AHRI Standard 885 with Addendum 1 (formerly ARI Standard 885)

2008 Standard for

Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets

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AHRI STANDARD 885-2008
WITH ADDENDUM 1,

PROCEDURE FOR ESTIMATING OCCUPIED SPACE SOUND LEVELS IN THE APPLICATION OF AIR TERMINALS AND AIR OUTLETS

March 2011

Addendum 1 (dated March 2011) of AHRI Standard 885-2008, *Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets*, is provided as follows.

The particular additions are shown with shading and the deletions shown with ~~strikethroughs~~.

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Table 8. Step-By-Step Calculation for the Procedural Example of Figure 6

SOUND PATH			Octave Band Mid Frequency, Hz					
PATH #		NAME	125	250	500	1000	2000	4000
1		**Radiated and Induction Inlet**						
	C_1	Radiated and induction inlet L_w (from mfr's data, Table 5)	64	60	57	58	55	52
	E	Environmental Adjustment Factor (6.2)	-2	-1	0	0	0	0
	P	Ceiling/Space Effect, Table D14, Type 1 Ceiling	-16	-18	-20	-26	-31	-36
	1	Radiated path L_p at receiver location	46	41	37	32	24	16
2		**Duct ~~Breakout~~ Transmission Loss ~~Path~~**						
	D_1	Terminal discharge L_w (from mfr's data, Table 5)	66	65	62	62	62	60
	E	Environmental Adjustment Factor (6.2)	-2	-1	0	0	0	0
	I_1	5.0 ft [1.5 m] lined rectangular duct 12 in x 12 in [300 mm x 300 mm], 1.0 in [25 mm] FG (D1.3.2) (See Note 1)	-1	-4	-10	-22	-20	-9
	B	Duct transmission loss ~~breakout noise~~, 0.03 in [0.7 mm] (D1.2.4)	~~-24~~ 7	~~-27~~ 10	~~-30~~ 13	~~-33~~ 16	~~-36~~ 19	~~-41~~ 24
	P	Ceiling/Space Effect, Table D14, Type 1 Ceiling	-16	-18	-20	-26	-31	-36
	2	Duct breakout transmission loss ~~path~~ L_p at receiver location	~~23~~ 40	~~15~~ 32	~~2~~ 19	*	*	*
3		**Distribution Duct ~~Breakout~~Transmission loss ~~Path~~**						
	D_1	Terminal discharge L_w (from mfr's data, Table 5)	66	65	62	62	62	60
	E	Environmental Adjustment Factor (6.2)	-2	-1	0	0	0	0
	I_1	10 ft [3 m] lined rectangular duct 12 in x 12 in [300 mm x 300 mm], 1.0 in [25 mm] FG (D1.3.2) (see Note 2)	-2	-6	-16	-40	-40	-25
	T	Rectangular Tee attenuation entering branch duct (D1.4.4)	0	0	-1	-5	-7	-5
	F	Branch power division 50% split (D1.1)	-3	-3	-3	-3	-3	-3
	I_2	5.0 ft [1.5 m] unlined rectangular duct (D1.3)	0	0	0	0	0	0

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Table 8. Step-By-Step Calculation for the Procedural Example of Figure 6 (continued)

SOUND PATH			Octave Band Mid Frequency, Hz					
PATH #		NAME	125	250	500	1000	2000	4000
	B	Duct ~~breakout noise~~ transmission loss, 0.03 in [0.7 mm] (D1.2.4) (12 ~~ft~~ in x 12 ~~ft~~ in [300 mm x 300 mm], 10 ft [3 m] long)	~~-2~~ 4	~~-27~~ 7	~~-30~~ 10	~~-33~~ 13	~~-36~~ 16	~~-41~~ 21
	P	Ceiling/Space Effect, (D1.6) Table D14, Type 1 Ceiling	-16	-18	-20	-26	-31	-36
	3	Distribution duct ~~breakout~~ transmission loss L_p at receiver location	~~19~~ 39	~~10~~ 30	12	*	*	*
4	**Flexible Duct ~~Breakout~~ Transmission Loss ~~Path~~**							
	D_1	Terminal discharge L_w (from mfr's data, Table 5)	66	65	62	62	62	60
	E	Environmental Adjustment Factor (6.2)	-2	-1	0	0	0	0
	I_1	10 ft [3 m] lined rectangular duct 12 in x 12 in [300 mm x 300 mm], 1.0 in [25 mm] fiberglass D1.3.2 (see Note 2).	-2	-6	-16	-40	-40	-5
	T	Rectangular Tee attenuation entering branch duct (D1.4.4)	0	0	-1	-5	-7	-5
	F	Branch Power Division, 50% split, D1.1	-3	-3	-3	-3	-3	-3
	I_2	5.0 ft [1.5 m] unlined rectangular duct (D1.3)	0	0	0	0	0	0
	I_3	3.0 ft [0.9 m] lined 8 in [200 mm] diameter non-metallic flexible duct (D1.3.3)	-4	-7	-14	-15	-16	-8
	B	Duct transmission loss, 8 in [200 mm] diameter non-metallic flexible duct (D1.2.2)	-8	-8	-8	-9	-10	-13
	P	Ceiling/Space Effect, Table D14, Type 1 Ceiling.	-16	-18	-20	-26	-31	-36
	4	Flexible duct ~~breakout~~ transmission loss ~~path~~ L_p at receiver location	31	22	0	*	*	*
5	**Discharge Path**							
	D_1	Terminal discharge L_w (from mfr's data, Table 5)	66	65	62	62	62	60
	E	Environmental Adjustment Factor (6.2)	-2	-1	0	0	0	0
	I_1	10 ft [3 m] lined rectangular duct, 12 in x 12 in [300 mm x 300 mm], 1.0 in [25 mm] fiberglass (D1.3.2) (see Note 2)	-2	-6	-16	-40	-40	-5
	T	Rectangular Tee attenuation entering branch duct (D1.4.4)	0	0	-1	-5	-7	-5
	F	Branch Power Division , 50% split (D1.1)	-3	-3	-3	-3	-3	-3
	I_2	5.0 ft [1.5 m] unlined rectangular duct (D1.3)	0	0	0	0	0	0

