



# Sound Advice



Presented by

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# What You Will Learn

- ① Sound power vs sound pressure
- ① Sound quality
- ① AHRI 880/885
- ① NC vs RC
- ① Liner effects
- ① Installation effects

# Sound Power vs Sound Pressure

- ◎ Sound power is the total sound energy produced
- ◎ Sound pressure is the sound level that results after some sound energy is lost to the environment
- ◎ If 80 dB is produced but only 70 dB is measured, the difference is a 10 dB room effect or attenuation

# The Decibel (dB)

- ◎ The decibel (dB) is measured against a **frequency** and averaged into **octave bands**

Octave Band Designations								
Center Frequency	63	125	250	500	1000	2000	4000	8000
Band Designation	1	2	3	4	5	6	7	8

# Octave Bands

Sound room size & design can affect octave band 1 & 8 readings



1 2 3 4 5 6 7 8

Speech interference bands

Typically report octave bands 2-7 only

# Decibel Addition

To add two decibel values:

$$\begin{array}{r} 80 \text{ dB} \\ + 74 \text{ dB} \\ \hline \end{array}$$

# Decibel Addition

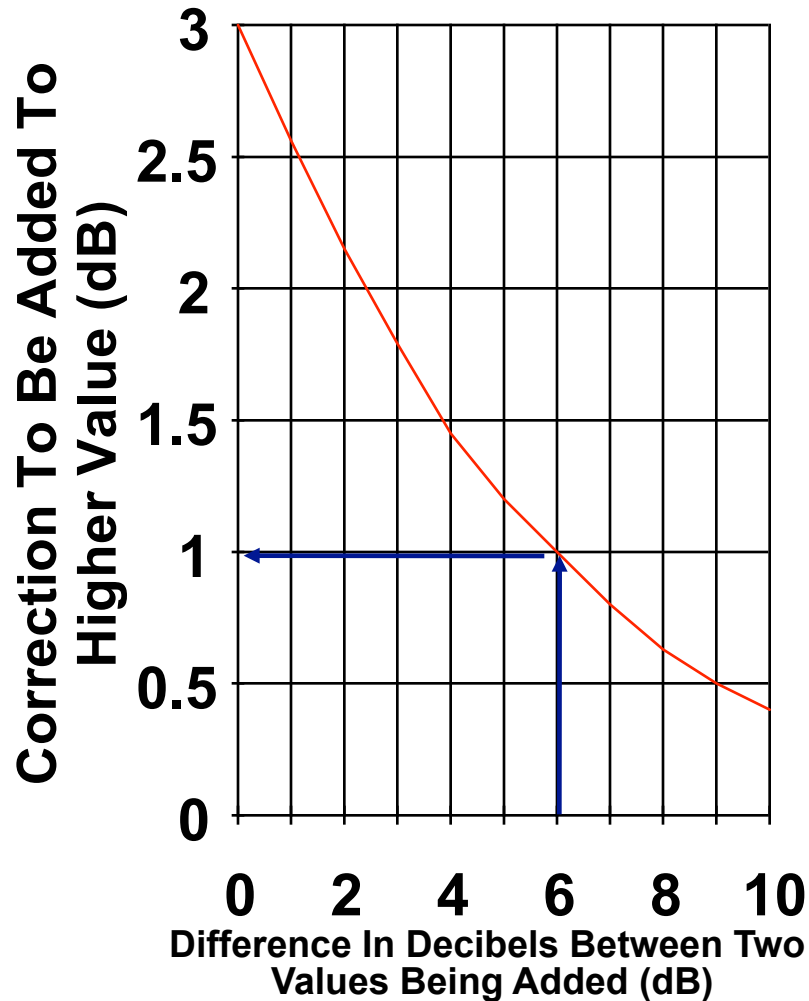
To add two decibel values:

$$\begin{array}{r} 80 \text{ dB} \\ + 74 \text{ dB} \\ \hline \end{array}$$

~~154 dB~~ (Incorrect)



# Decibel Addition



To add two decibel values:

$$\begin{array}{r} 80 \text{ dB} \\ - 74 \text{ dB} \\ \hline = 6 \text{ dB} \end{array}$$

Difference in Values: 6 dB

From Chart: Add 1.0 dB  
to higher Value

$$\begin{array}{r} 80 \text{ dB} \\ + 1 \text{ dB} \\ \hline \end{array}$$

**81 dB (Correct)**

## Good to Know

- ⦿ Any sound source 10 dB lower than background level will not be heard
- ⦿ Add 3 dB (or 3 NC) to double a sound source
  - Two NC40 terminal units over an office would likely create an NC43 sound level
  - Two NC20 diffusers in a room would create at most a sound level of NC23 (if they are close together)
  - Don't try to add-up dissimilar products in this manner

# Source Multiplication

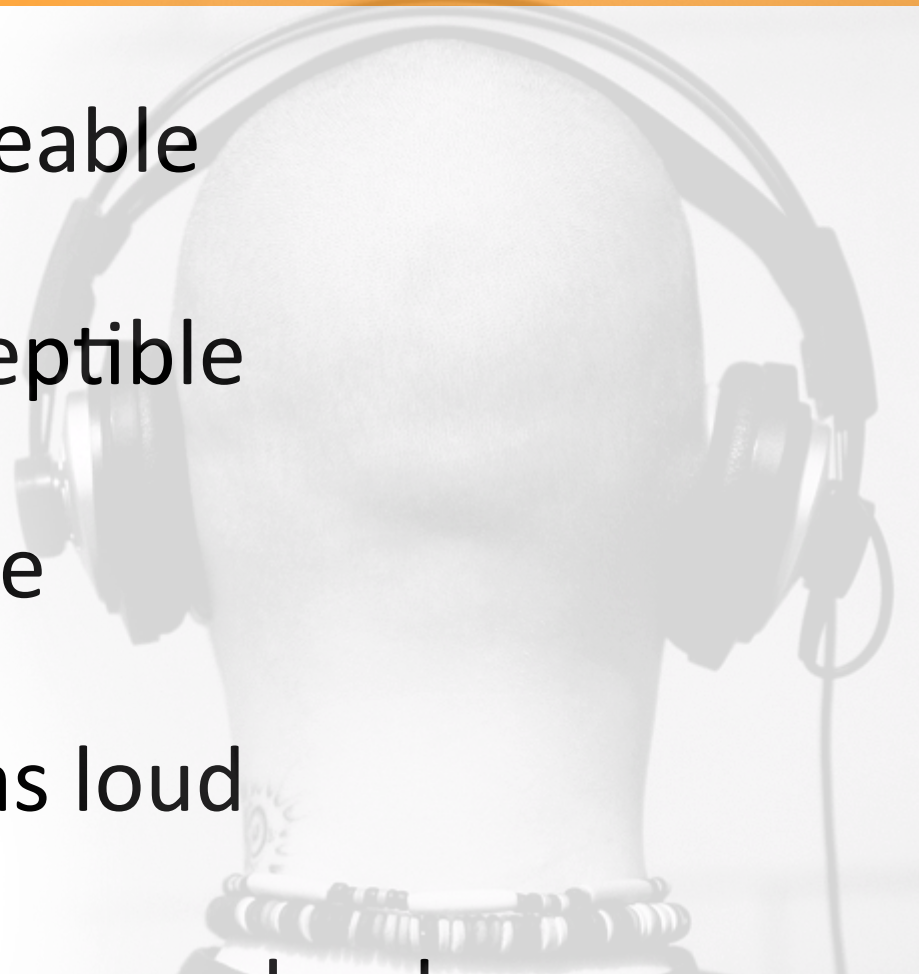
Equation for sound power changes = $10\log n$			
1 Fan on	vs. 2 Fans on	$n=2$	Add 3 dB
1 Fan on	vs. 4 Fans on	$n=4$	Add 6 dB
1 Fan on	vs. 10 Fans on	$n=10$	Add 10 dB
1 Fan on	vs. 100 Fans on	$n=100$	Add 20 dB
50 Fans on	vs. 100 Fans on	$n=2$	Add 3 dB

