Acoustical Considerations for Building Design

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Acoustical Considerations for Building Design

Presenter

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- Oversees the Noise Control Design and Application Engineering teams as well as Noise Control product research and development
- 15+ Years of Experience in HVAC Industry
- Primarily focused on commercial building HVAC acoustics and noise mitigation solutions

AGENDA

- Importance
- Relevant Terminology
- 3 Main Aspects
  - Source
  - Path
  - Receiver
- Quiet HVAC Systems

Importance

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Importance

"…*patients complain about noise two times more often than anything else in a hospital, including the food*." – Fick and Vance

"…guest reviews for 5,683 hotels found that **noise gained more negative mentions than any other complaints**."

-ReviewPro

EPA

U.S. GREEN BUILDING COUNCIL LEED USGBC

ASHRAE

OSHA

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Importance

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Importance

The Acoustical Environment: "Dead" → "Live"

Use of the room dictates the acoustical goals

- Highly reflective = "live"
- Very absorptive = "dead"

Requirements of most rooms will fall somewhere between these two extremes

Relevant Terminology

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Relevant Terminology

- Noise ?

Any unwanted sound

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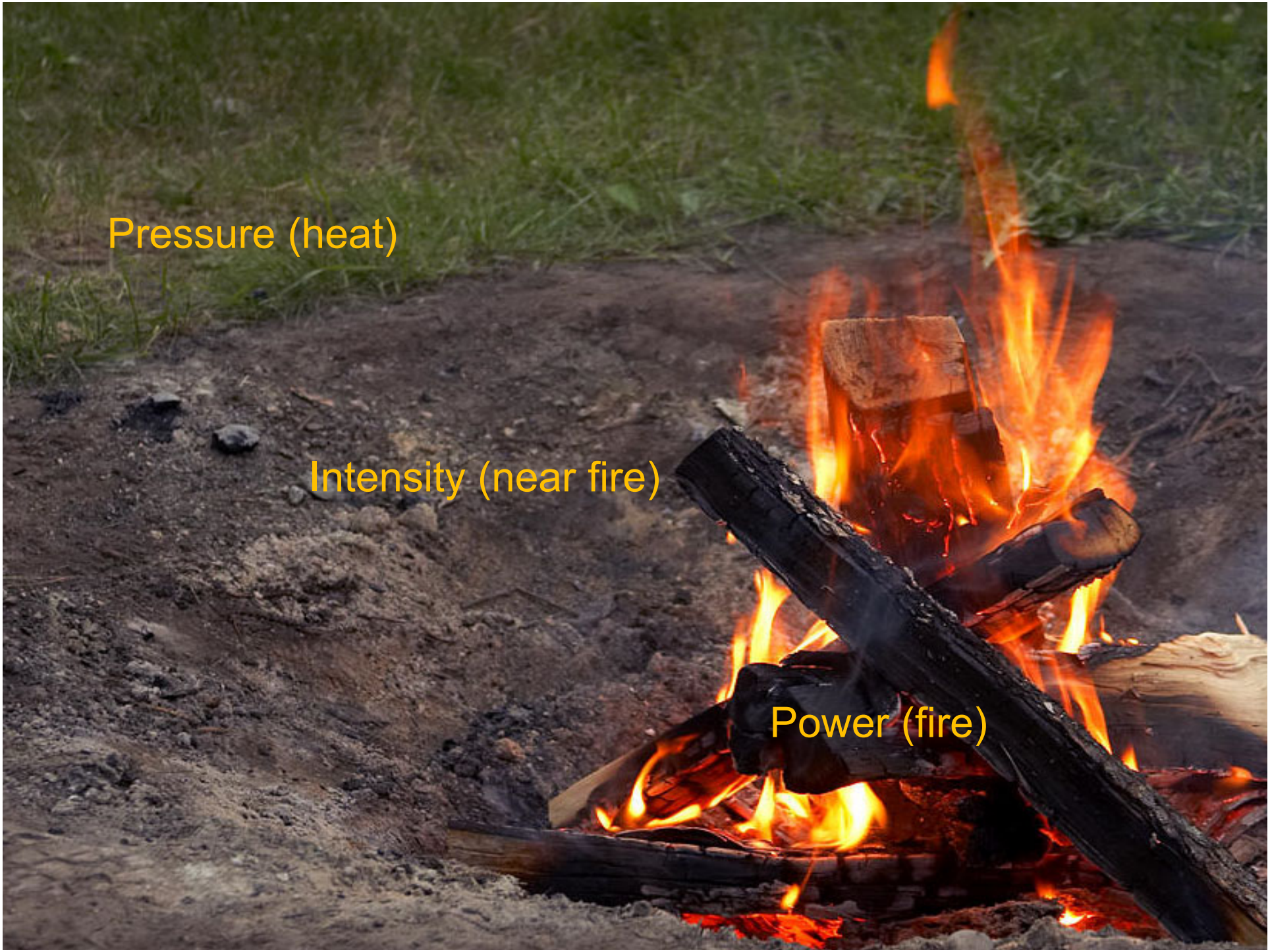
Relevant Terminology

Describing Sound

- Sound Power (Lw)
  - The amount of acoustical power a source radiates **independent** of the environment, measured in **Watts** (W)
  - Equipment → Source
- Sound Pressure (Lp)
  - The pressure fluctuation of a sound source that is **dependent** on source distance and the acoustical environment, measured in **Pascals** (Pa)
  - Design Criteria →NC / dBA = Receiver


Pressure (heat)
Intensity (near fire)
Power (fire)