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Table 8. Step-By-Step Calculation for the Procedural Example of Figure 6 (continued)

SOUND PATH		Octave Band Mid Frequency, Hz					
PATH #	NAME	125	250	500	1000	2000	4000
	I_3 5.0 ft [1.5 m] lined, 8 in [200 mm] diameter non-metallic flexible duct (D1.3.3)	-5	-10	-18	-19	-21	-12
	R End reflection Factor, 8.0 in [200 mm] diameter (D1.5)	-10	-5	-2	-1	0	0
	S Space Effect (5.0 ft [1.5 m], 2400 cu ft [67 m^3] room, Table D15)	-5	-6	-7	-8	-9	-10
	5 Discharge L_p at receiver location	39	34	15	*	*	25
6	**Outlet #1 Generated**						
	O_1 Outlet generated L_w (from mfr's data, Table 5)	40	43	46	46	44	42
	E Environmental Adjustment Factor (6.2)	-2	-1	0	0	0	0
	S Space Effect (5.0 ft [1.5 m], 2400 cu ft [67 m^3] room, Table D15)	-5	-6	-7	-8	-9	-10
	6 Outlet generated L_p at receiver location	33	36	39	38	35	32

* Less than zero dB

Note 1: For lined duct lengths up to 15 ft [4.5 m], take ½ duct insertion loss before calculating ~~breakout~~ transmission loss (max. 7.5 ft [2.3 m])

Note 2: The maximum recommended lined duct attenuation in any octave band is 40 dB. See D1.3.2.

The contributions of the six individual paths as shown on the acoustic model will be combined to obtain the total Sound Pressure Level, L_p at the receiver location. A similar calculation may be completed for various receiver locations (i.e., directly under the terminal or directly under the diffuser) in order to determine the acoustically critical receiver location.

The paths considered are:

1. Radiated and induction inlet
2. Duct Transmission Loss ~~Breakout~~
3. Distribution Duct Transmission Loss ~~Breakout~~
4. Flexible Duct Transmission Loss ~~Breakout~~
5. Discharge
6. Outlet #1 Generated

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Table 9. Summary – Combination of Path Results Using Logarithmic Addition, dB							
Path #	Description	Octave Band Mid Frequency, Hz					
		125	250	500	1000	2000	4000
1	Radiated and induction inlet path	46	41	37	32	24	16
2	Duct ~~breakout~~ transmission loss ~~path~~	~~23~~ 40	~~15~~ 32	~~2~~ 19	*	*	*
3	Distribution duct ~~breakout~~ transmission loss ~~path~~	~~19~~ 39	~~10~~ 30	~~0~~ 12	*	*	*
4	Flexible duct ~~breakout~~ transmission loss ~~path~~	31	22	0	*	*	*
5	Discharge path	39	34	15	*	*	~~26~~ 25
6	Outlet #1 generated path	33	36	39	38	35	32
Total L_p at receiver location check numbers here		~~47~~ 48	43	41	39	35	33

* less than zero dB

Note: In this example it can be seen that the critical paths are casing radiated (Path #1), discharge (Path #5) and outlet generated (Path #6).

6.6 *Additional Acoustic Models.* Examples of the acoustic paths involved with single/dual duct terminal boxes and integral diffuser terminals are illustrated in Figures 7 and 8. The associated path factor calculations are tabulated in the summary calculation Tables 10 and 11 which list the source of the attenuation data.