# Proximity To Sound Sources

- ⦿ Would you really expect to hear 100 fans running at the same time?
- ⦿ Properly selected diffusers shouldn't be heard from more than 10 feet away
- ⦿ Although there may be multiple diffusers in a space, it's unlikely that more than one or two are within 10 feet of an occupant
- ⦿ We would only expect to be able to hear a 10 foot section of continuous linear diffuser from any single location

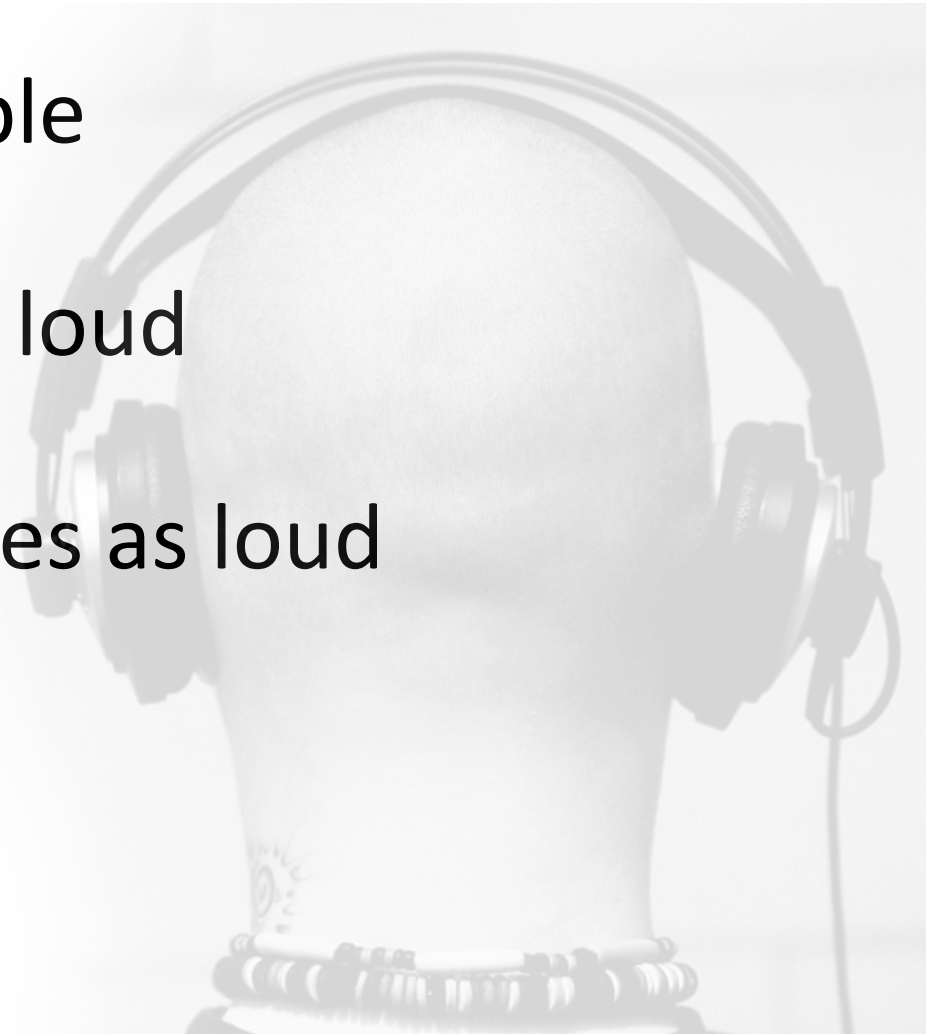
## For High Frequencies

- ① 1 dB not noticeable
- ③ 3 dB just perceptible
- ⑤ 5 dB noticeable
- ⑩ 10 dB twice as loud
- ⑫ 20 dB four times as loud



## For Low Frequencies

- ③ 3 dB noticeable
- ③ 5 dB twice as loud
- ③ 10 dB four times as loud



Both tones are equally loud

65 dB @ 63 Hz

40 dB @ 1000 Hz



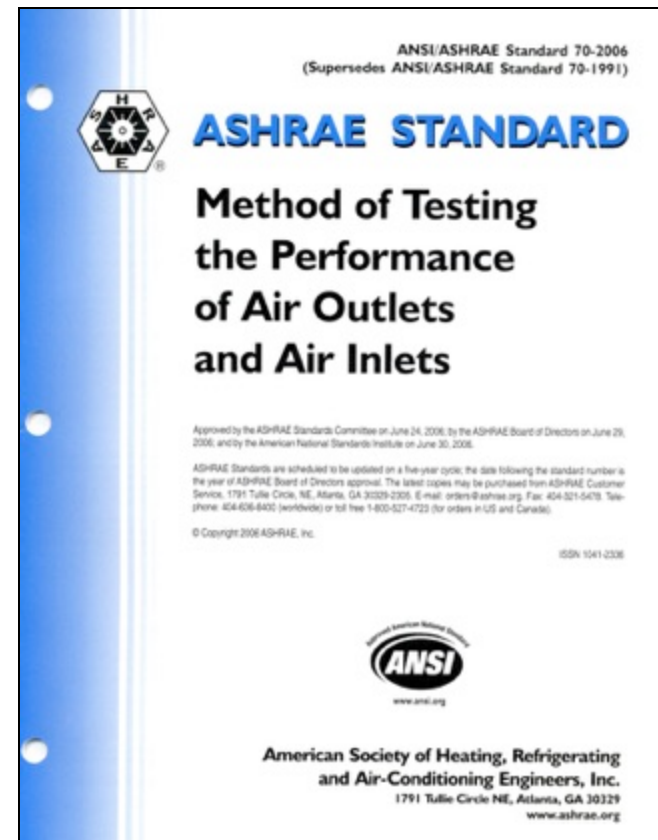
# Acoustic Quality

Not too quiet	Don't destroy acoustic privacy
Not too loud	Avoid hearing damage Don't interfere with speech
Not too annoying	No rumble, no hiss No identifiable machinery sounds No time modulation
Not to be felt	No noticeable wall vibration



