0.10	0.14	0.08
11																		-0.02	0.02	0.06	0.10	0.14	0.18	0.12
12																	-0.02	0.02	0.06	0.10	0.14	0.18	0.22	0.16
13																-0.02	0.02	0.06	0.10	0.14	0.18	0.22	0.26	0.20
14															-0.02	0.02	0.06	0.10	0.14	0.18	0.22	0.26	0.30	0.24
15														-0.02	0.02	0.06	0.10	0.14	0.18	0.22	0.26	0.30	0.35	0.28
16													-0.02	0.02	0.06	0.10	0.14	0.18	0.22	0.26	0.30	0.35	0.40	0.33
17													0.02	0.06	0.10	0.14	0.18	0.22	0.26	0.30	0.35	0.40	0.45	0.38
18												-0.03	0.06	0.10	0.14	0.18	0.22	0.26	0.30	0.35	0.40	0.45	0.50	0.43
19												0.02	0.10	0.14	0.18	0.22	0.26	0.30	0.35	0.40	0.45	0.50	0.55	0.48
20											-0.03	0.07	0.14	0.18	0.22	0.26	0.03	0.35	0.40	0.45	0.50	0.55	0.61	0.53
21											0.02	0.12	0.18	0.22	0.26	0.30	0.35	0.40	0.45	0.50	0.55	0.61	0.67	0.58
22										-0.03	0.07	0.16	0.22	0.26	0.30	0.35	0.40	0.45	0.50	0.55	0.61	0.67	0.73	0.64
23										0.02	0.12	0.21	0.26	0.30	0.35	0.40	0.45	0.50	0.55	0.61	0.67	0.73	0.80	0.50
24									-0.03	0.07	0.16	0.26	0.30	0.35	0.40	0.45	0.50	0.55	0.61	0.67	0.73	0.80	0.87	0.77
25									0.02	0.12	0.21	0.30	0.35	0.40	0.45	0.50	0.55	0.61	0.67	0.73	0.80	0.87	0.94	0.84
26								-0.03	0.07	0.16	0.26	0.35	0.40	0.45	0.50	0.55	0.61	0.67	0.73	0.80	0.87	0.94	1.02	0.91
27								0.02	0.12	0.21	0.31	0.40	0.45	0.50	0.55	0.61	0.67	0.73	0.80	0.87	0.94	1.02	1.10	0.98
28							-0.03	0.07	0.16	0.26	0.37	0.45	0.50	0.55	0.61	0.67	0.73	0.80	0.87	0.94	1.02	1.10	1.18	1.06
29							0.02	0.12	0.21	0.31	0.43	0.50	0.55	0.61	0.67	0.73	0.80	0.87	0.94	1.02	1.10	1.18	1.27	1.14
30						-0.03	0.07	0.16	0.26	0.37	0.49	0.55	0.61	0.67	0.73	0.80	0.87	0.94	1.02	1.10	1.18	1.27	1.35	1.23
31						0.02	0.12	0.21	0.31	0.43	0.55	0.61	0.67	0.73	0.80	0.87	0.94	1.02	1.10	1.18	1.27	1.35	1.44	1.31
32					-0.03	0.07	0.16	0.26	0.37	0.49	0.61	0.67	0.73	0.80	0.87	0.94	1.02	1.10	1.18	1.27	1.35	1.44	1.54	1.40
33					0.02	0.12	0.21	0.31	0.43	0.55	0.67	0.73	0.80	0.87	0.94	1.02	1.10	1.18	1.27	1.35	1.44	1.54	1.64	1.49
34				-0.03	0.07	0.16	0.26	0.37	0.49	0.62	0.73	0.80	0.87	0.94	1.02	1.10	1.18	1.27	1.35	1.44	1.54	1.64	1.75	1.59
35				0.02	0.12	0.21	0.31	0.43	0.55	0.69	0.80	0.87	0.94	1.02	1.10	1.18	1.27	1.35	1.44	1.54	1.64	1.75	1.87	1.70
36			-0.03	0.07	0.16	0.26	0.37	0.49	0.62	0.77	0.87	0.94	1.02	1.10	1.18	1.27	1.35	1.44	1.54	1.64	1.75	1.87	1.99	1.82
37			0.02	0.12	0.21	0.31	0.43	0.55	0.69	0.86	0.94	1.02	1.10	1.18	1.27	1.35	1.44	1.54	1.64	1.75	1.87	1.99	2.11	1.94
38		-0.03	0.07	0.16	0.26	0.37	0.49	0.62	0.77	0.94	1.02	1.10	1.18	1.27	1.35	1.44	1.54	1.64	1.75	1.87	1.99	2.11	2.24	2.06
39		0.02	0.12	0.21	0.31	0.43	0.55	0.69	0.86	1.02	1.10	1.18	1.27	1.35	1.44	1.54	1.64	1.75	1.87	1.99	2.11	2.24	2.38	2.18
40	-0.03	0.07	0.16	0.26	0.37	0.49	0.62	0.77	0.94	1.10	1.18	1.27	1.35	1.44	1.54	1.64	1.75	1.87	1.99	2.11	2.24	2.38	2.53	2.32
41	0.02	0.12	0.21	0.31	0.43	0.55	0.69	0.86	1.04	1.18	1.27	1.35	1.44	1.54	1.64	1.75	1.87	1.99	2.11	2.24	2.38	2.53	2.68	2.46
42	0.07	0.16	0.26	0.37	0.49	0.62	0.77	0.94	1.13	1.27	1.35	1.44	1.54	1.64	1.75	1.87	1.99	2.11	2.24	2.38	2.53	2.68	2.84	2.61
43	0.12	0.21	0.31	0.43	0.55	0.69	0.86	1.04	1.23	1.35	1.44	1.54	1.64	1.75	1.87	1.99	2.11	2.24	2.38	2.53	2.68	2.84	3.00	2.77
44	0.16	0.26	0.37	0.49	0.62	0.77	0.94	1.13	1.33	1.44	1.54	1.64	1.75	1.87	1.99	2.11	2.24	2.38	2.53	2.68	2.84	3.00	3.20	2.93
45	0.21	0.31	0.43	0.55	0.69	0.86	1.04	1.23	1.44	1.54	1.64	1.75	1.87	1.99	2.11	2.24	2.38	2.53	2.68	2.84	3.00	3.20	3.40	3.11
46	0.26	0.37	0.49	0.62	0.77	0.94	1.13	1.33	1.54	1.64	1.75	1.87	1.99	2.11	2.24	2.38	2.53	2.68	2.84	3.00	3.20	3.40	3.60	3.31
47	0.31	0.43	0.55	0.69	0.86	1.04	1.23	1.44	1.64	1.75	1.87	1.99	2.11	2.24	2.38	2.53	2.68	2.84	3.00	3.20	3.40	3.60	3.80	3.51
48	0.37	0.49	0.62	0.77	0.94	1.13	1.33	1.56	1.75	1.87	1.99	2.11	2.24	2.38	2.53	2.68	2.84	3.00	3.20	3.40	3.60	3.80	4.10	3.71
49	0.43	0.55	0.69	0.86	1.04	1.23	1.44	1.68	1.87	1.99	2.11	2.24	2.38	2.53	2.68	2.84	3.00	3.20	3.40	3.60	3.80	4.10	4.30	3.96
50	0.49	0.62	0.77	0.94	1.13	1.33	1.56	1.82	1.99	2.11	2.24	2.38	2.53	2.68	2.84	3.00	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.21

