AHRI Standard 885
(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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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 occupied space. (O) 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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= *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.*



= *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.



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



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



= *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.



= *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.



= *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*.

1 = Resultant Sound Pressure Level at the receiver calculated along Path 1.

2 = Resultant Sound Pressure Level at the receiver calculated along Path 2.

N = Resultant Sound Pressure Level at the receiver calculated along Path N.

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.

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:

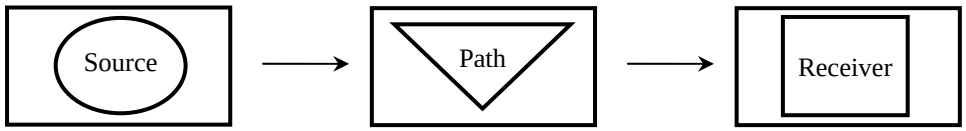
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1. The airborne sound from the system central fan;
2. Airborne regenerated sound from upstream takeoffs and fittings;
3. Sound traveling upstream from the terminal.

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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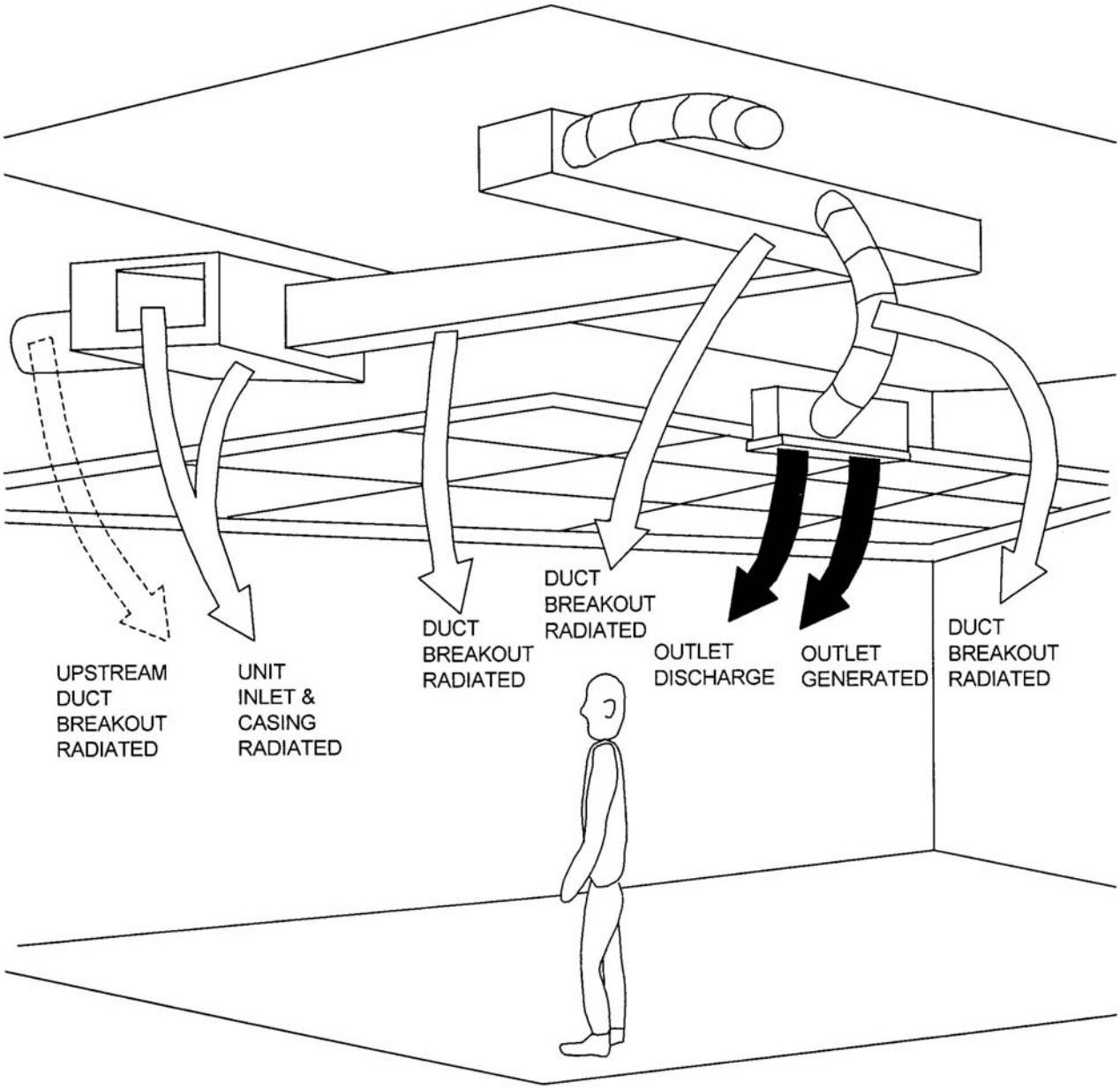