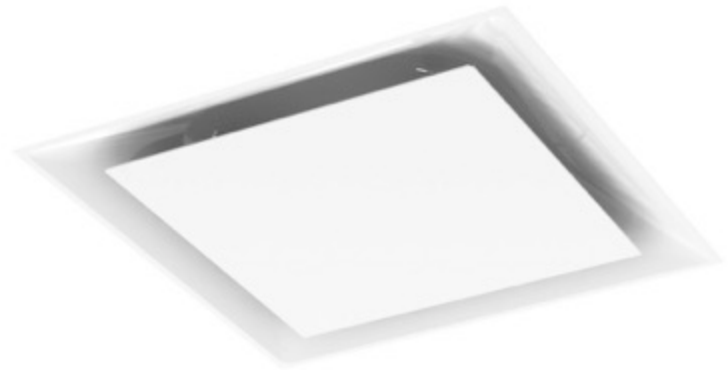
# Diffuser Testing

- Diffusers tested per ASHRAE Standard 70



# Sound Tests

- ◎ Diffusers and grilles
  - Supply sound
  - Return/exhaust sound



# Terminal Unit Testing

- Terminal units tested per ASHRAE Standard 130



# Sound Tests

- ◎ VAV terminals
  - Radiated sound
  - Discharge sound

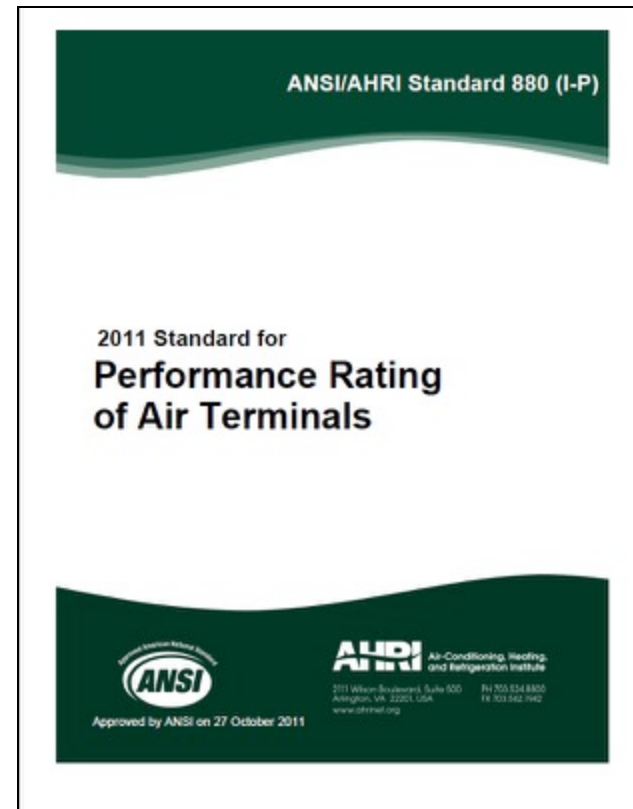


# Performance Rating

- ① Terminal unit performance rated per AHRI Standard 880
  - Now includes new end reflection loss (ERL) correction that must be applied to discharge sound levels

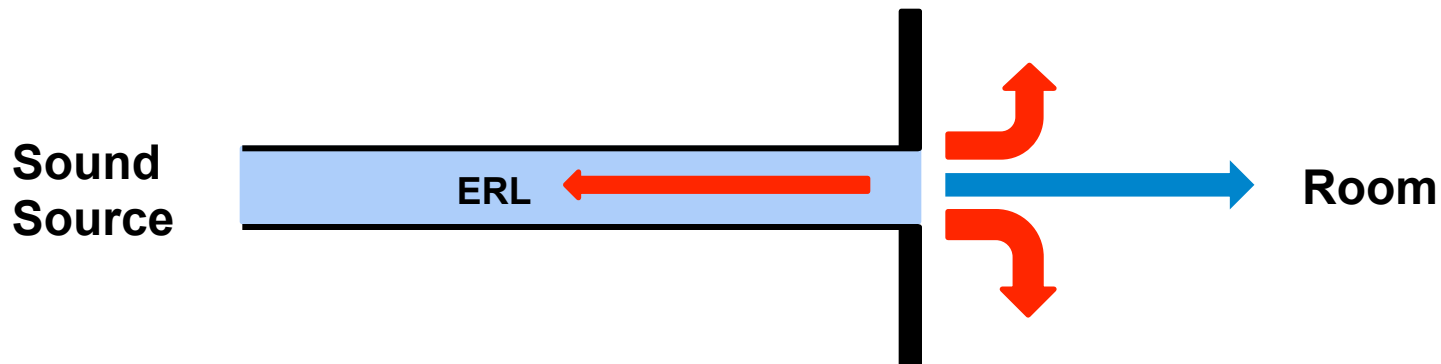


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# What is end reflection?