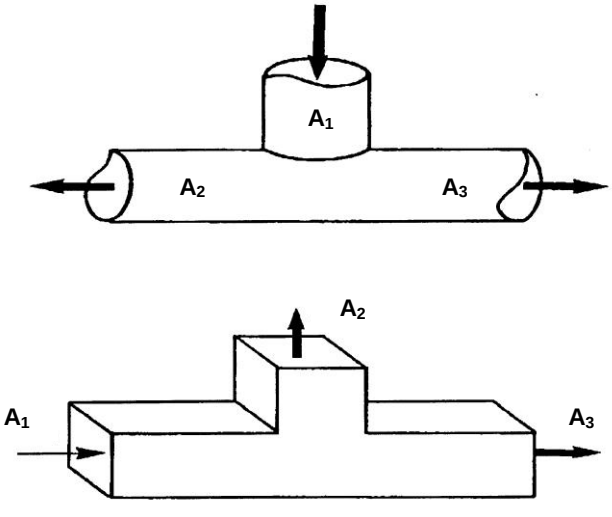


Figure D1. Branch Power Division

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Table D2. Power Level Division at Branch Takeoffs			
B/T	Division, dB	B/T	Division, dB
1.00	0	0.100	10
0.80	1	0.080	11
0.63	2	0.063	12
0.50	3	0.050	13
0.40	4	0.040	14
0.32	5	0.032	15
0.25	6	0.025	16
0.20	7	0.020	17
0.16	8	0.016	18
0.12	9	0.012	19

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D1.2 *Duct Transmission Loss, Lined or Unlined* B. Airborne acoustic energy within a duct can be transmitted through the duct walls. This transmission loss ~~path~~ is termed Duct ~~Breakout~~ Transmission Loss.

The amount of acoustic energy transmitted is independent of external or internal duct insulation; the transmission loss is dependent on the duct geometry.

D1.2.1 *Circular Sheet Metal Duct.* B is calculated from the transmission loss characteristics of the duct and from the cross sectional & surface areas of the duct (see Figure D2.).

$$B = TL_{out} - 10 \log (A_o/A_i) = L_{wi} - L_{wo}$$

Where:

A_o = $\pi d_o L$ (Duct Outer Surface Area), in^2 [mm^2]

A_i = $\pi \frac{d_i^2}{4}$ (Duct Internal Cross Sectional Area), in^2 [mm^2]

d_i = Inside Diameter, in [mm]

d_o = Outside Diameter, in [mm]

L = Length, in [mm]

L_{wi} = Sound Power Level at Duct Inlet, dB

L_{wo} = Sound Power Level Breaking Out of Ductwall, dB

TL_{out} = Transmission loss, dB

Values for TL_{out} are given in Table D3.

NOTE: The dimensions, d and L must be expressed in the same units. For single-wall ducts, $d_i = d_o$

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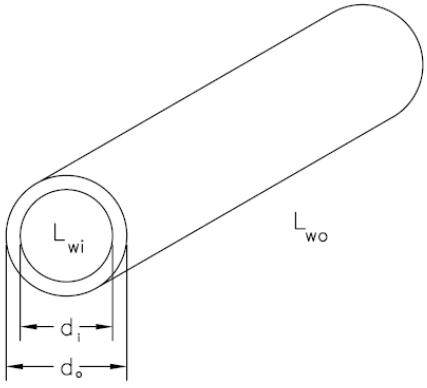


Figure D2. Circular Duct ~~Breakout~~ Transmission Loss

D1.2.2 *Flexible Duct, Lined & Unlined* $\triangledown_B$. Unlike circular sheet metal duct, radiated duct ~~breakout~~ transmission loss for flexible duct (according to 2007 ASHRAE Handbook, HVAC Applications) is not directly proportional to length. Most ~~breakout~~ transmission loss occurs in the first 1-2 ft [0.3 - 0.6 m] of the duct.

$\triangledown_B = L_{wi} - L_{wo}$

Values for TL_{out} for flexible duct are given in Table D4.

The values shown in Table D4 are for 10 ft [3 m] of length but can be used for any length up to 10 ft [3 m].