Band Pressure Level, L_P (dB)	One-third Octave Band (Hz)																							
	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
51	0.55	0.69	0.86	1.04	1.23	1.44	1.68	1.97	2.11	2.24	2.38	2.53	2.68	2.84	3.00	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.90	4.47
52	0.62	0.77	0.94	1.13	1.33	1.56	1.82	2.11	2.24	2.38	2.53	2.68	2.84	3.00	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.90	5.20	4.77
53	0.69	0.86	1.04	1.23	1.44	1.68	1.97	2.24	2.38	2.53	2.68	2.84	3.00	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.06
54	0.77	0.94	1.13	1.33	1.56	1.82	2.11	2.38	2.53	2.68	2.84	3.00	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.80	5.36
55	0.86	1.04	1.23	1.44	1.68	1.97	2.27	2.53	2.68	2.84	3.00	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.80	6.20	5.66
56	0.94	1.13	1.33	1.56	1.82	2.11	2.44	2.68	2.84	3.00	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	6.02
57	1.04	1.23	1.44	1.68	1.97	2.27	2.62	2.84	3.00	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	6.42
58	1.13	1.33	1.56	1.82	2.11	2.44	2.81	3.00	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	6.82
59	1.23	1.44	1.68	1.97	2.27	2.62	3.00	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	7.22
60	1.33	1.56	1.82	2.11	2.44	2.81	3.20	3.40	3.60	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	7.62
61	1.44	1.68	1.97	2.27	2.62	3.00	3.40	3.60	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	8.07
62	1.56	1.82	2.11	2.44	2.81	3.24	3.60	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	8.57
63	1.68	1.97	2.27	2.62	3.00	3.48	3.80	4.10	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	9.07
64	1.82	2.11	2.44	2.81	3.24	3.72	4.10	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	9.63
65	1.97	2.27	2.62	3.00	3.48	4.04	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	10.2
66	2.11	2.44	2.81	3.24	3.72	4.30	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	10.8
67	2.27	2.62	3.00	3.48	4.04	4.60	4.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	11.5
68	2.44	2.81	3.24	3.72	4.30	5.90	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	12.2
69	2.62	3.00	3.48	4.04	4.66	5.20	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	13.1
70	2.81	3.24	3.72	4.30	5.02	5.50	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	14.0
71	3.00	3.48	4.04	4.66	5.38	5.80	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	14.9
72	3.24	3.72	4.30	5.02	5.74	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	15.8
73	3.48	4.04	4.66	5.38	6.20	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	17.0
74	3.72	4.30	5.02	5.74	6.60	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	18.2
75	4.04	4.66	5.38	6.20	7.00	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	19.4
76	4.30	5.02	5.74	6.68	7.40	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	20.8
77	4.66	5.38	6.20	7.16	7.80	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	22.3
78	5.02	5.74	6.68	7.64	8.30	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	23.9
79	5.38	6.20	7.16	8.20	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	25.7
80	5.74	6.68	7.64	8.80	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	27.6
81	6.20	7.16	8.20	9.30	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	29.6
82	6.68	7.64	8.80	9.90	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	31.9
83	7.16	8.20	9.42	10.5	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	34.3
84	7.64	8.80	10.1	11.1	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	36.8
85	8.20	9.42	10.9	11.8	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	39.6
86	8.80	10.1	11.7	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	42.6
87	9.42	10.9	12.6	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	46.2
88	10.1	11.7	13.5	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	50.2
89	10.9	12.6	14.4	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	54.2
90	11.7	13.7	15.3	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	58.4
91	12.6	14.8	16.4	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	63.7
92	13.7	16.0	17.5	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	68.7
93	14.8	17.3	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	74.3
94	16.0	18.7	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	80.3
95	17.3	20.0	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	86.8