- ⦿ Occurs when sound source is ducted to room
- ⦿ Noise reflected back to source
- ⦿ Not captured in reverb room testing
- ⦿ Deducted when estimating NC (??????)
- ⦿ Can be calculated based on duct dimensions

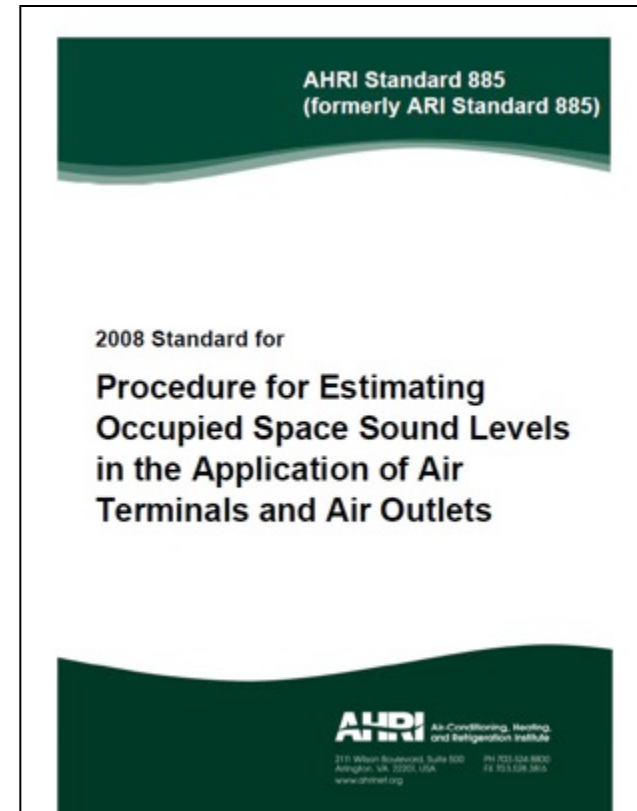


# Sound Path Estimation

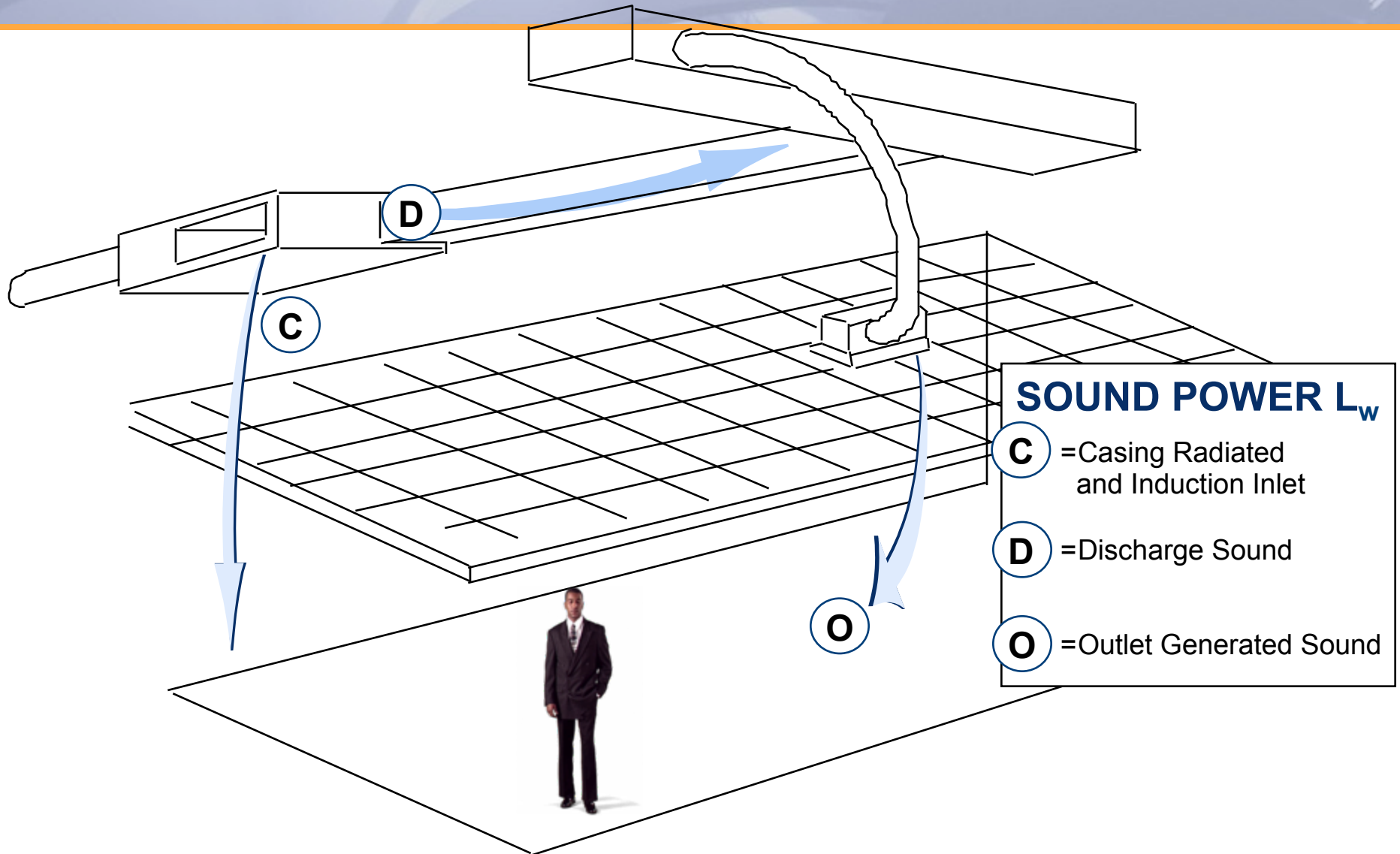
- ① AHRI Standard 885 provides sound path and attenuation values for
  - Lined duct
  - Ceiling materials
  - Elbows
  - Flex duct
  - Etc