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Table D3. Transmission Loss Versus Frequency for Various Circular Metal Ducts[a] (Ref: D1.2.1), dB										
Duct Diameter in [mm]	Duct Type in [mm]	Duct Length ft [m]	Octave Band Mid Frequency, Hz							
			63	125	250	500	1000	2000	4000	8000
8 in [200 mm]	0.022 in [0.55 mm] long seam	15 ft [4.5 m]	(45)	(53)	55	52	44	35	34	26
14 in [350 mm]	0.028 in [0.70 mm] long seam	15 ft [4.5 m]	(50)	60	54	36	34	31	25	38
22 in [550 mm]	0.034 in [0.85 mm] long seam	15 ft [4.5 m]	(47)	53	37	33	33	27	25	43
32 in [800 mm]	0.034 in [0.85 mm] long seam	15 ft [4.5 m]	(51)	46	26	26	24	22	38	43
8 in [200 mm]	0.022 in [0.55 mm] spiral wound	10 ft [3 m]	(48)	(64)	(75)	(72)	56	56	46	29
14 in [350 mm]	0.022 in [0.55 mm] spiral wound	10 ft [3 m]	(43)	(53)	55	33	34	35	25	40
26 in [650 mm]	0.028 in [0.70 mm] spiral wound	10 ft [3 m]	(45)	50	26	26	25	22	36	43
26 in [650 mm]	0.064 in [1.6 mm] spiral wound	10 ft [3 m]	(48)	(53)	36	32	32	28	41	36
32 in [800 mm]	0.034 in [0.85 mm] spiral wound	10 ft [3 m]	(43)	42	28	25	26	24	40	45
14 in [350 mm]	0.028 in [0.70 mm] long seam with two 90° elbows	15 ft [4.5 m] plus elbows	(50)	54	52	34	33	28	22	34

[a] Parentheses indicate measurements in which background noise has produced a greater uncertainty than usual in the data. Parentheses are estimated values.

Table D4. ~~Breakout~~ Transmission Loss Versus Frequency for 10 ft [3 m] Sections of Non-Metallic Flexible Duct, Lined and Unlined (Ref: D1.2.2), dB								
Duct Diameter in [mm]	Octave Band Mid Frequency, Hz							
	63	125	250	500	1000	2000	4000	8000
4-6 [100-150]	9	9	9	9	10	12	15	21
7-8 [170-200]	8	8	8	8	9	10	13	18
9 [205]	7	7	7	8	8	10	12	17
10 [250]	7	7	7	7	8	9	11	16
12-16 [300-400]	5	5	5	5	6	7	9	13

Reference: Compilation of Manufacturers Data

dB = F · 0.00179 + 10.79 – D · (0.0000563 · F + 0.41419) Where: F = octave band mid-frequency in Hz, and D = diameter in inches.

D1.2.3 *Flat Oval Sheet Metal Duct, Lined & Unlined* B. Duct ~~Breakout~~ transmission loss can be calculated from 2007 ASHRAE Handbook, HVAC Applications (see Figure D3.).

B $= TL_{out} - 10 \log (A_o/A_i) = L_{wi} - L_{wo}$

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Where:

A_o = $L\,[2(a_o - b_o) + \pi b]$ = Duct Outer Surface Area, in^2 [mm^2]

A_i = $b(a_i - b_i) + \pi \frac{b^2}{4}$ = Duct Internal Cross Sectional Area, in^2 [mm^2]

a_i = inner width, in [mm]
a_o = Outer width, in [mm]
b_i = inner height, in [mm]
b_o = Outer height, in [mm]
L = Length, in [mm]
L_{wi} = Sound power level at inlet, dB
L_{wo} = Sound power level at outlet, dB
TL_{out} = Transmission loss, dB

NOTE: The dimensions a, b and L must be in the same units. For single-wall ducts, $a_i = a_o$ and $b_i = b_o$.

Values of TL_{out} for flat oval duct are given in Table D5.

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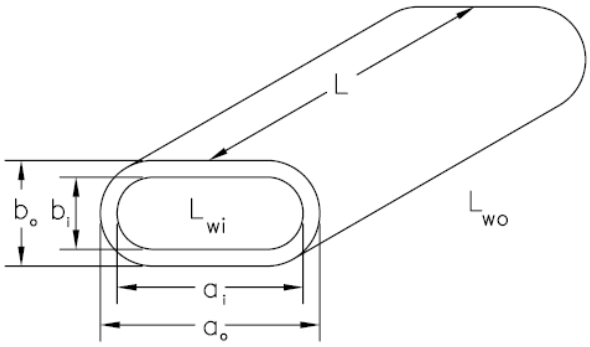


Figure D3. Flat Oval Duct ~~Breakout~~ Transmission Loss

D1.2.4 *Rectangular Sheet Metal Duct, Lined & Unlined* B. Duct ~~Breakout~~ transmission loss can be calculated from 2007 ASHRAE Handbook, HVAC Applications, Chapter 47 (see Figure D4.).