Band Pressure Level, L_P (dB)	One-third Octave Band (Hz)																							
	50	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**	**800**	**1000**	**1250**	**1600**	**2000**	**2500**	**3150**	**4000**	**5000**	**6300**	**8000**	**10000**
96	18.7	21.4	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	93.8
97	20.3	23.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	101
98	22.0	24.7	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	109
99	24.0	26.5	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	117
100	26.1	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	126
101	28.5	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	135
102	30.5	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	144
103	33.0	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	155
104	35.3	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	166
105	38.0	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	178
106	41.0	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	191
107	44.0	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	226	205
108	48.0	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	226	242	219
109	52.0	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	226	242	260	235
110	56.0	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	226	242	260	278	252
111	61.0	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	226	242	260	278	298	270
112	66.0	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	226	242	260	278	298		289
113	71.0	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	226	242	260	278	298			
114	77.0	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	226	242	260	278	298				
115	83.0	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	226	242	260	278	298					
116	90.0	97.0	105	113	121	130	139	149	160	171	184	197	211	226	242	260	278	298						
117	97.0	105	113	121	130	139	149	160	171	184	197	211	226	242	260	278	298							
118	105	113	121	130	139	149	160	171	184	197	211	226	242	260	278	298								
119	113	121	130	139	149	160	171	184	197	211	226	242	260	278	298									
120	121	130	139	149	160	171	184	197	211	226	242	260	278	298										
121	130	139	149	160	171	184	197	211	226	242	260	278	298											
122	139	149	160	171	184	197	211	226	242	260	278	298												
123	149	160	171	184	197	211	226	242	260	278	298													
124	160	171	184	197	211	226	242	260	278	298														
125	171	184	197	211	226	242	260	278	298															
126	184	197	211	226	242	260	278	298																
127	197	211	226	242	260	278	298																	
128	211	226	242	260	278	298																		
129	226	242	260	278	298																			
130	242	260	278	298																				
131	260	278	298																					
132	278	298																						
133	298																							
134																								

Note: This table is based on ANSI S3.4-1980 (ASA 37-1980) (R2003) with modifications to extend indices to lower levels. That standard has been superseded by newer versions but, for the purposes of this standard, the 1980 version is being maintained.

8. Figures

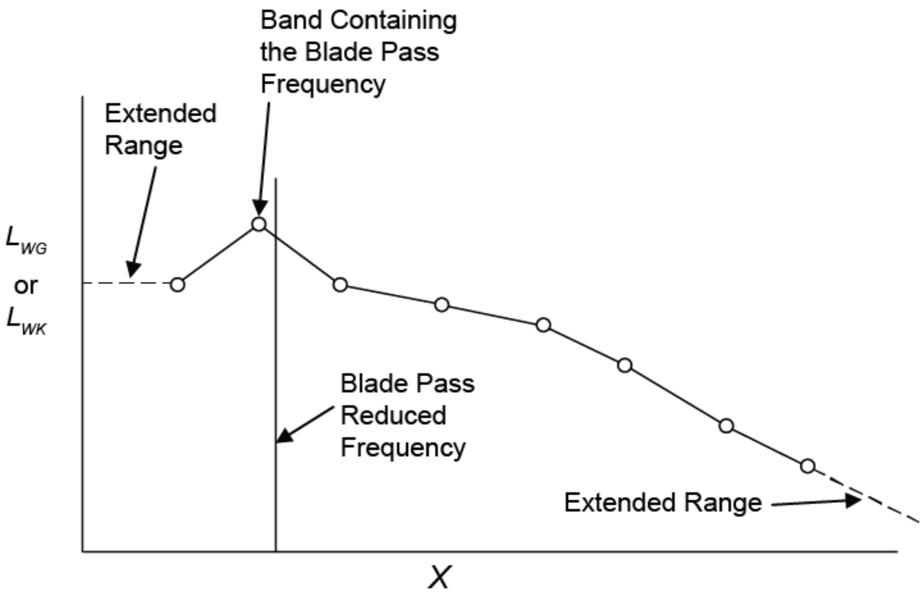

Figure 1 — Reduced Sound Power Spectrum of the Test Fan for a Single Determination