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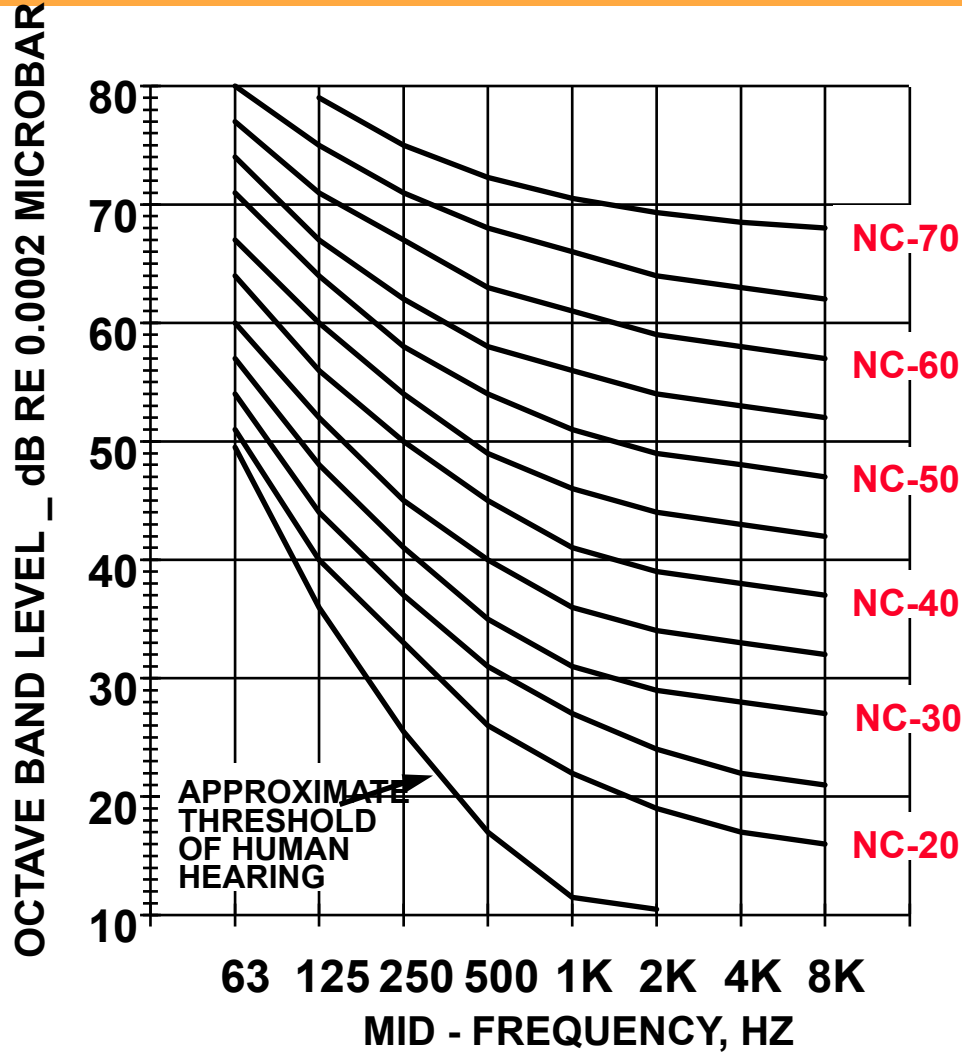


# Sound Path Estimation





# NC Chart

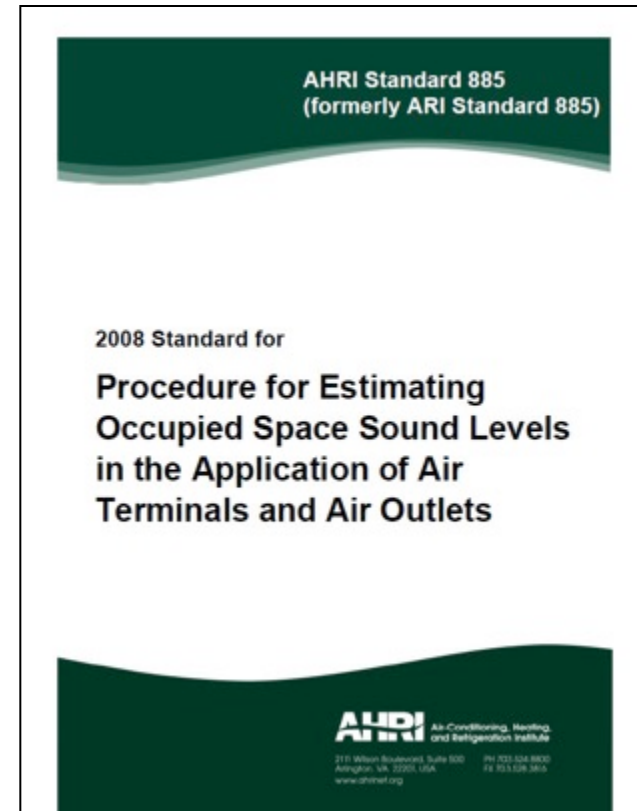


# Typical NC Levels

- ⊙ Conference Rooms  $\leq$  NC30
- ⊙ Private offices  $\leq$  NC35
- ⊙ Open offices = NC40
- ⊙ Hallways, utility rooms, rest rooms  $\leq$  NC45
- ⊙ NC should match purpose of room
- ⊙ Difficult to achieve less than NC30
- ⊙ Select diffusers for NC20-25 (or less)

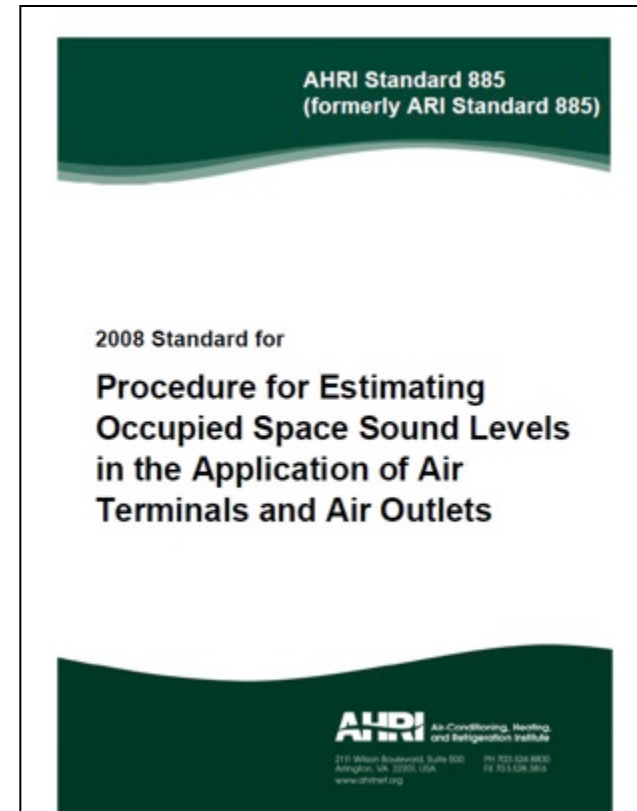
# Catalog Radiated NC Values

- Terminal unit radiated NC values based on standard assumptions from AHRI 885 Appendix E
  - 3 ft deep ceiling plenum with unbounded sides
  - 5/8" thick, 20 lb/ft<sup>3</sup>, mineral fiber lay-in ceiling



# Catalog Discharge NC Values

- Terminal unit discharge NC values are based on standard assumptions from Appendix E
  - 5 ft of 8x8" lined ductwork
  - End reflection losses based on an 8" round diffuser neck
  - 5 ft of 8" vinyl core flex duct
  - 2500 ft<sup>3</sup> room with listener 5 ft from diffuser
  - Additional deductions based on division of flow as airflow