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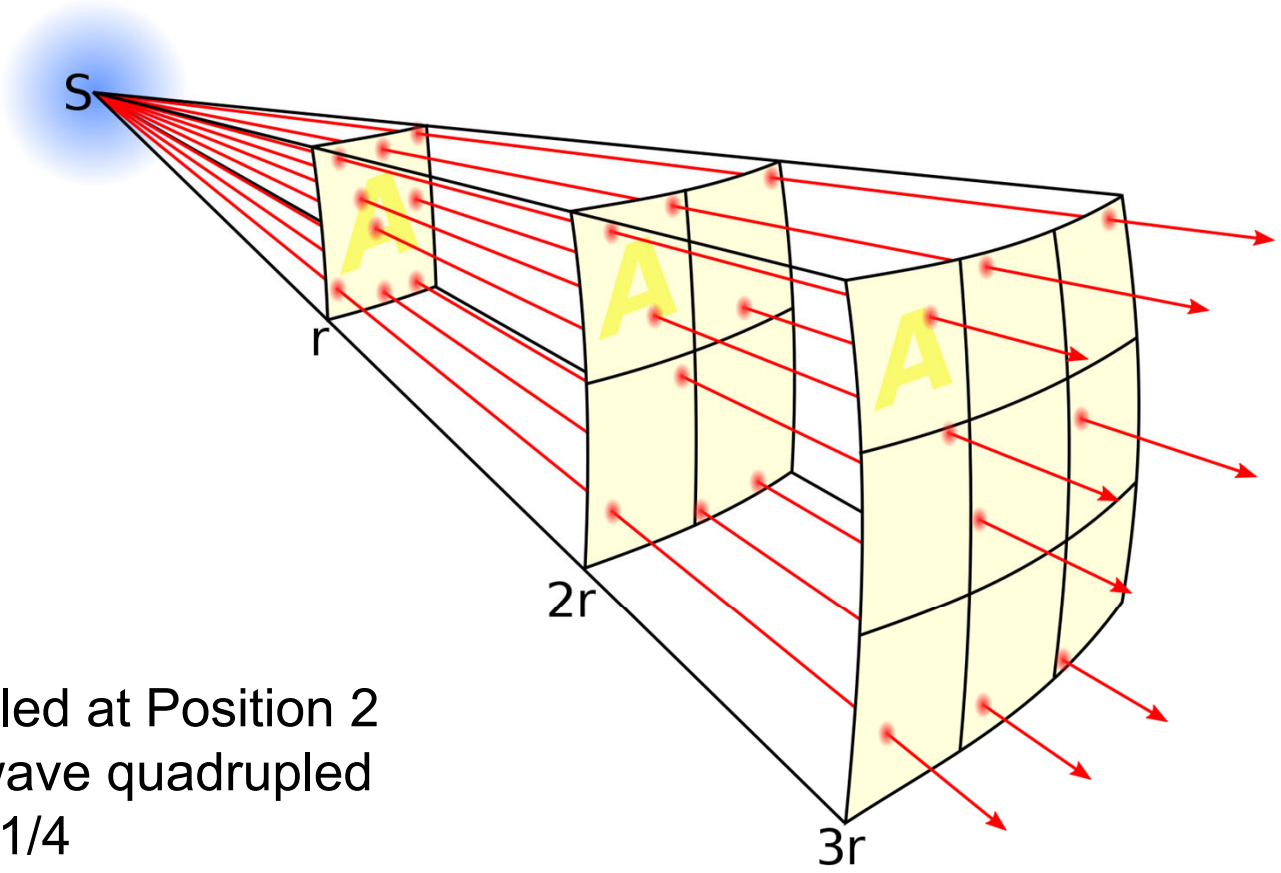
Relevant Terminology

- Inverse-square law (for sound)



Distance r doubled at Position 2 so Area (A) of wave quadrupled and Intensity is 1/4

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Relevant Terminology

- Free Field Example #1

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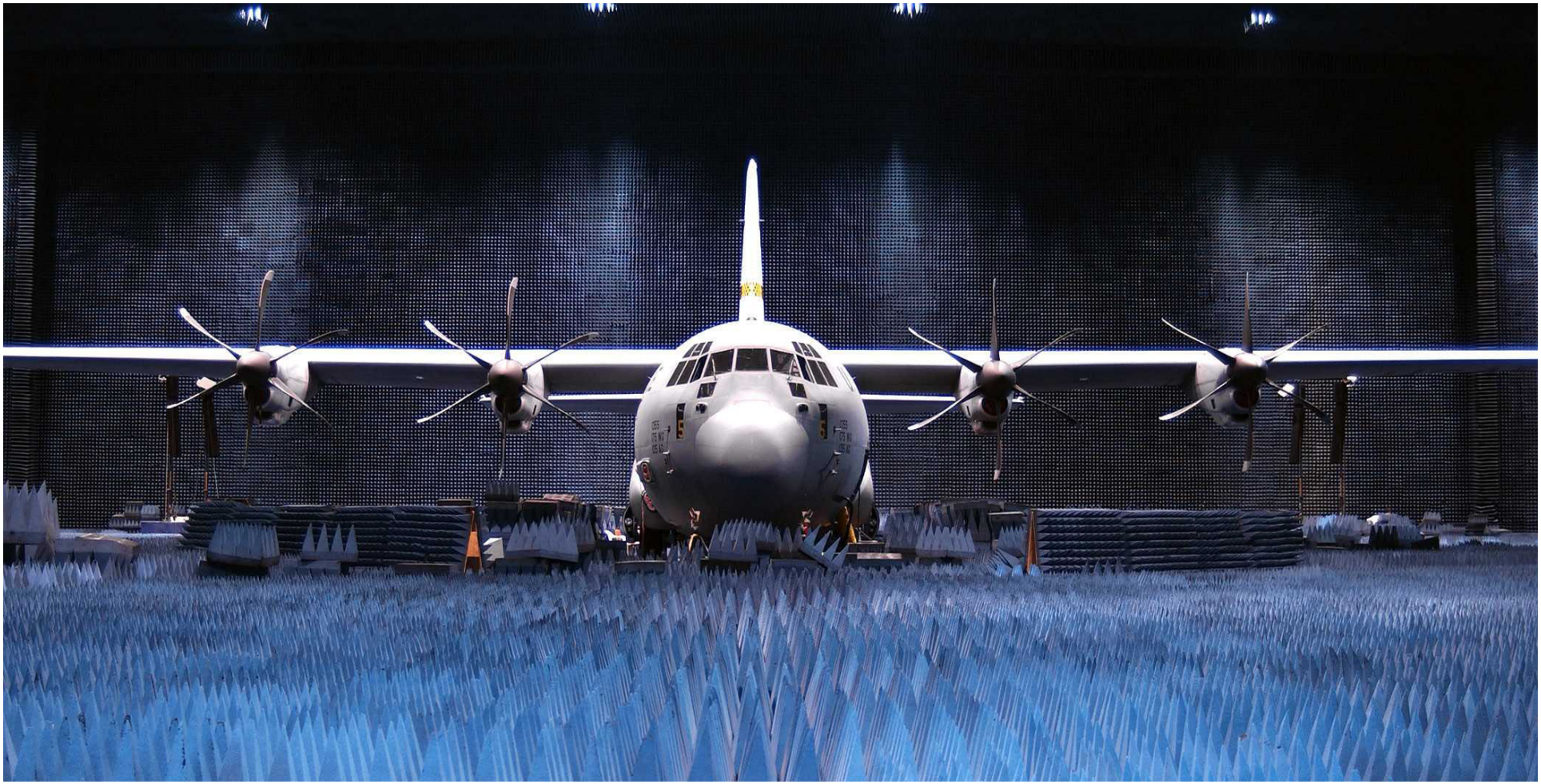
Relevant Terminology

- Free Field Example #2



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Relevant Terminology

- Line Source

Sound energy decreases by 3dB for each doubling of distance from source.