B $= TL_{out} - 10 \log (A_o/A_i) = L_{wi} - L_{wo}$

Where:

A_o = $2L\,(a+b)$, in^2 [mm^2] = Duct Outer Surface area, in^2 [mm^2]
A_i = $a \cdot b$, in^2 [mm^2] = Duct internal cross-sectional area, in^2 [mm^2]
a_i = inner width, in [mm]
a_o = Outer width , in [mm]
b_i = outer width, in [mm]
b_o = Outer height,in [mm]

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L	=	Length, in [mm]
L_{wi}	=	Sound Power Level at duct inlet, dB
L_{wo}	=	Sound Power Level, dB
TL_{out}	=	Transmission loss, dB

NOTE: The dimensions a, b and L must be in the same units. For single-wall ducts, $a_i = a_o$ and $b_i = b_o$.

Values for TL_{out} for rectangular ducts are given in Table D6.

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AHRI uses its best efforts to develop standards/guidelines employing state-of-the-art and accepted industry practices. AHRI does not certify or guarantee that any tests conducted under the standards/guidelines will not be non-hazardous or free from risk.

FOREWORD

This standard has been developed by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) for the purpose of establishing a uniform industry procedure for estimating Sound Pressure Levels in occupied spaces served by Air Terminals and/or air outlets.

AHRI Standard 885 establishes uniform application practices for making Air Terminal sound path attenuation calculations. Such standards and procedures will be of mutual benefit to designers, engineers, consultants, building owners and other users for the purpose of providing building design information to meet acoustic goals.

It should be recognized that the acoustical models and data used in AHRI Standard 885 are based on the best available data from both the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) and recognized industry sources.

Use of AHRI Standard 885 acoustical calculation procedures should provide a methodology for significantly improving the reliability of estimating the NC or RC levels in the occupied space over the more simplified acoustical models that have often been used in the past. The accuracy of all estimations depends on a significant body of experience accumulated with the use of this standard. AHRI Standard 885 has been in use for several years now, and has been proven to be a reliable method of sound estimation. Where the actual environment closely matches the assumptions, uncertainties of less than 5 dB in the estimated space sound level are commonly observed when these methods are employed.

AHRI Standard 880 does not provide for determination of Sound Power in the 63 Hz octave band. These products do not contribute significantly to the sound levels in occupied spaces in the 63 Hz octave band. The dominant source of sound levels in occupied spaces in the 63 Hz band is controlled by the primary air supply system. Since AHRI Standard 885 could be used to determine occupied space sound levels from the primary air supply system, data is provided where available in the 63 Hz octave band.

Note:

This standard supersedes ARI Standard 885-98.

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The Relationships of AHRI Standard 880 and 885

Although this standard does not take into account space sound level contributions from the central system fan, ductwork upstream of the Air Terminal, equipment room machinery or exterior ambient, these often significant sound sources should be considered in the designer's work to achieve a complete estimate of room sound level.

AHRI Standard 880 "Air Terminals" provides industry agreed-upon methods for determining sound power ratings of Air Terminal and air distribution devices. These sound power ratings are published in manufacturers' data sheets.

AHRI Standard 885 provides industry agreed-upon methods to use AHRI Standard 880 sound ratings to estimate the sound levels which will occur in the conditioned, occupied space. It provides calculation methods to examine and compare sound sources and attenuation in the application of Air Terminals and air distribution devices.

What's New

This revision to AHRI Standard 885 includes several updated tables and methods, reflecting research conducted and reported since the preparation of the 1998 version of the Standard. An electronic calculation spreadsheet has been added to accompany the Standard. The ISO end reflection table has been replaced with one based on recent ASHRAE sponsored research.

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PROCEDURE FOR ESTIMATING OCCUPIED SPACE SOUND LEVELS IN THE APPLICATION OF AIR TERMINALS AND AIR OUTLETS

Section 1. Purpose

1.1 *Purpose.* The purpose of this standard is to provide a consistent industry-accepted method for estimating Sound Pressure Levels in a conditioned occupied space for the application of Air Terminals and air outlets.

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

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

Section 2. Scope

2.1 *Scope.* This standard includes sound levels from most but not all components in the air distribution system. Air Terminals, air outlets and the low pressure ductwork which connects them are considered as sound sources and are the subject of this Standard.

This Standard does not make provisions to estimate space sound level contributions from the central system fan, ductwork upstream of the Air Terminal, equipment room machinery or exterior ambient sound.

This Standard is not currently applicable for underfloor radiated or discharge sound calculations.

AHRI Standard 880 does not provide for determination of sound power in the 63 Hz octave band. These products do not contribute significantly to the sound levels in occupied spaces in the 63 Hz octave band. The dominant source of sound levels in occupied spaces in the 63 Hz band is controlled by the primary air supply system. Since AHRI Standard 885 could be used to determine occupied space sound levels from the primary air supply system, data is provided where available in the 63 Hz octave band.

The methods described in this Standard can be used to identify acoustically critical paths in the system design. The design effects of inserting alternative components and changes in the system can be evaluated. The accuracy of evaluating the difference in sound pressure between two alternatives is greater than individual estimations.