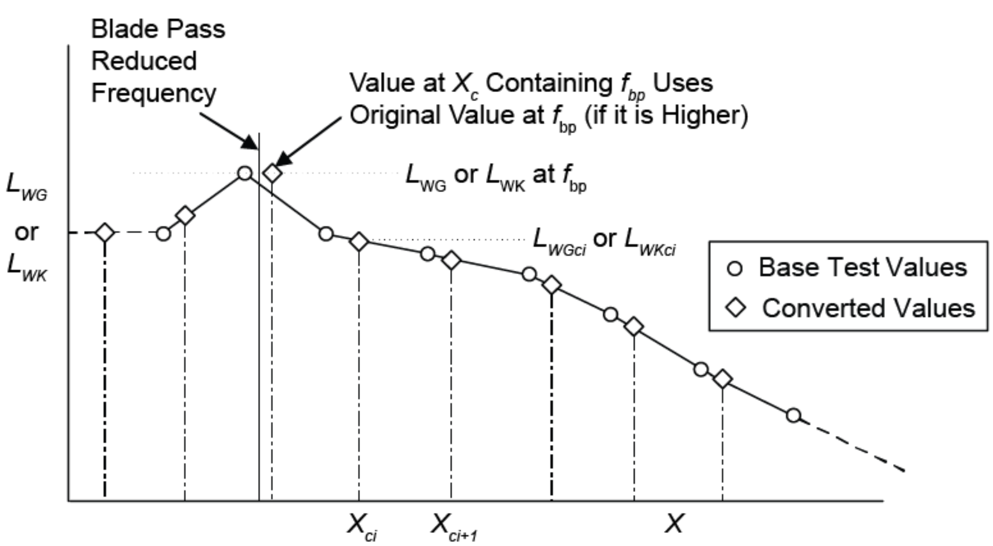

Figure 2 — Conversion of Reduced Spectrum to Rated X_c Values

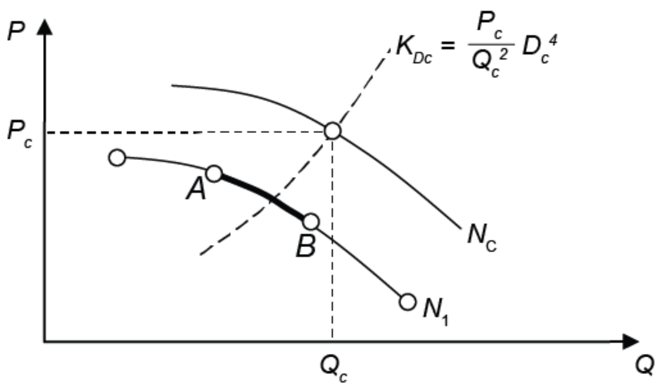

Figure 3 — Location of Determinations Used for Rating from Single Base Speed

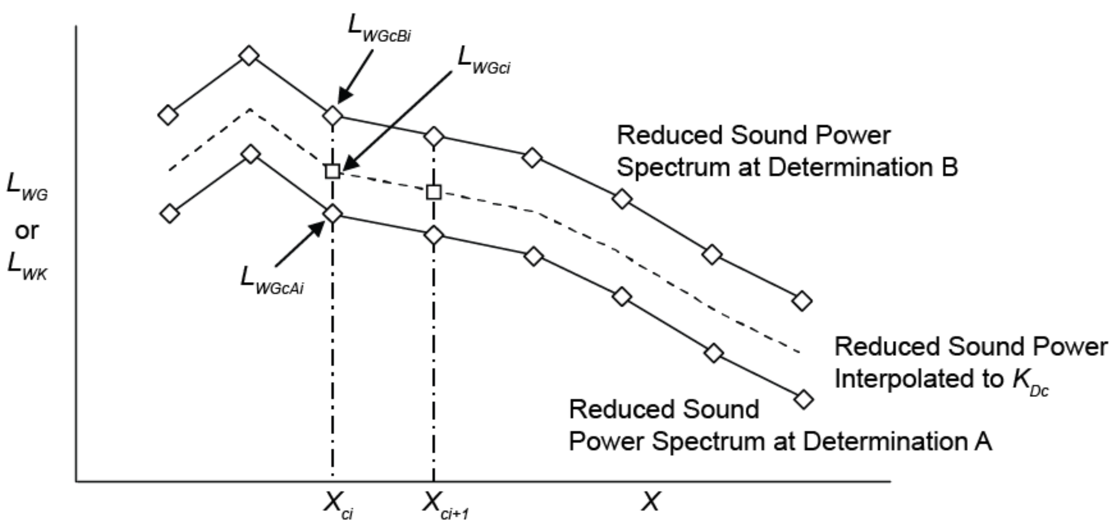

Figure 4 — Interpolation of Reduced Sound Spectra

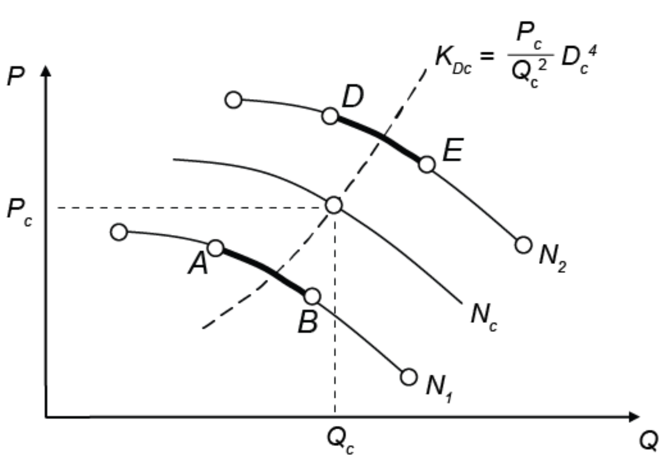

Figure 5 — Location of Determinations Used for Rating from Multiple Base Speeds

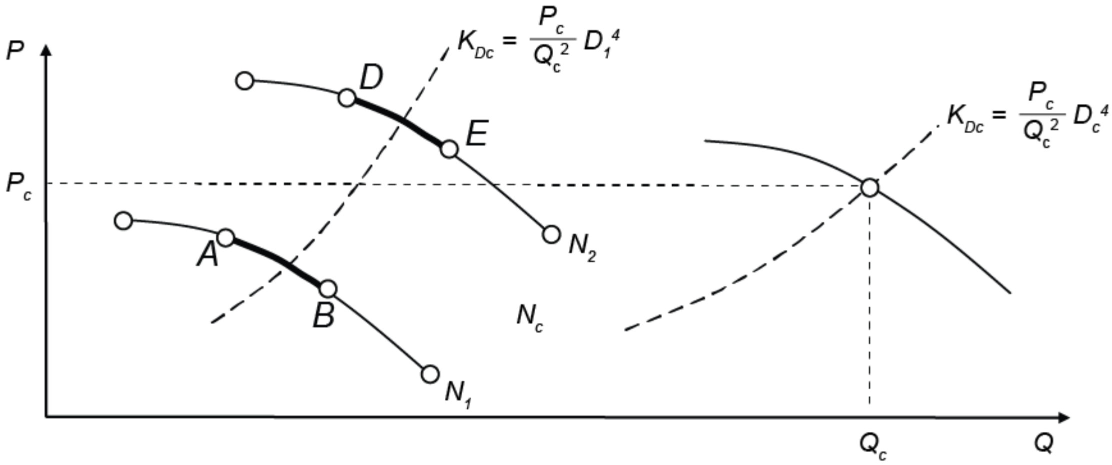

Figure 6 — Location of Determinations Used for Rating from a Smaller Fan Size

Annex A
Recommended Test Sizes, Speeds and Operating Points (Informative)

A.1 Test sizes

The fan manufacturer is responsible for determining the fan sizes to be tested and the number of tests that shall be performed to provide the data necessary for the development of certified ratings for each fan size. The following guidelines normally will provide a sufficient number of base test sizes:

1. The minimum test size shall be the same as the minimum catalog size.
2. Small fan sizes with impeller tip diameters under 305 mm (12 in.) should be tested individually.
3. Fan sizes with impeller tip diameters from about 305 mm (12 in.) to 914 mm (36 in.) should be tested in increments not to exceed a diameter ratio of 1.5.

   $$1 \leq \frac{D_C}{D} \leq 1.5$$

4. Ideally, the largest test size should be consistent with the maximum size cataloged. However, this usually is not practical because of limitations of the laboratory. For catalog sizes above tip diameters of 927 mm (36.5 in.), it is recommended that the test size be at least 927 mm (36.5 in.) and the tester use a test speed as recommended in Section A.2.

A.2 Test speeds

The fan manufacturer is responsible for determining the test speeds necessary to provide reliable sound data. Specific recommendations are contained in the following:

1. The minimum test fan speed should be within 5% of the minimum catalog speed for that size fan.
2. Intermediate test speeds should be no greater than 1.6 times the next lower test speed.
3. Test the maximum catalog speed, if possible. Otherwise, test the maximum speed achievable within the limits of the laboratory.