Figure 1. Fan-Powered Terminal or Induction Terminal Acoustic Model

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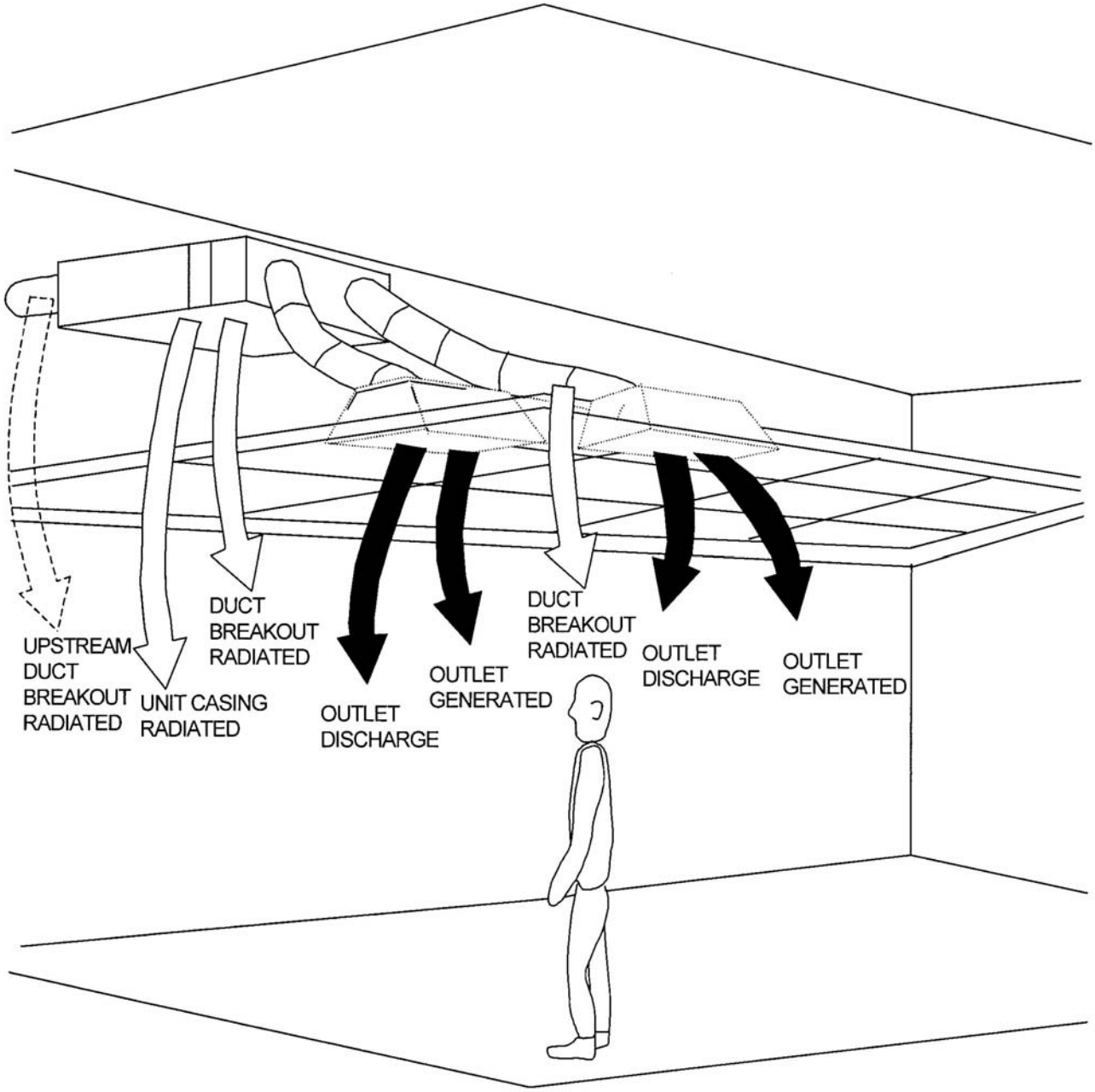