Point sources reinforce each other!

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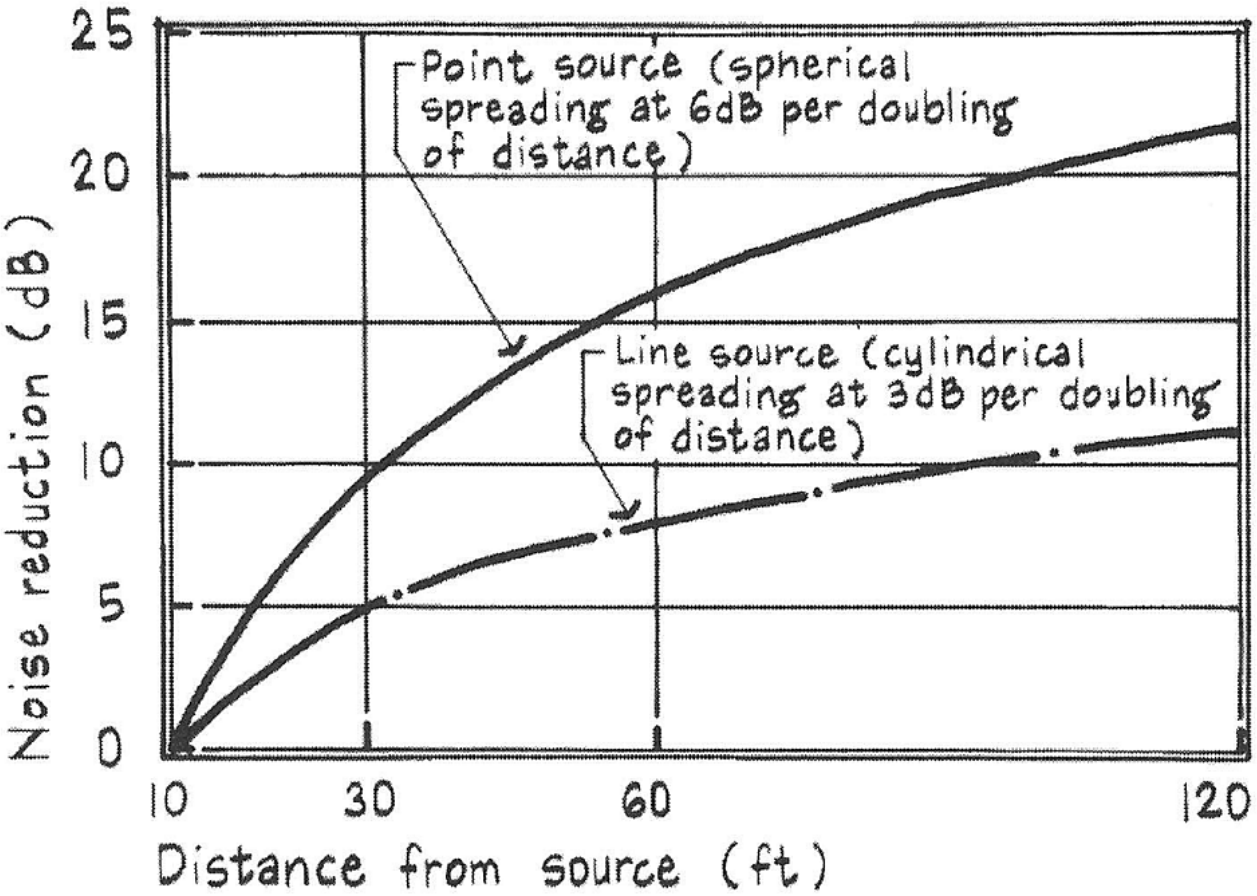
Relevant Terminology

- Distance (Easy)



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Relevant Terminology

Hearing Range

Animal	Range, Hz
Elephant	5 – 12,000
Fish	20 – 4,000
Human	**20 – 20,000**
Cat	45 – 65,000
Dog	50 – 45,000
Dolphin	75 – 150,000
Human Speech	**125 – 8,000**
Mouse	1,000 – 100,000
Bat	2,000 – 120,000
Politicians	**N/A**

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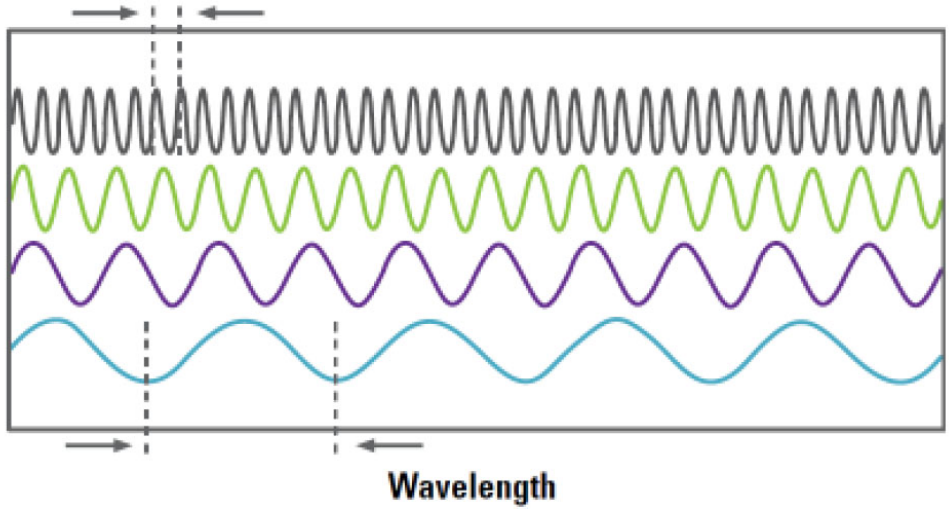
Relevant Terminology