4. Test speed should be selected so that the blade pass frequency is not located close to either the upper limit or the lower limit of one-third octave bands. See Table 3 for band limits. Ideally, the speed should set the blade pass near the center of a one-third octave band.

A.3 Test fan operating points

The fan manufacturer is responsible for determining the number of operating points necessary to provide reliable sound data. Specific guidelines are contained in the following:

1. When more than one size or speed is being tested, base fan operating test points should be consistent with operation along corresponding points for fan curves of other speeds, often referred to as a system curve or system line. Doing so will ease the interpolation process. These test points may be expressed in terms the fan manufacturer prefers, such as “Percent Wide Open Volume,” “$P_{s,max}/P_s$,” “System Resistance Parameter,” etc.
2. Sound can vary drastically in particular areas of the fan curve; therefore, determining test points may not simply rely on equal spacing. Rather, more focus may be placed on areas of interest, such as free delivery, peak pressure, peak efficiency or end points of the catalog range. It is recommended to obtain direct test data for these points of interest rather than relying on interpolation.
3. It is good practice to obtain sound data such that the sound power values between adjacent operating points do not differ by more than 5 dB in any one-third octave band of interest.
4. The range of operating points should include the full aerodynamic performance selection range being cataloged. Traditionally, this would include points near free delivery, near the maximum pressure prior to stall, and approximately three or more well-spaced intermediate points (see Figure A.1). This maximum pressure does not necessarily correspond to shutoff but may be defined by stall, instability in pressure development and other

conditions. Identification of these points is necessary for use in interpolating sound data points for other fan sizes or speeds.