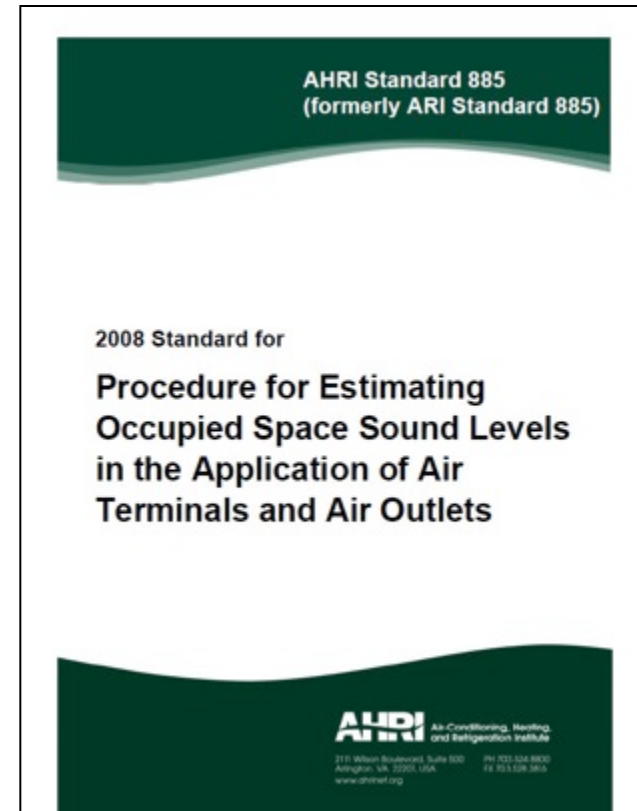


# Catalog Diffuser NC Values

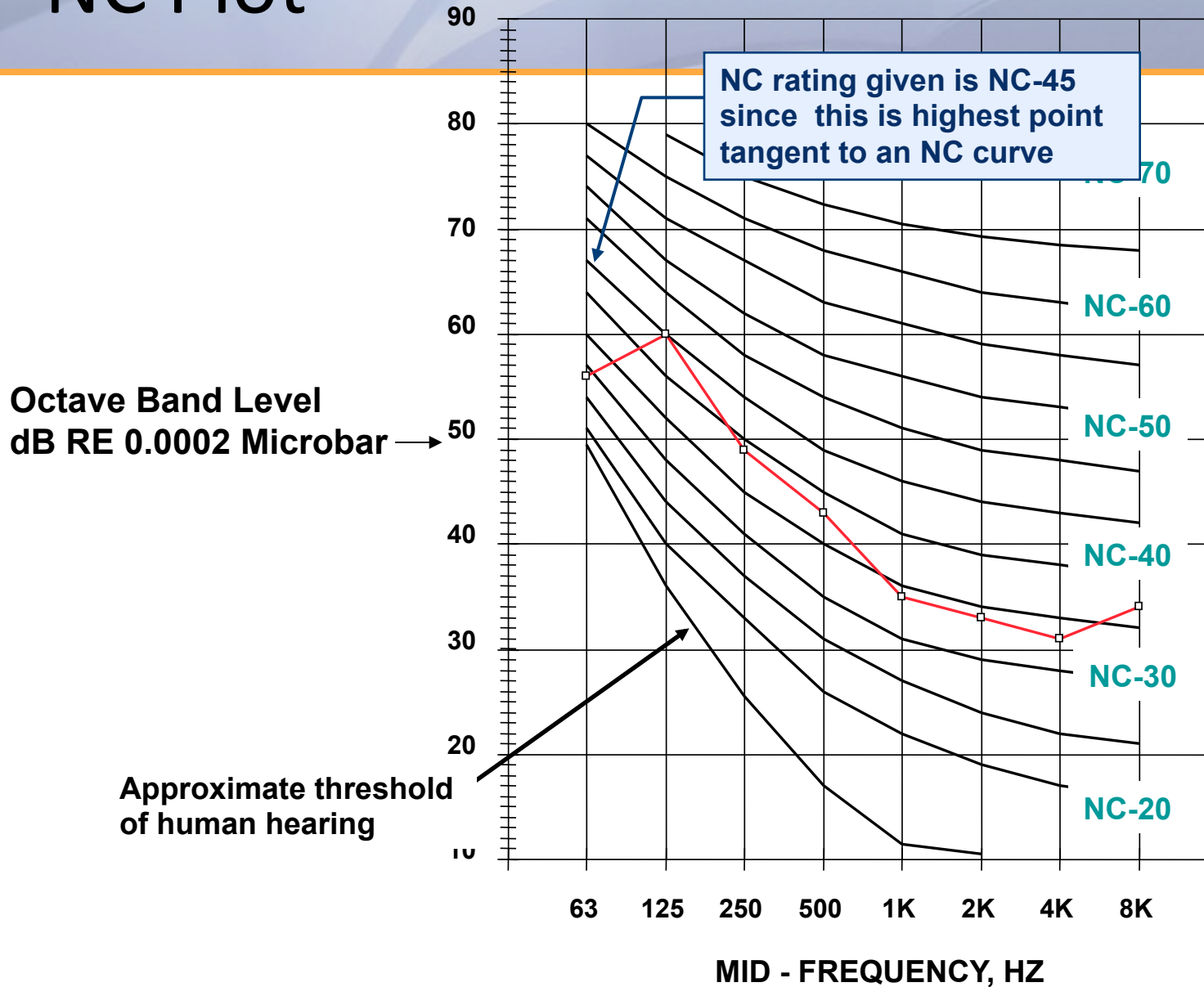
- Diffuser NC values are based on a 10 dB room effect deduction in each octave band
  - Typical medium office with 8-10 ft high lay-in ceiling, commercial carpet, sheetrock walls, and some office furniture
  - 10 dB is a reasonable room effect deduction for the critical octave bands
  - Critical octave bands are 4<sup>th</sup> (500 Hz), 5<sup>th</sup> (1000 Hz), and 6<sup>th</sup> (2000 Hz)