Section 3. Definitions

All terms in this document follow the standard industry definitions in the current edition of *ASHRAE Terminology of Heating, Ventilation, Air Conditioning and Refrigeration* unless otherwise defined in this section.

3.1 *Air Terminal (Terminal).* A device that modulates the volume of air delivered to a conditioned space in response to a given load. The various types of Air Terminals are defined as follows:

3.1.1 *Bypass Terminal.* Air Terminal that diverts excess primary air to the return.

3.1.2 *Integral Diffuser Terminal.* Diffuser with the features of an Air Terminal.

3.1.3 *Dual Duct Terminal.* Air Terminal with two supply inlets that is used primarily for mixing cold and warm air streams at varying proportions.

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3.1.4 *Induction Terminal*. Air Terminal that supplies varying proportions of primary and induced air.

3.1.5 *Parallel Flow Fan-Powered Terminal*. Air Terminal in which primary airflow is modulated in response to the cooling demand and in which the integral fan is operated to deliver induced air.

3.1.6 *Reheat Terminal*. Air Terminal that heats a single source of supply air.

3.1.7 *Series Flow Fan-Powered Terminal*. Air Terminal in which the primary airflow is modulated and mixed with induced air by a continuously operated integral fan to provide a relatively constant volume discharge.

3.1.8 *Single Duct Terminal*. Air Terminal supplied with one source of primary air.

3.2 *Ceiling/Space Effect*. Attenuation of Sound Power transmitted to an occupied space from above the ceiling as a result of the ceiling itself and the size of the space above the ceiling.

3.3 *Duct Breakout*. Sound associated with fan or airflow noise that radiates through the duct walls into the surrounding area.

3.4 *Environmental Adjustment Factor*. Difference between Sound Power Levels measured using a free field calibrated reference sound source and a reverberant field calibrated reference sound source. Sound Power measured in accordance with ASHRAE Standard 130 is based upon a free field calibrated reference sound source and the Environmental Adjustment Factors are used to correct these values to those using a reverberant field calibrated reference sound source because building spaces more closely represent a reverberant sound field.

3.5 *Equivalent Diameter*. Diameter of a circular equivalent of any duct for equal cross-sectional areas.

3.6 *Insertion Loss.* Reduction in observed Sound Pressure Level caused by installation of an Air Terminal, ductwork, or silencer.

3.7 *Noise*. Any unwanted sound.

3.7.1 *Background Noise*. Total noise that interferes with the measurement of the particular sound of interest which may include airborne sound, structure borne vibrations, and electrical noise in instruments.

3.7.2 *Generated Noise*. Noise produced from the flow of air past a restriction, rough wall, or other aerodynamic disturbance.

3.8 *Noise Criteria (NC)*. Standard curves used to describe a spectrum of measured Sound Pressure Levels with a single number.

3.9 *Octave Band*. Frequency band with an upper band limit that is twice the frequency of the lower band limit. The mid frequency (center frequency) of an octave band is the geometric mean of its upper and lower band limits. The octave band mid frequencies of interest are listed in Table 1.

3.10 *Published Ratings.* A statement of the assigned values of those performance characteristics, under stated rating conditions, by which a unit may be chosen to fit an application. These values apply to all units of like nominal size and type produced by the same manufacturer. As used herein, the term Published Rating includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated rating conditions.

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Table 1. Octave Band Mid Frequencies	
Octave Band	Mid Frequency, Hz
1	63
2	125
3	250
4	500
5	1000
6	2000
7	4000
8	8000

3.10.1 *Standard Rating.* A rating based on tests performed at standard rating conditions.

3.10.2 *Application Rating.* A rating based on tests performed at application rating conditions (other than standard rating conditions).

3.11 *Reverberation Room*. A test room with highly reflective surfaces that is designed to create a nearly homogeneous field of sound for the measurement of Sound Power Levels of a sound source.

3.12 *Room Criteria (RC).* Standard curves used to describe a well balanced spectrum of measured Sound Pressure Levels with a single number.

3.13 *"Shall" or "Should".* "Shall" or "Should" shall be interpreted as follows:

3.13.1 *Shall.* Where "shall" or "shall not" is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

3.13.2 *Should.* "Should" is used to indicate provisions which are not mandatory, but which are desirable as good practice.

3.14 *Silencer*. Device used to attenuate sound transmitted through an HVAC system.

3.15 *Sound Attenuation.* The reduction of the intensity of sound as it travels from the source to a receiving location. Sound absorption is often involved as, for instance, in a lined duct. Spherical spreading and scattering are other attenuation mechanisms.

3.16 *Sound Power*. In a specified frequency band, the rate at which sound energy is radiated by a sound source, measured in watts.