5. Unique characteristics of the fan and its corresponding catalog range, such as inflection points in the performance curve and points near the extremities of the operating range, should be considered when determining test points.
6. Figure A.2 shows the typical performance graphs for a forward-curved (FC) centrifugal fan. The peak efficiency point of an FC fan lies near the peak pressure point or slightly to its left. Therefore, the recommended operating range of this fan type normally includes the peak pressure point and extends left past the traditional stall point. Projecting sound data across the inflection points of fan curves by interpolation or extrapolation is not recommended. Should the extrapolation of data from one side of an inflection point be found to have a significant variance when predicted to the other side, this is an indication that the calculation is not suitable and more test data is required. The manufacturer is responsible for taking the appropriate number of determinations on each side and at peak pressure to ensure appropriate base data is gathered for interpolation.
7. Figure A.3 shows the typical performance curves of an adjustable pitch axial flow fan for a number of blade pitch angles. The following points should be noted:
    a. The effects of size, speed, blade pitch and hub ratio should be considered in the determination of test sizes and the number of required test determinations.
    b. The peak rated pressure and stall point of a given fan size varies with blade pitch. Consideration should be made to accurately depict the sound performance for all blade pitches when selecting test determinations.
    c. To ease interpolation, it is recommended that test determinations across a range of blade pitches within a given size be taken at the same fan static or fan total pressure.
8. Recommended basis for interpolation/extrapolation:
    a. It is up to the manufacturer to determine the most appropriate calculation basis for a given fan type. The method used should provide accurate sound power level data across the operating range.
    b. Section 5.1 describes three primary bases for calculation: airflow, fan pressure and system parameter.
    c. Figure A.1 – Typical Centrifugal Fan
        i. The region right of the stall curve can be calculated using any of the methods described in Section 5.1 of this standard.
    d. Figure A.2 – Typical Forward-Curved Fan
        i. The region right of the peak pressure can be calculated using any of the methods described in Section 5.1 of this standard.
        ii. The region left of the peak pressure is recommended to use the airflow or free-air percentage basis.
    e. Figure A.3 – Typical Axial Fan
        i. The region right of the stall curve can be calculated using any of the methods described in Section 5.1 of this standard.

A.4 Density correction

Where the air density differs from standard air at 1.2 kg/m^3 (0.075 lbm/ft^3) because of temperature, elevation, humidity, molecular weight or a combination of these factors, correction for density is allowable provided that the effect of a density change is compensated by using the formula given in Section 5.5.

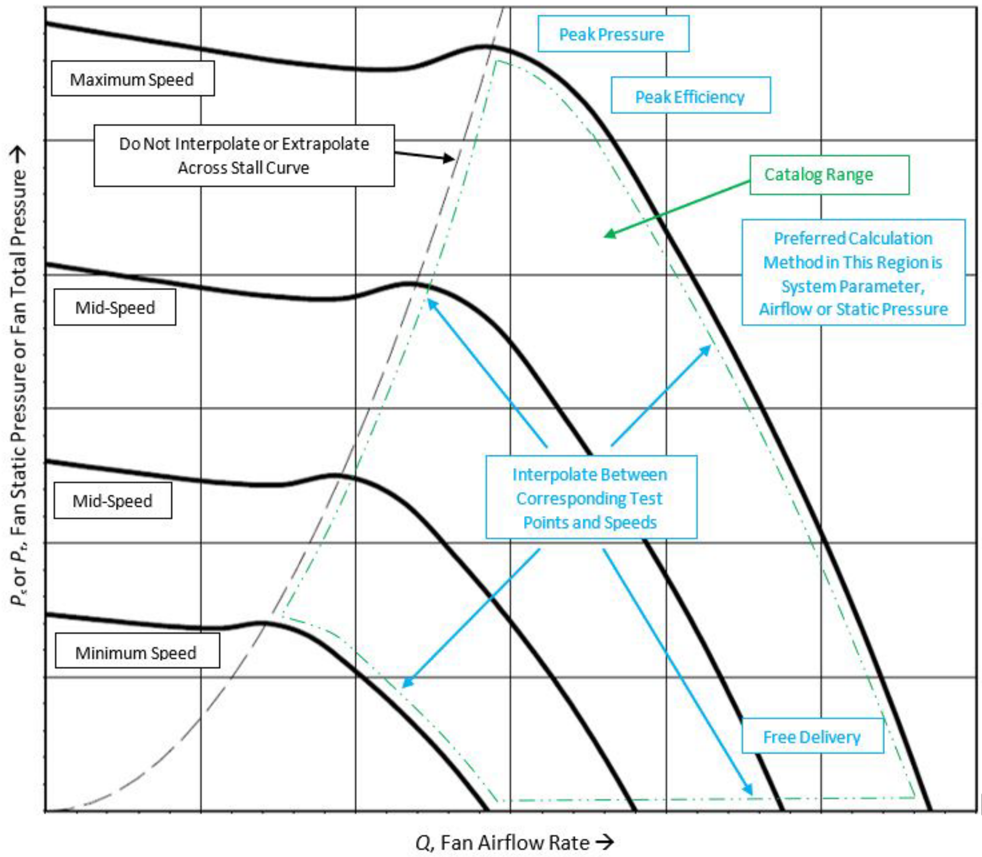

Figure A.1 — Typical Centrifugal Fan

Note: When using total pressure, the bottom of the curve will be past free delivery.