Figure 2. Single, Double Duct Terminal Acoustic Model

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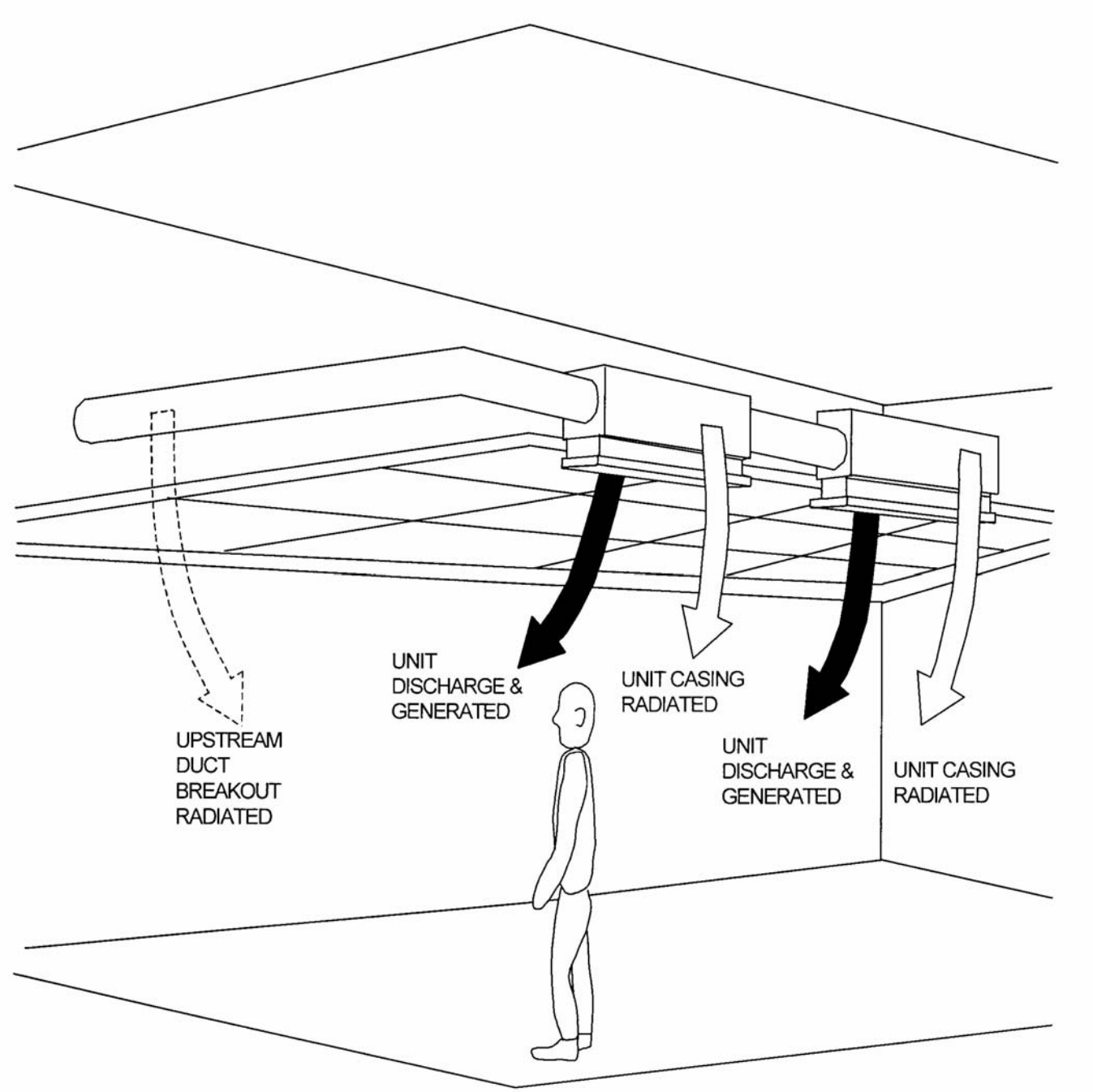


Figure 3. Integral Diffuser Terminal Acoustic Model

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Section 6. Calculation Procedures for Estimating Sound Levels in Occupied Spaces

6.1 *Introduction.* Figures 5, 6 and 7 display the source paths which must be evaluated to enable the net sound level in a conditioned space to be estimated. Each path is broken into individual source and attenuation segments. Source sound levels are obtained from the terminal or outlet manufacturer's data and path factor attenuation is determined according to the procedures which follow.