3.16.1 *Sound Power - Discharge*. Sound Power transmitted from an Air Terminal outlet.

3.16.2 *Sound Power - Radiated*. Sound Power transmitted from an Air Terminal casing (plus induction port for fan-powered Air Terminals).

3.17 *Sound Power Level (L_w).* In a specified frequency band, ten times the common logarithm of the ratio of the Sound Power radiated by the sound source under test to the standard reference sound power of 10^{-12} Watt, dB.

3.18 *Sound Pressure*. In a specified frequency band, a fluctuating pressure superimposed on the static pressure by the presence of sound.

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3.19 *Sound Pressure Level (L_p).* In a specified frequency band, 20 times the common logarithm (base 10) of the ratio of the Sound Pressure radiated by the noise source under test to the standard reference pressure of 20 µ pascals, dB.

3.20 *Source-Path-Receiver Process.* The sound estimating method used in this Standard. In this process, a given Source of sound travels over a given Path to an occupied space where a Receiver hears the sound produced by the Source as in Table 3. Air Terminals and outlets are examples of sound Sources. The sound travels over one or more Paths where attenuation takes place. A person in the occupied space hears the noise at the Receiver location.

3.21 *Space Effect.* Attenuation of Sound Power entering a space as a result of the absorption properties of the space and the distance from the sound source to the receiver.

Section 4. Symbols

4.1 The symbols used within this Standard are included as an aid to the user. They are identified by the following:

a. Sound source 

b. Sound attenuation elements 

c. Sound paths 

These symbols are used in pictorial acoustic models, tabulated acoustic paths, calculations and summary results as an aid to the user. They are identified by the following symbol definitions.

(C) = *Casing Radiated and Induction Inlet Sound Power*. Sound transmitted through the casing or through the induction port of an Air Terminal to the surrounding space, typically, a ceiling plenum. (C) is derived from (C_1) which is casing Radiated Sound Power obtained from manufacturer's sound power data determined in accordance with AHRI Standard 880.

(D) = *Discharge Sound Power*. Airborne Sound Power transmitted through the ductwork from the outlet of an Air Terminal device. (D) is derived from (D_1) which is discharge Sound Power obtained from manufacturer's sound power data determined in accordance with AHRI Standard 880.

(O) = *Outlet Generated Sound Power.* Sound Power generated by and transmitted from an air outlet into the surrounding space; typically, the (O) occupied space. is derived from (O_1) which is outlet generated Sound Power obtained from manufacturer's sound power data determined in accordance with ASHRAE Standard 70 and ASHRAE Standard 130.

(C), (D) and (O) are calculated as follows:

(C) = (C_1) - ⟨E⟩

(D) = (D_1) - ⟨E⟩

(O) = (O_1) - ⟨E⟩

where ⟨E⟩ is the Environmental Adjustment Factor

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E = *Environmental Adjustment Factor.* The Environmental Adjustment Factor is required in order to use the calculation procedures defined herein (refer to Appendix C).

Sound power measurement for Air Terminals is defined in AHRI Standard 880.
Real rooms at low frequencies are highly reverberant which causes the source to radiate less low frequency noise than if the source were operating in a free field (outdoors). For this reason, it is necessary to adjust manufacturers' sound power data before applying the data to estimate Sound Pressure in occupied spaces. Differential values between the two sources have been determined and must be subtracted from manufacturers' data as a part of the calculation. The values are shown in Table 2.

Table 2. Environmental Adjustment Factor

Octave Band Center Frequency, Hz	Environmental Adjustment Factor, dB
63	4
125	2
250	1
500	0
1000	0
2000	0
4000	0
8000	0

Note: This reflects the results of ASHRAE RP755, *Sound Transmission through Ceilings from Air Terminal Devices in the Plenum.*

A more detailed explanation of the environmental adjustment factor is found in Appendix C.

4.2 *Sound Path.*

B = *Duct Breakout Transmission Loss, Lined or Unlined.* Difference between Octave Band Sound Power Level entering a duct section and the Sound Power radiated by the section of duct.

F = *Flow Division Noise Reduction.* Reduction in octave band Sound Power Level along a path, attributable to the division of air flow.

I = *Duct Insertion Loss.* Difference between the octave band airborne Sound Power entering a duct section and the airborne Sound Power leaving the duct section.

M = *Manufacturer's Attenuation Element.* Difference between the airborne octave band Sound Power Level entering the manufacturer's attenuation element and the Sound Power leaving the element.

P = *Ceiling/Space Effect.* Difference between the octave band Sound Power Level from the source located in the plenum/ceiling cavity and the Sound Pressure received in the occupied space.