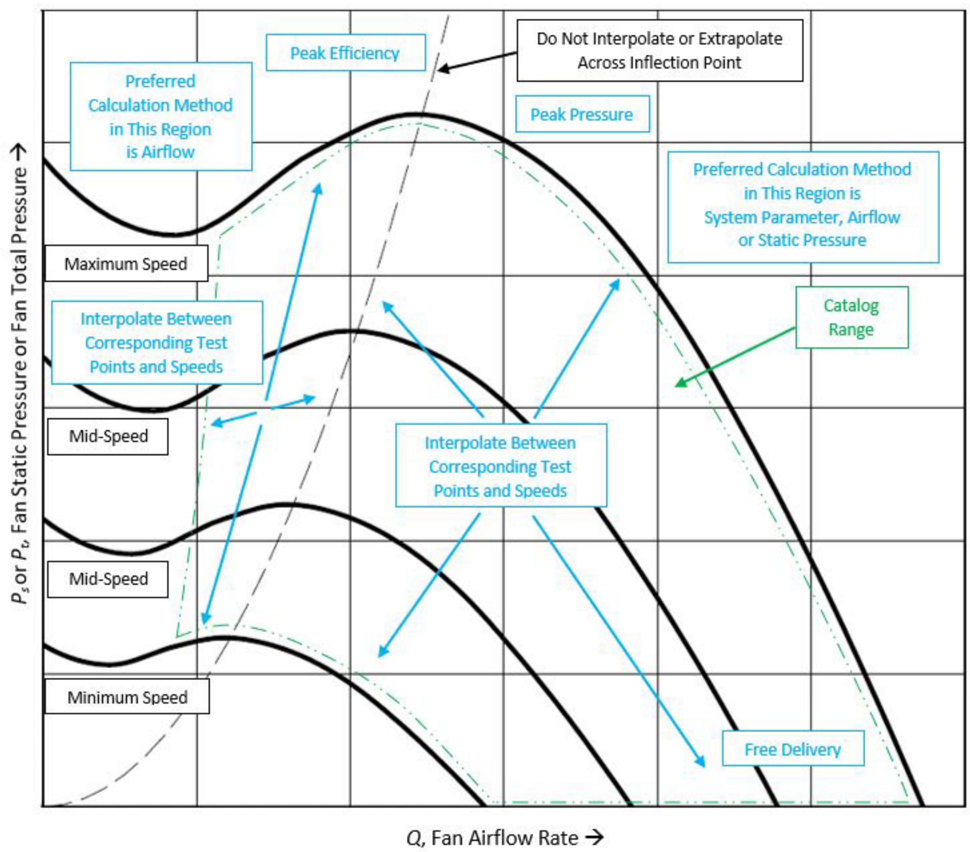

Figure A.2 — Typical Forward-Curved Fan

Note: When using total pressure, the bottom of the curve will be past free delivery.

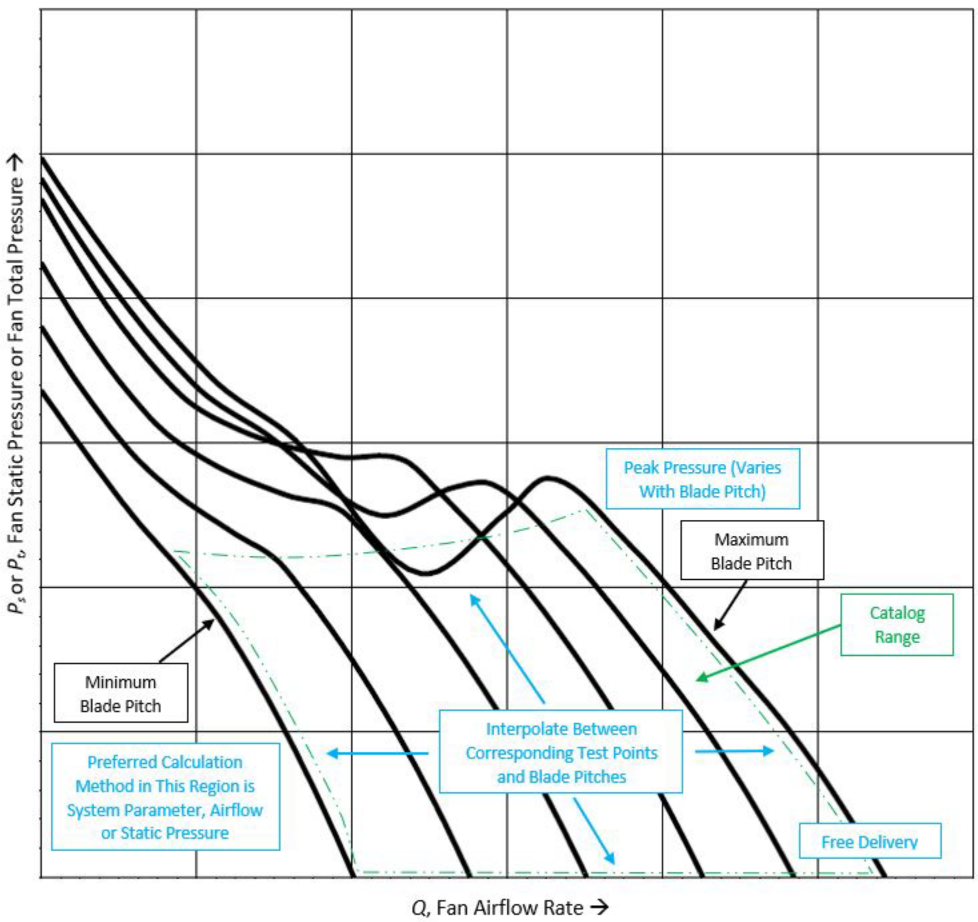

Figure A.3 — Typical Axial Fan

Note: When using total pressure, the bottom of the curve will be past free delivery.