- Wavelength, $\lambda = 1130 / f$

Band	0	1	2	3	4	5	6	7	8
Hz	31.5	63	125	250	500	1k	2k	4k	8k
λ	36’	18’	9’	4.5’	2.25’	1.1’	6.8”	3.4”	1.7”



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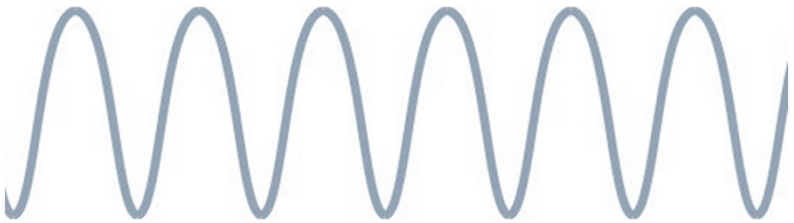
Relevant Terminology

Band	0	1	2	3	4	5	6	7	8
Hz	31.5	63	125	250	500	1k	2k	4k	8k

Low Frequency (Rumble) 31 to 63 Hz

Mid Frequency (Neutral) 125 to 500 Hz



High Frequency (Hiss) 1000 to 8000Hz

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Relevant Terminology

- Typical Background Noise*

Type of Space	NC / RC(N)	dBA
Recording Studio, Concert Hall	15-25	20-30
Teleconference Rooms	25 (max)	30
Boardroom, Conference Rooms, Courtroom	25-35	30-40
Doctor's offices, exam & patient rooms	30-40	35-45
Private Office, Group teaching lab	35-45	40-50
Operating rooms, Patient Care areas	35-45	40-50
Open Plan Office, Corridor	40	45
Restaurants, Retail, Gymnasium	40-45	45-50
Corridors, Lobbies & Public Spaces	40-45	45-50
Testing/research Laboratory	45-55	50-60

*ASHRAE Applications 48.3, Table 1

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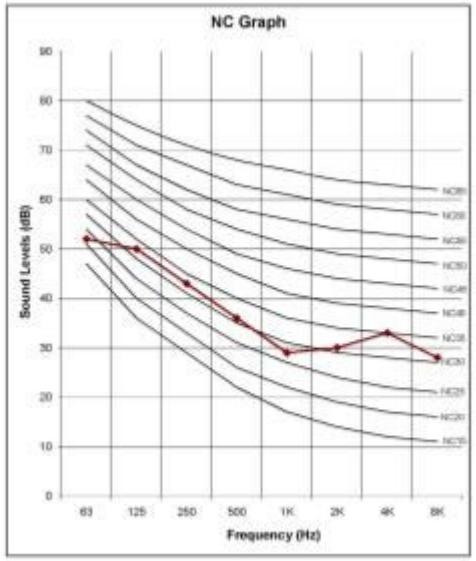
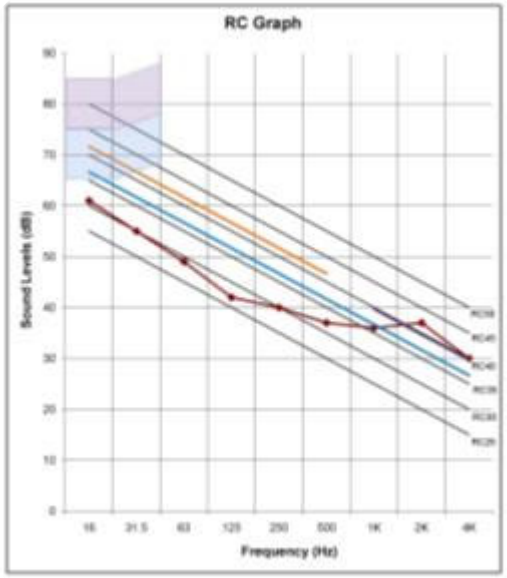
Relevant Terminology

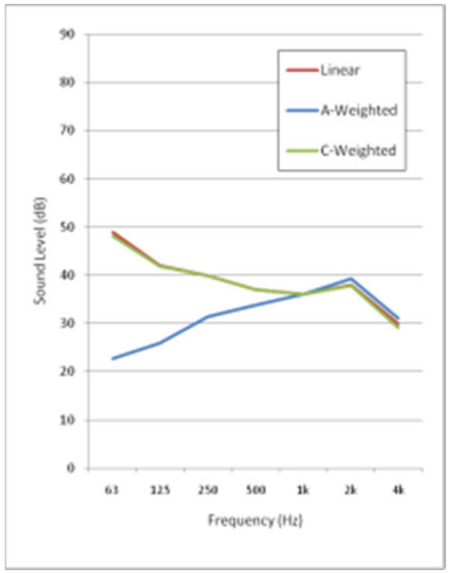
Frequency	63	125	250	500	1000	2000	4000	8000
Lp	49	42	40	37	36	38	30	25



NC 39



RC 37



42.5 dBA

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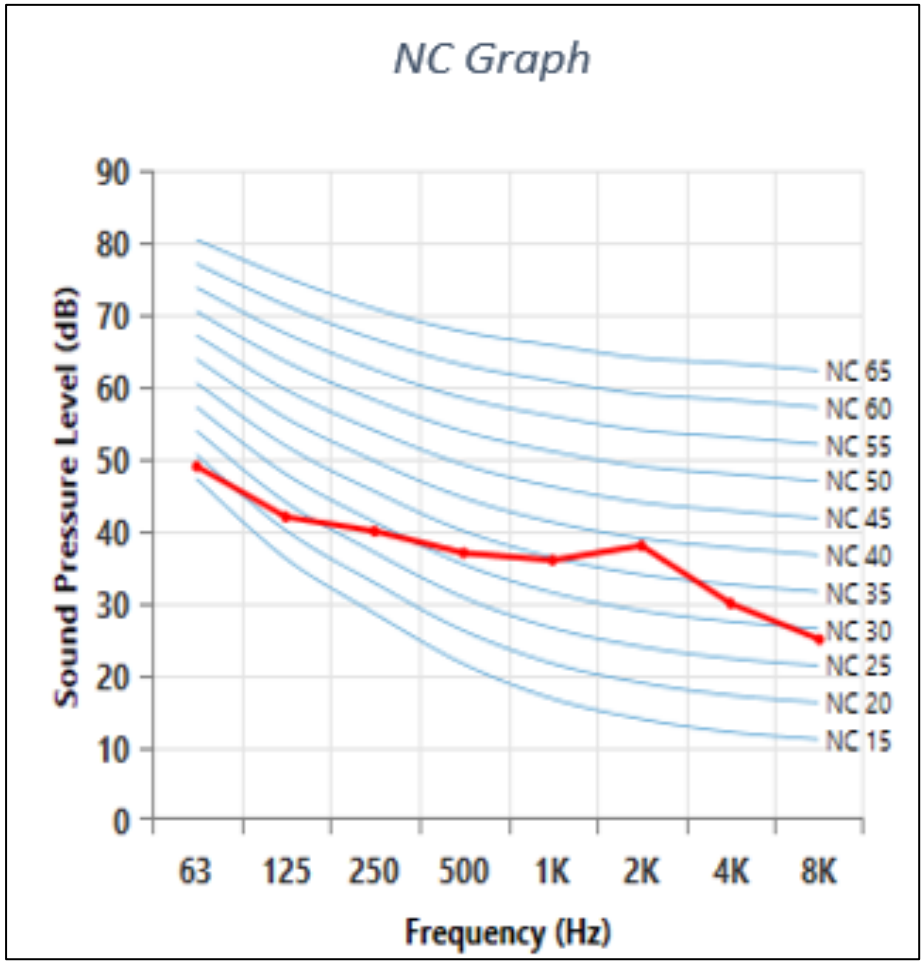
Relevant Terminology