The designer must select paths from the acoustic models which match the particular applications of the job. For example, single and dual duct terminals are applied with multiple and individual flex duct connections. The Air Terminals are also applied with extended discharge plenums and lateral take-offs. Each application will require a specific acoustic model.

If the designer knows which paths are most significant, the calculation procedure can be simplified. Otherwise, it is recommended that all paths of the specific acoustic model be evaluated until the designer is comfortable with a simplified model.

After experience is gained in using Standard 885, the dominant sound source(s) and path(s) will become apparent. In drawing the specific acoustic model for the application it is recommended that the receiver location be placed directly under the dominant sound source and 5.0 ft [1.5 m] from the floor. Where more than one significant sound source is possible, an additional model should be drawn for these sources, again with the receiver location directly under the source and 5.0 ft [1.5m] from the floor. An illustration of these positions is shown in Figure 11.

6.2 *Environmental Adjustment Factor.* As explained in Section 3, it is necessary to reference the source Sound Power Levels to a reverberant sound source before proceeding with the calculation. Using the values given in Section 3, the procedure can be illustrated as shown in Tables 5 and 6, using data from an actual situation. The following tabulation contains manufacturers' sound power level data, taken in accordance with ASHRAE Standard 130 and ASHRAE Standard 70.

6.3 *Decibel Addition Example*. To add two dB values together, a simplified method may be used, as shown in the following example, Figure 4. It can be seen that differences of 10 dB make the lower value insignificant, while the sum of two equal values results in an increase of 3 dB.

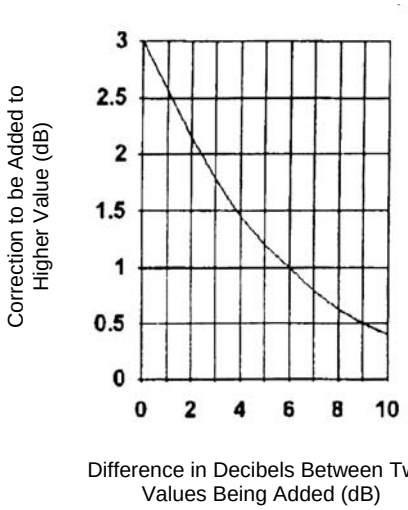


Figure 4. Decibel Addition Example

To add two decibel values:

80 dB
+74 dB

Difference in values: 6 dB

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From chart: Add 1.0 dB to higher value:

80 dB
+1 dB
81 dB

6.4 *Example of a Specific Acoustic Model.* To demonstrate the procedure, a fan powered box/induction unit acoustic model (Figure 5) was selected and the specific sound paths defined.

Figure 5 outlines six sound paths:

Receiver	Path
1	Radiated and Induction Inlet
2	Duct Breakout
3	Distribution Duct Breakout
4	Flexible Duct Breakout
5	Discharge
6	Outlet I Generated Sound

In an application of this type, there will often be several other diffusers or outlets not shown in Figure 5.

Table 4 then lists each sound path and its components which may be involved in a fan powered terminal or induction unit installation and provides direction for calculation of each receiver value. (An explanation of the symbols used in the calculation procedure can be found in Section 4.)

Each of the sound path attenuation factors is now determined using the detailed data of Section 7.

The summary or net sound calculation can then be made by subtracting the path attenuation factors from the sound source and logarithmically summing the path results.

For the fan powered terminal or induction unit in our example, the path calculations are as follows: (Ref. Figure 5.)

Sound Summary Calculation

$$\boxed{L_{PT}} = \boxed{1} \oplus \boxed{2} \oplus \boxed{3} \oplus \boxed{4} \oplus \boxed{5} \oplus \boxed{6}$$

Where $\oplus$ is log addition as defined below:

$$\boxed{L_{PT}} = 10 \text{ Log } \left[10^{\left(\frac{\boxed{1}}{10}\right)} + 10^{\left(\frac{\boxed{2}}{10}\right)} + ... + 10^{\left(\frac{\boxed{n}}{10}\right)} \right]$$

Where n = the number of paths being added logarithmically.

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