Annex B
Logarithmic Addition of One-Third Octave Bands (Informative)

Analyzing sound power by one-third octave bands may result in improved accuracy for size-speed conversion procedures, particularly where a significant tone at the blade pass frequency exists.

One-third octave band L_W values may be converted to full octave band L_W values by logarithmic addition using the following formula:

$$L_W = 10\log\left(10^{L_{W1}/10} + 10^{L_{W2}/10} + 10^{L_{W3}/10}\right) \quad \text{Eq. B.1}$$

Where:

L_{W1}, L_{W2} and L_{W3} are one-third octave band sound power values in dB.

For example, the one-third octave band L_W values in bands centered at 800 Hz, 1,000 Hz and 1,250 Hz are 65 dB, 70 dB and 66 dB, respectively. The full octave band (L_W values), centered at 1,000 Hz, is calculated as follows:

$$\begin{aligned} L_W &= 10 \log \left(10^{6.5} + 10^{7.0} + 10^{6.6}\right) \\ &= 10\,(7.234) \\ &= 72.3 \text{ dB} \end{aligned}$$

Annex C
Presentation of Fan Sound Ratings (Normative)

C.1 Methods of presenting sound ratings in full octave band sound power levels

All octave band sound power levels for each fan size shall be presented in decibels (re 1.0 × 10^{-12} W) for each of the eight octave bands identified by mid-band frequencies (63, 125, 250, 500, 1,000, 2,000, 4,000 and 8,000 Hz) at various points of operation and speeds. For ducted products, ratings shall be presented for the same installation types tested. Where one-third octave sound test results are available, do the initial ratings calculations for the 24 one-third octave bands. Present the final data in 8 full octave bands. This will result in better accuracy.

C.2 Method of presenting A-weighted sound power values (L_WA)

For a given fan speed, L_WA values may be presented for various points of rating. A single value may be used, provided it is the highest value over the cataloged aerodynamic performance range.

C.3 Method of presenting sound ratings in sones

For a given fan speed, sone values may be presented for various points of rating. A single sone value may be used, provided it is the highest value over the cataloged range.

For a fan operating at a fan static pressure of 25 Pa (0.1 in. wg), the spherical sone value shall be presented, at a minimum. Spherical sone values may be presented for other operating points as well.

Annex D
Procedure for Calculating Sound Power Ratings from Test Results (Normative)

Table D.1 — Calculation of Sound Power Level Ratings from Test Results per ANSI/AMCA Standard 300 or ANSI/AMCA Standard 320, Figure 1, 2 or 3

Step	Description
1	Obtain ANSI/AMCA Standard 300, ANSI/AMCA Standard 320 or ISO 5136 results
2	Correct test results for density (if necessary)
3	Calculate L_{WG} or L_{WK} and X
4	Calculate Q and P_t for another fan diameter and speed using fan laws
5	Calculate new values of X_c
6	Determine L_{WGc} or L_{WKc}
7	Calculate L_{wi}, L_{Wo}, or L_{wi} and L_{Wo} for new diameter or speed

Annex E
Non-Geometrically Similar Fans (Informative)

E.1 Presenting double-width data from single-width tests

Tests of single-width, single-inlet (SWSI) centrifugal fans may be used as the basis for similarly symmetrical double-width, double-inlet (DWDI) fans of the same size and speed, at equivalent percentage-wide open volume or percentage-peak pressure, if three decibels are added to single-width L_W or L_WA values, where appropriate (see Annex A). L_W or L_WA values for double-width fans that are not symmetrical, such as those with internally mounted motors, cannot be calculated in this manner.

E.2 Presenting partial-width data from full-width impeller tests

Tests of full-width centrifugal fans may be used as the basis for similar partial-width centrifugal fans of the same size and speed, at equivalent percentage-wide open volume or percentage-peak pressure, where appropriate (see Annex A). Partial-width data is approximated by the following:

$$L_{W,pw} = L_{W,fw} + 10\log\left(\frac{Q_{pw}}{Q_{fw}}\right) \qquad \text{Eq. E.1}$$

Where:

$L_{W,pw}$ = Sound power level of partial-width fan
$L_{W,fw}$ = Sound power level of full-width fan
Q_{pw} = Volume flow rate of partial-width fan
Q_{fw} = Volume flow rate of full-width fan

This is calculated from a projection of width ratio or tests of partial-width impellers, as appropriate.

E.3 Interpolation of fan sound data on non-geometrically similar variables

Prior to interpolation for fans that are not geometrically similar (varying in blade pitch, hub-to-tip ratio, impeller width, solidity, etc.), sound power data at each boundary point may be reduced to the reference values using definitions and methods outlined in Section 5. Reduced uncertainty can be obtained if midrange test results based on the parameters listed above are known (see Figure A.3).

RESOURCES

AMCA Membership Information
http://www.amca.org/member

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