Noise Criteria (NC)

- Developed in 1957
- Single number rating comparing background sound levels to set of defined NC curves
- 63Hz to 8000 Hz octave bands
- Often used for rating Terminals & Diffusers
- Does not provide a sound characteristic



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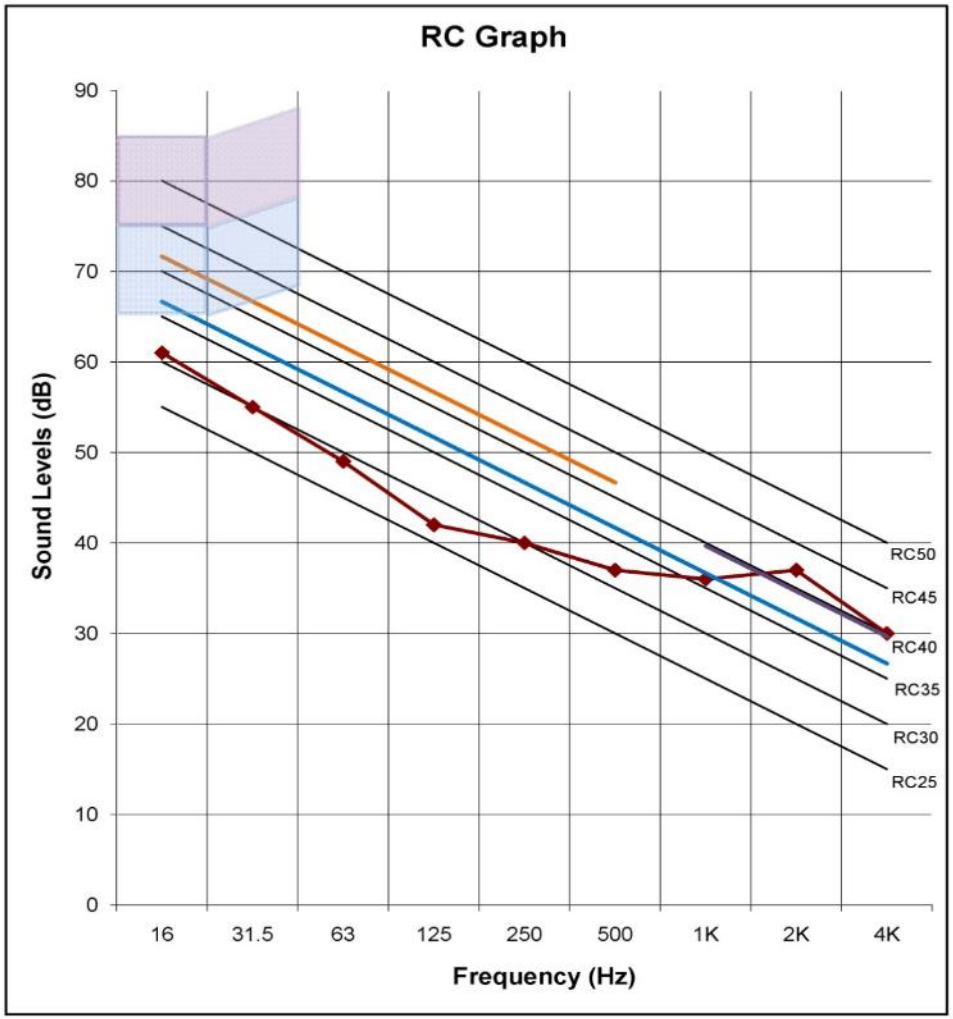
Relevant Terminology

Room Criteria (RC)

- Developed in 1981
- Intended to establish design goals or as diagnostic tool
- RC curves follow constant slope of negative 5dB per octave band
- Average of 500, 1000 & 2000 Hz octave bands
- Indication of sound level and sound characteristics (Rumble(R), Neutral(N) or Hiss(H))