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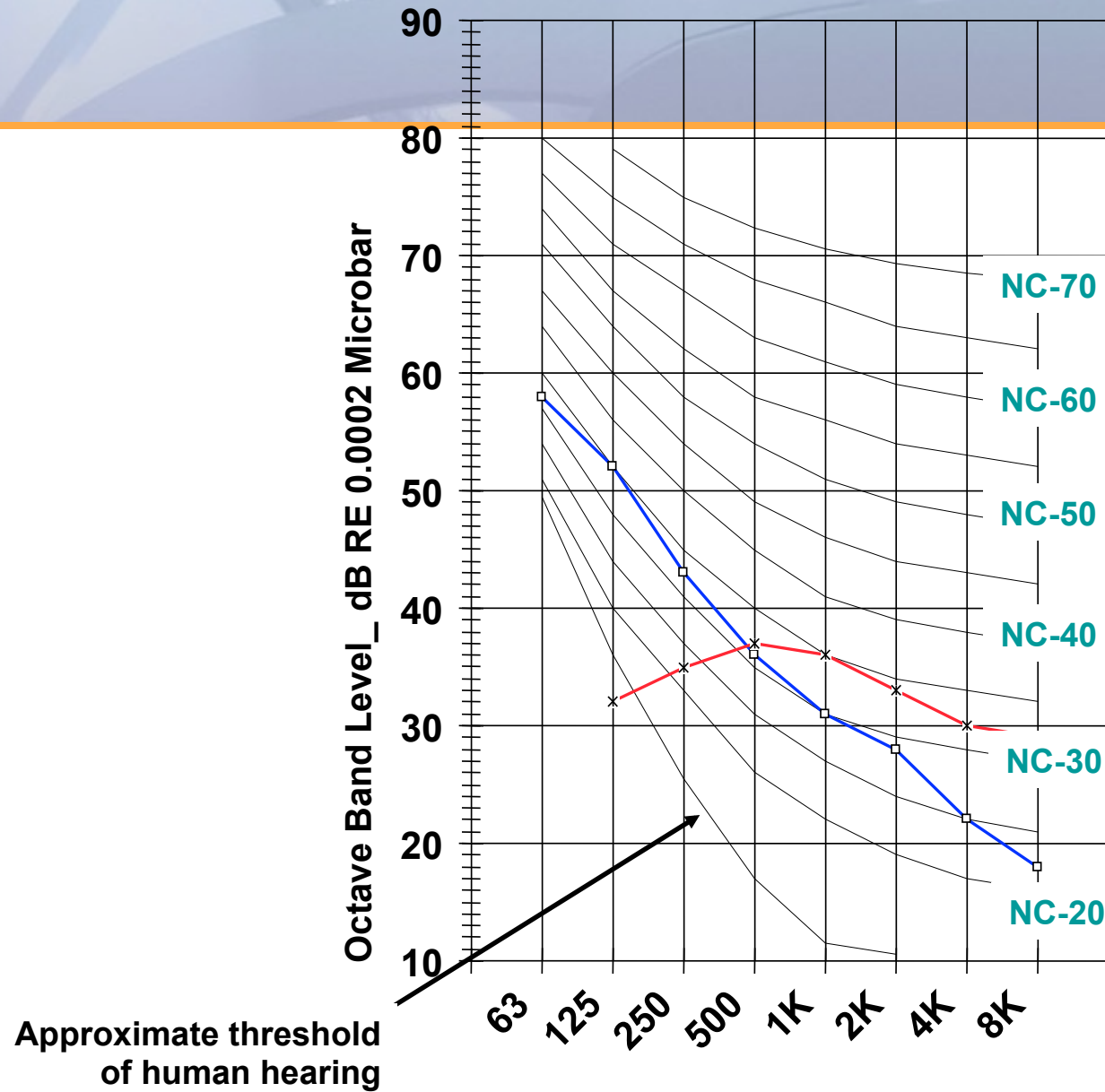
# NC Plot



# NC Specifying

- ⦿ Specifying an unqualified NC value is an 'open' specification
- ⦿ Specifying an NC with specific path attenuation elements could result in acceptable sound quality
- ⦿ It is far preferable to set maximum allowable sound power levels than to specify NC

# NC Plots







Question:

**What does NC35 sound like?**

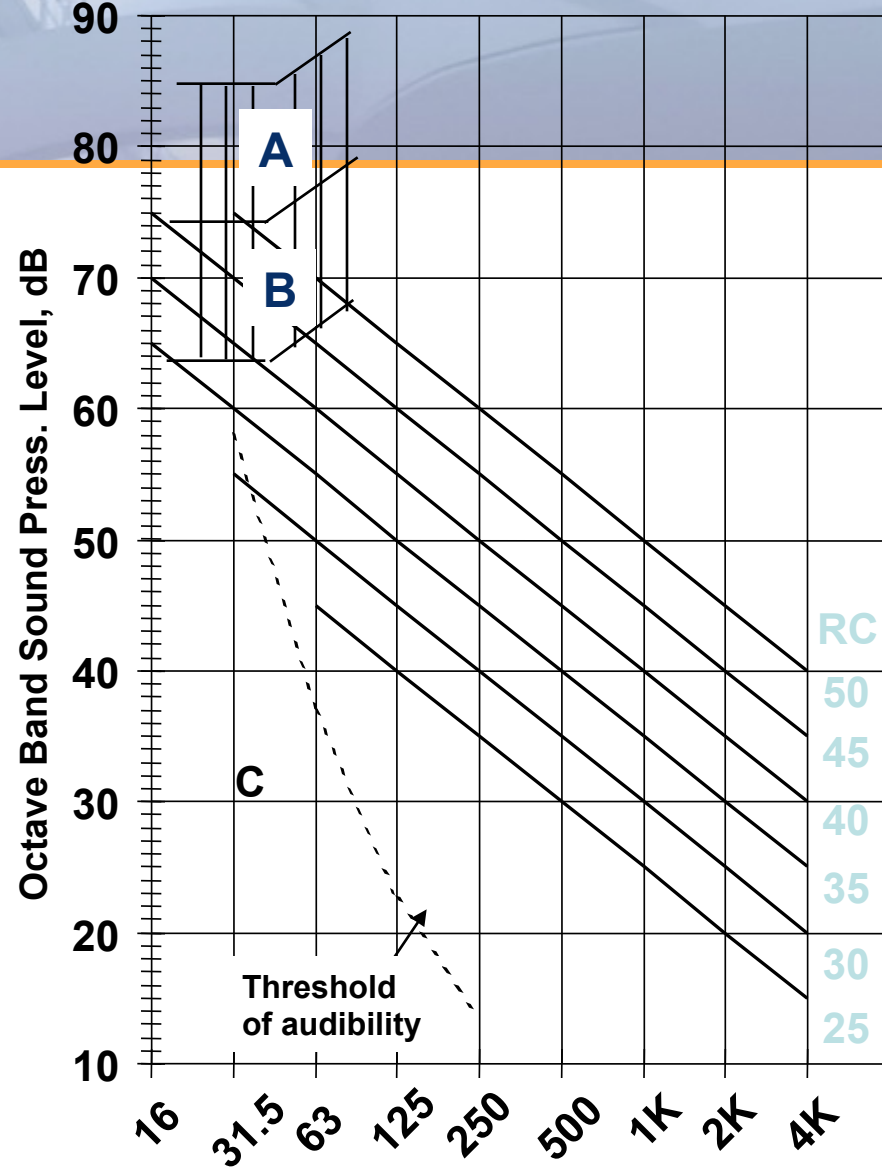
# Room Criteria (RC) Curves

## Region A

High probability that noise induced vibration levels in light wall and ceiling structures will be noticeable. Rattling of lightweight light fixtures, doors and windows should be anticipated.