R = *Duct End Reflection Loss.* The sudden area change at the exit of an integral terminal unit or outlet can reflect significant low frequency energy back into the attached ductwork. The end reflection loss accounts for this. It is the difference between the octave band Sound Power incident on a duct end and the Sound Power transmitted out of the end of a duct.

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∇_S = *Space Effect.* Difference between the octave band Sound Power Level entering the occupied space and the resulting octave band Sound Pressure Level at a specific point in an occupied space.

∇_S = $L_w - L_p$

where:

L_w = Sound Power Level
L_p = Sound Pressure Level

∇_T = *Duct Elbow and Tee Loss*. Difference between the airborne octave band Sound Power Level entering a lined or unlined elbow or tee duct connection and the airborne Sound Power leaving the elbow or tee when the elbow or tee is coupled with at least three duct diameters of lined duct upstream and/or downstream of the elbow or tee.

4.3 *Receiver Symbols and Definitions*.

$\boxed{1}$ = Resultant Sound Pressure Level at the receiver calculated along Path 1.

$\boxed{2}$ = Resultant Sound Pressure Level at the receiver calculated along Path 2.

$\boxed{N}$ = Resultant Sound Pressure Level at the receiver calculated along Path N.

$\boxed{L_p}$ = Resultant logarithmic sum of Sound Pressure Levels at the receiver from all sound paths for a specific Octave Band.

Section 5. Description of Sound Estimating Method

5.1 *Introduction.* The sound estimating method used in this standard is based on a simple process called Source-Path-Receiver. A given *Source* of sound travels over a given *Path* to an occupied space where a *Receiver* hears the sound produced by the *Source* as in Table 3.

5.2 *Outline of the Sound Pressure Estimating Procedure.* This standard estimates space Sound Pressure Levels when the acoustic performance of Air Terminals and/or outlets is known. A second use of the standard is to estimate the maximum permissible Sound Power Level from a terminal device so that a selected acoustical design criteria (NC or RC) will not be exceeded.

Four steps are required to estimate Sound Pressure Levels by Octave Band:

5.2.1 Obtain Air Terminal or outlet Sound Power Levels at the specific unit operating point(s). Source: Manufacturer's Data.

5.2.2 Identify the sound paths to be evaluated. Source: Acoustic Model.

5.2.3 Determine the attenuation path factors for each path. Source: Appendix D, Standard 885.

5.2.4 Logarithmically add the acoustic contribution from each sound path to determine overall Sound Pressure Level.

5.3 *Acoustical Models.* Acoustical models for each of the major Air Terminal/distribution applications are shown in Figures 1, 2 and 3 which follow. The models identify receiver sound paths and graphically illustrate the process of sound level prediction.

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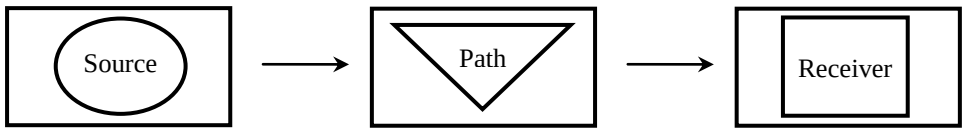
5.4 *Upstream Sound Sources.* This standard does not take into consideration sound breaking out of the inlet ducts to Air Terminal devices as shown (by the dashed-line arrow) in the upstream duct breakout radiated path in Figure 1. Sound emitted from this element can come from these sources:

1. The airborne sound from the system central fan;
2. Airborne regenerated sound from upstream takeoffs and fittings;
3. Sound traveling upstream from the terminal.

At the present time, catalog data is not available for sound traveling upstream from the Air Terminal. It is difficult to estimate because of the wide variety of fittings used.

If the designer feels upstream noise might be significant (e.g., where a terminal is mounted close to the supply fan), it is recommended that hard duct be used or that flex duct be lagged.

Table 3. Source – Path – Receiver Process

Process			
Description	Air Terminals and outlets are examples of *sound Sources.*	The sound travels over one or more *Paths* where attenuation takes place.	A person in the occupied spaces who hears the sound at the receiver location.
Symbols Used in this Standard	 A circle denotes a sound Source. The letter defines which Source.	 A triangle denotes an attenuation on the sound path. The letter defines the type of attenuation	 A square denotes a sound Receiver. The number defines the sound path being considered.
Nature of Data	Octave band Sound Power Level	Octave band Path Attenuation	Octave band Sound Pressure Level
	(L_w) of Source in decibels (dB).	Sound reduction due to ducting, ceiling tile, etc.	(L_p) at receiver location. Often evaluated as Noise Criteria (NC) or Room Criteria (RC).
Sources of Data	Manufacturer's data tested in accordance with: • Air Terminals ASHRAE 130 • Air outlets ASHRAE 70	AHRI Standard 885, Appendix D.	Calculated by procedures in AHRI Standard 885.

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