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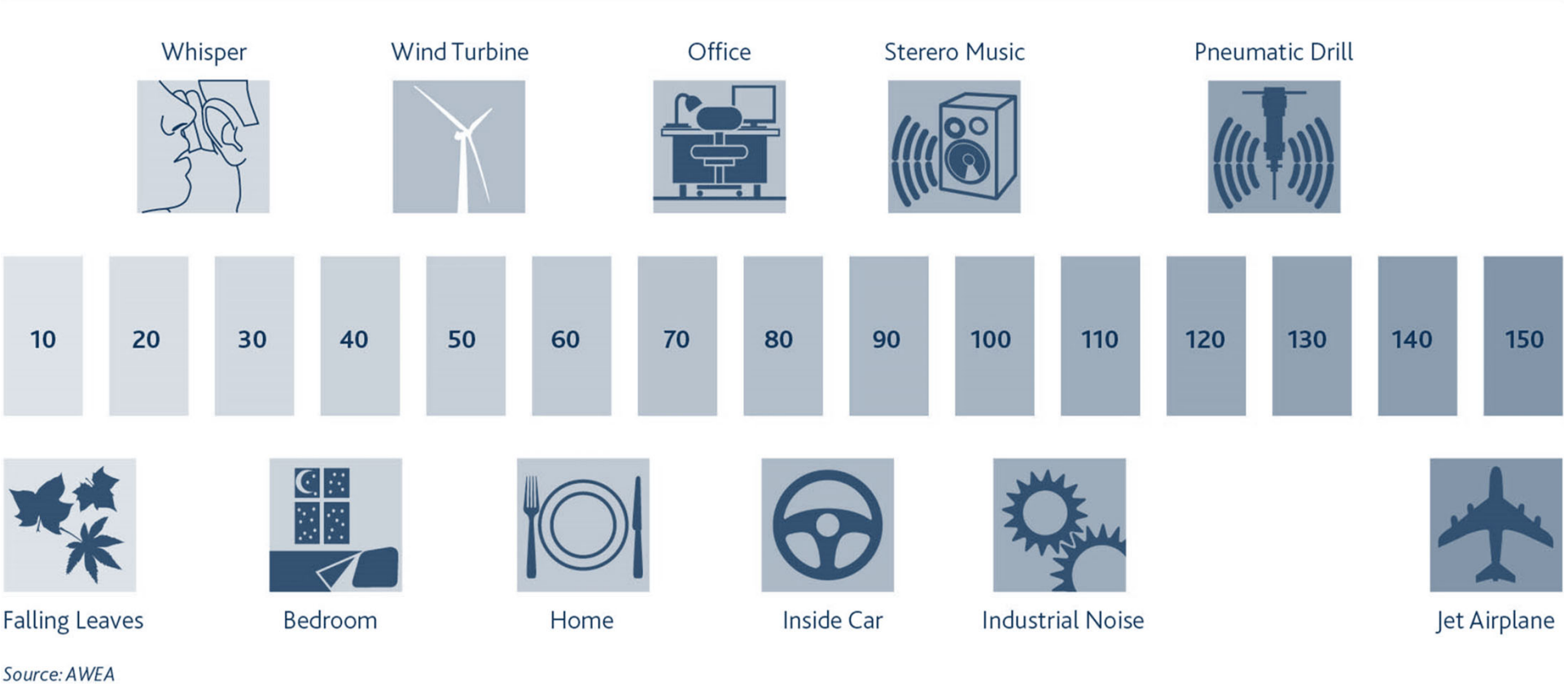
Relevant Terminology

- Decibel Comparison:



Source: AWEA

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Relevant Terminology

- dB addition

Source #1

80 dB

Source #2

80 dB

80 dB + 80 dB = 160 dB

X

10 log (10^80dB/10 + 10^80dB/10) = 83 dB

80 dB + 80 dB = 83 dB

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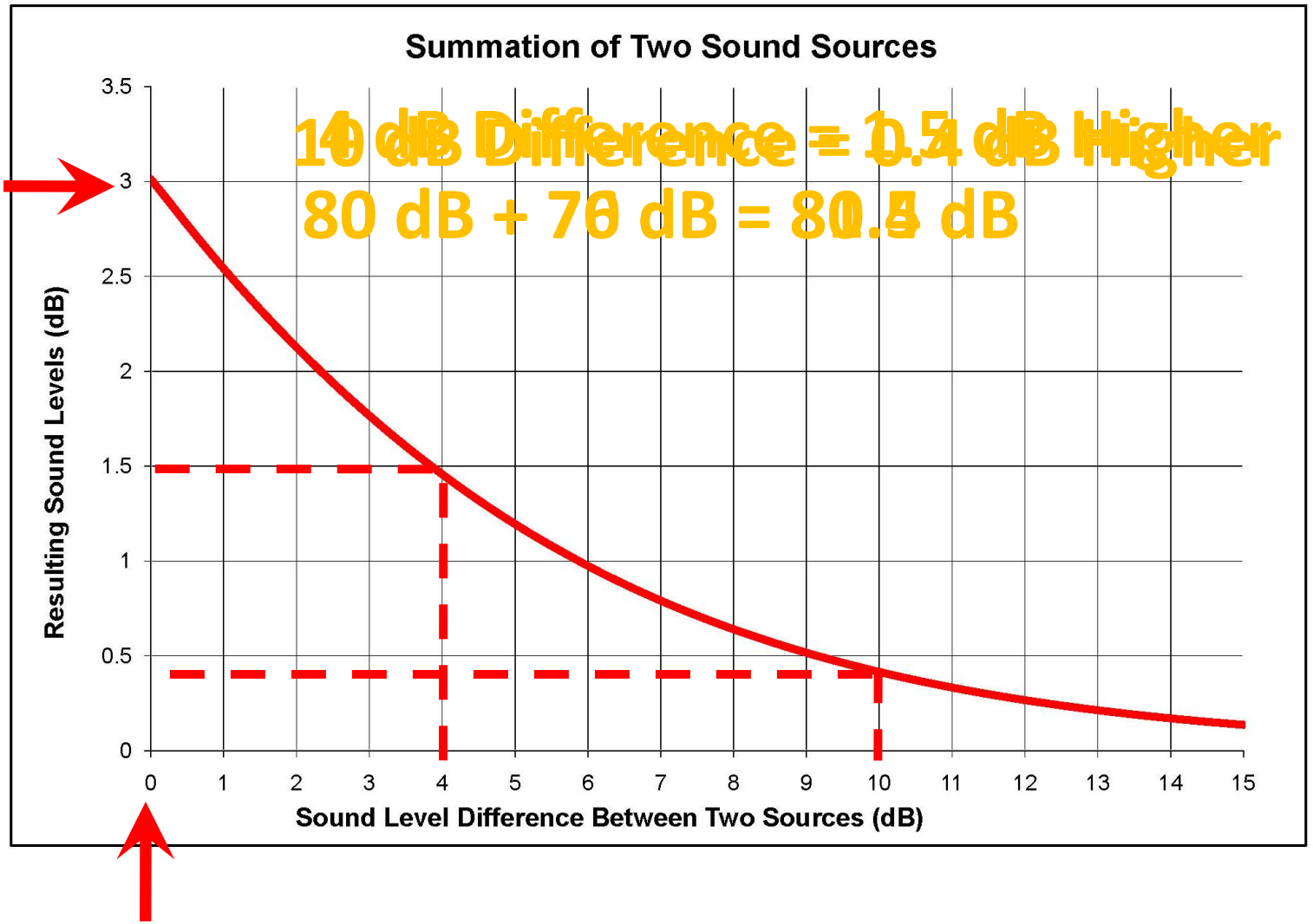
Relevant Terminology