## Region B

Moderate probability that noise-induced vibration will be noticeable in lightweight light fixtures, doors and windows.



# NC vs RC

## ⦿ Noise criteria

- Rates speech interference and puts limits on loudness
- Gives no protection for low frequency fan noise problems
- Stops at 63 Hz octave band

# NC vs RC

## ⊙ Room criteria

- Includes the 31.5 Hz and 16 Hz octave bands
- Indicates acoustical quality

# Two Parts of RC

- ⊙ Example – RC 40 N
- ⊙ The number is the speech interference level
- ⊙ The letter tells you speech quality
  - **(N) = neutral spectrum**
  - **(R) = too much rumble**
  - **(H) = too much hiss**
  - **(V) = possible wall vibration**

# Who Uses RC?

- ① NC is preferred for equipment selection
- ① RC is preferred as an analysis tool
- ① Acoustical consultants will typically report whether or not equipment meets NC spec but will describe the resulting sound spectrum in terms of RC
- ① You should continue to see catalog application data in terms of NC

# Attenuators

## ◎ Single duct

- Equivalent to lined ductwork

## ◎ Dual duct

- Provides temperature mixing, but little sound attenuation

## ◎ Fan powered

- Lined elbow or “boot” may provide 2dB attenuation by removing line of sight to motor
- Carefully engineered attenuators can provide additional sound reductions

# Silencers

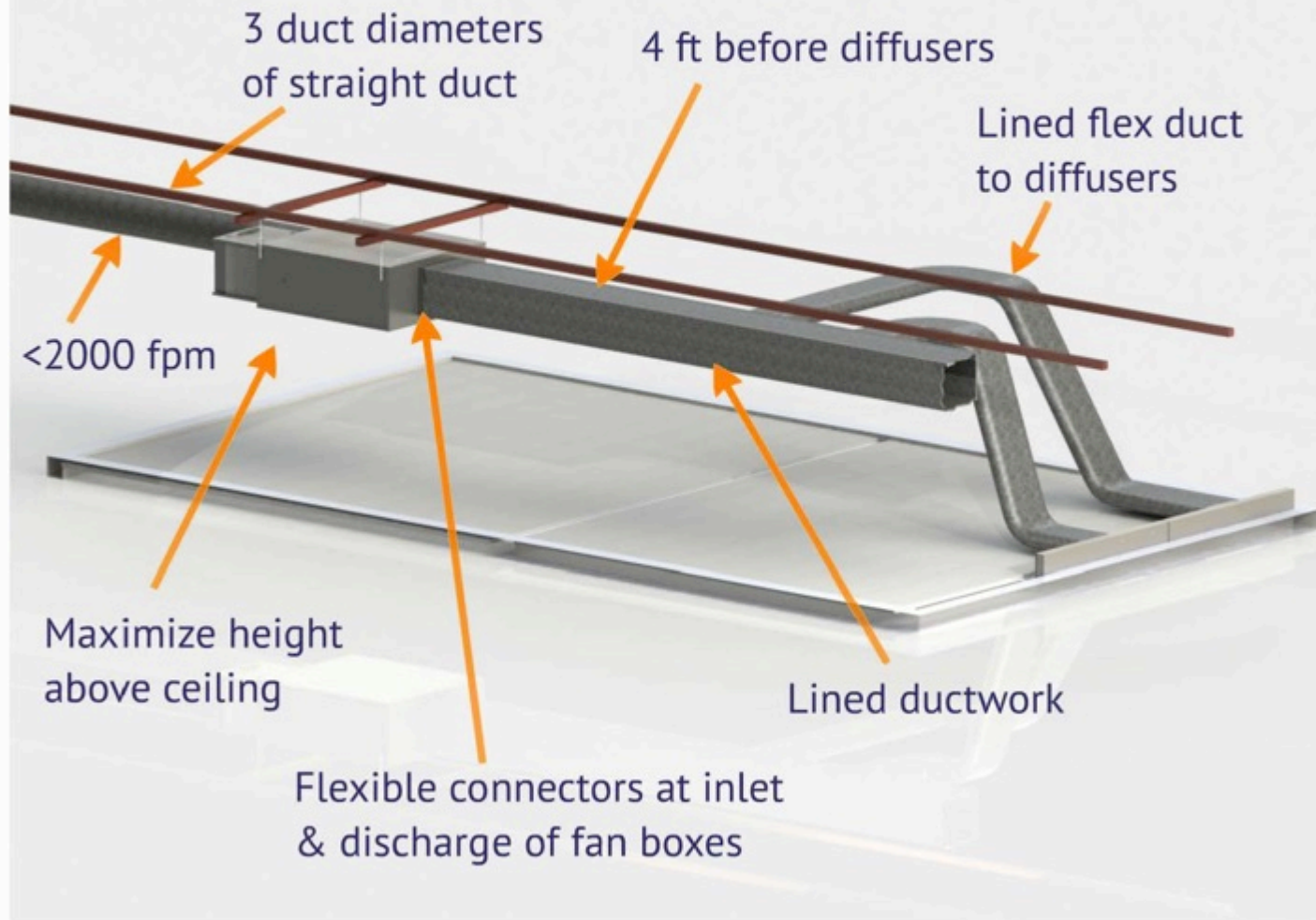
- ⦿ Must be tested with terminal unit
  - Don't assume that silencer will provide published sound reduction
  - A silencer could actually increase noise!
- ⦿ Silencers are tested to a different standard
  - Silencers work when applied as intended
  - They perform differently when close coupled



# Liners

- ◎ Softer and thicker liners tend to absorb sound
  - Lower discharge sound
- ◎ Harder or more dense liners tend to block or reflect sound
  - Lower radiated sound
  - Higher discharge sound
- ◎ Lining effects on fan-powered products can be hard to predict

# Ideal Terminal Unit Installation



# Diffuser Installation

- ⦿ Locate balancing dampers at branch takeoff
- ⦿ Keep flexible duct bends as gentle as possible
  - Flex duct is a great attenuator of upstream noise sources
- ⦿ Keep duct velocities as low as possible
  - But over-sizing can result in higher thermal loss

# Summary

- ⦿ NC remains the preferred sound specification
- ⦿ RC is often used after-the-fact
- ⦿ Specified max sound power levels are safest
- ⦿ Lining materials affect sound levels

# Summary

- ◎ Careful selection, design and installation are required to avoid problems
- ◎ AHRI Standard 885 can be used to estimate sound path effects
- ◎ Multiple sound paths must be considered
- ◎ Open ceilings require adjustments to catalog data