3 Main Aspects

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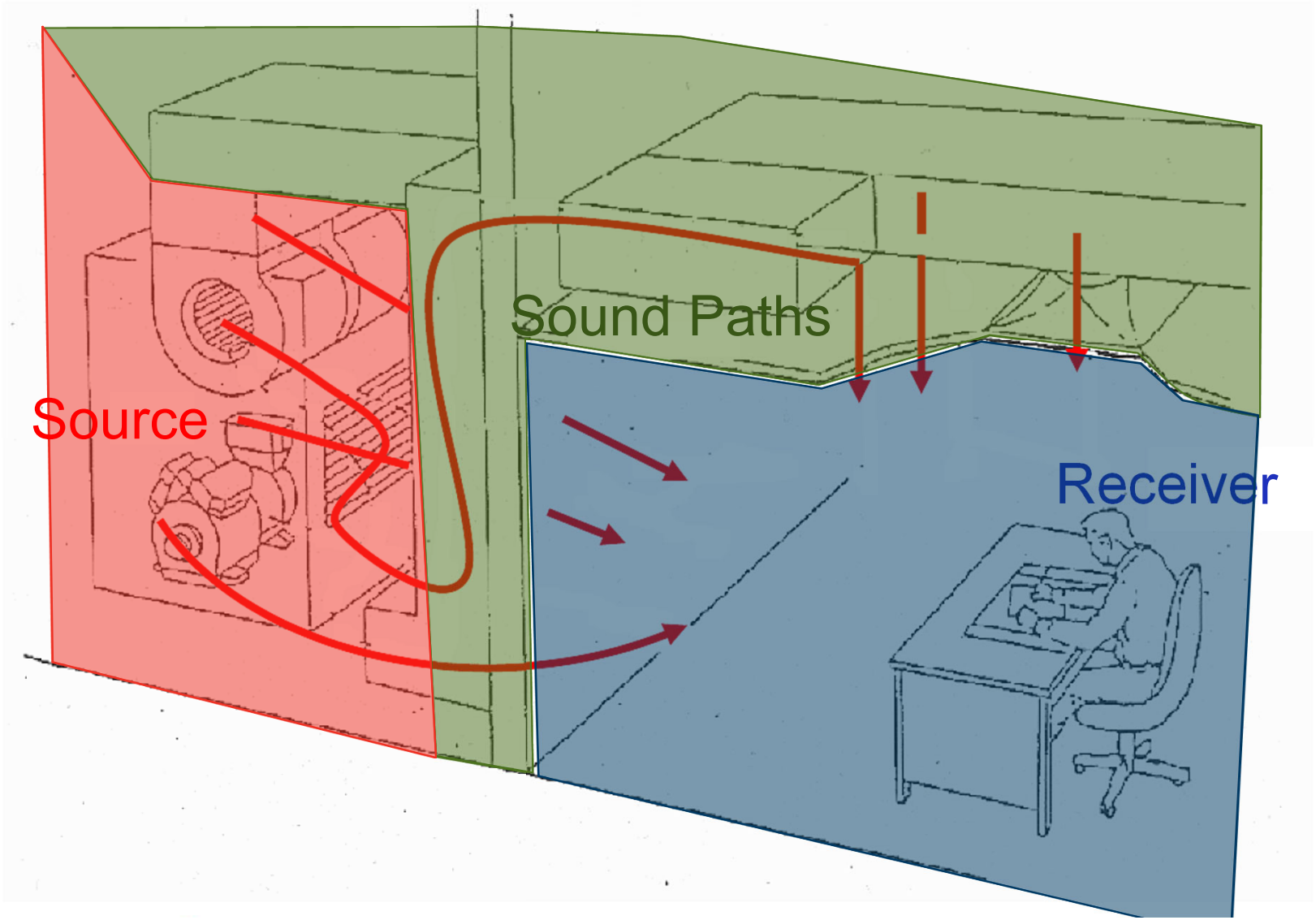
3 Main Aspects



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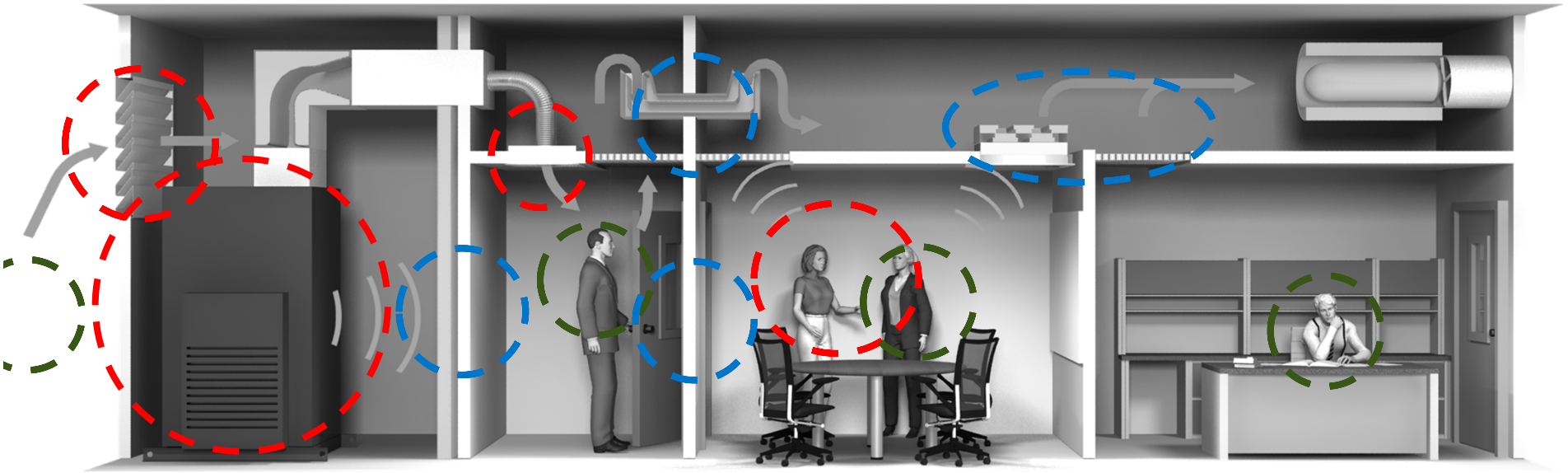
3 Main Aspects

Source (red)

Path (blue)

Receiver (green)



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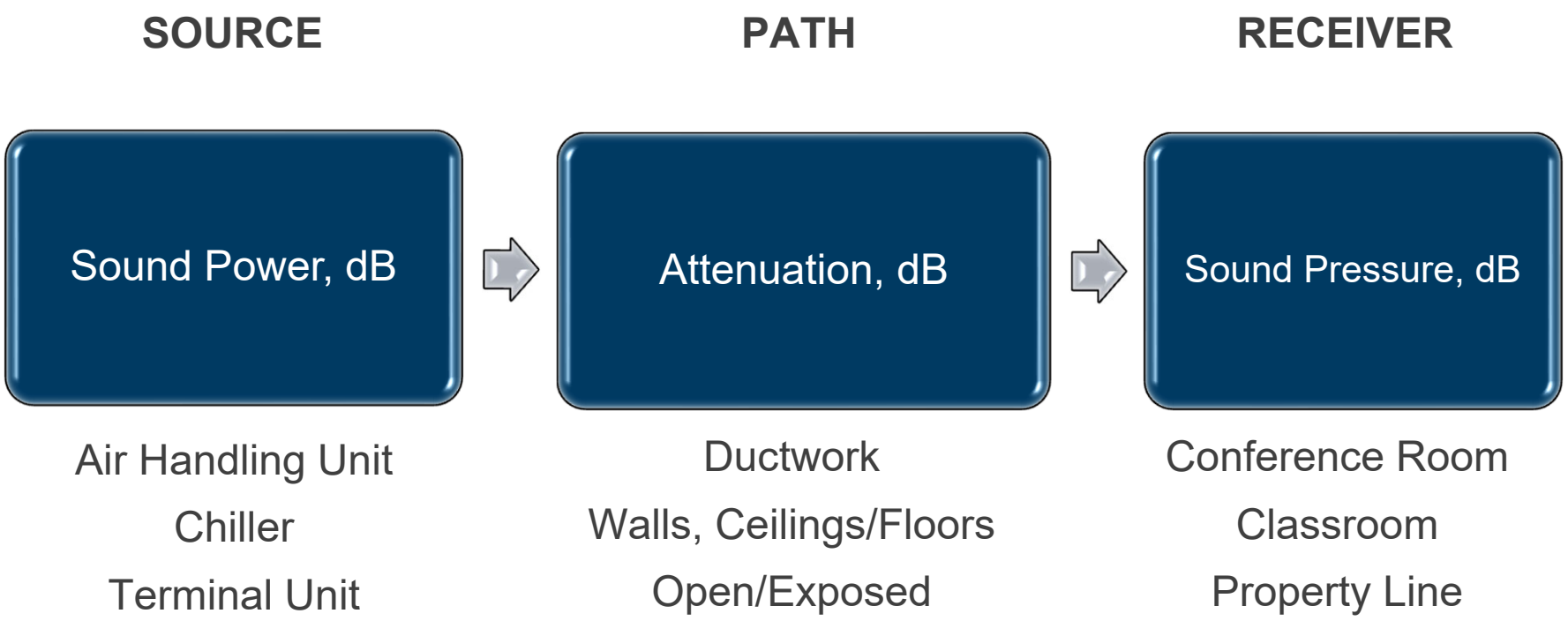
3 Main Aspects



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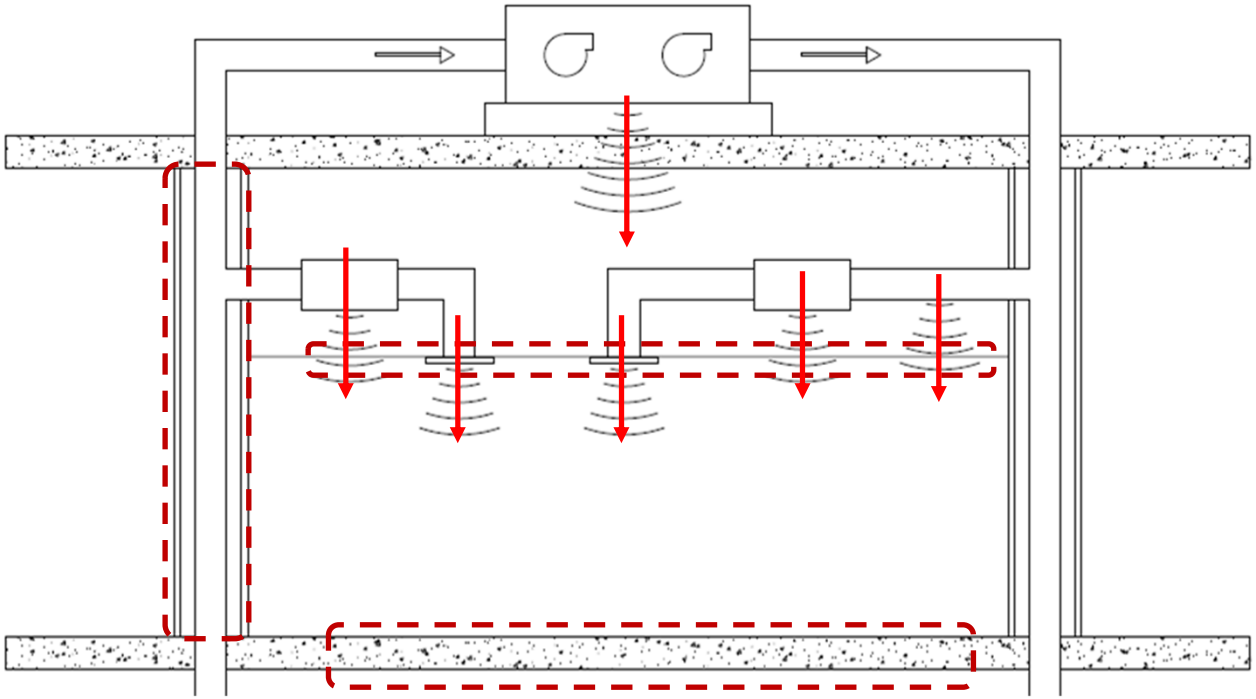
3 Main Aspects

Multiple **Sources** and **Paths** may need to be considered



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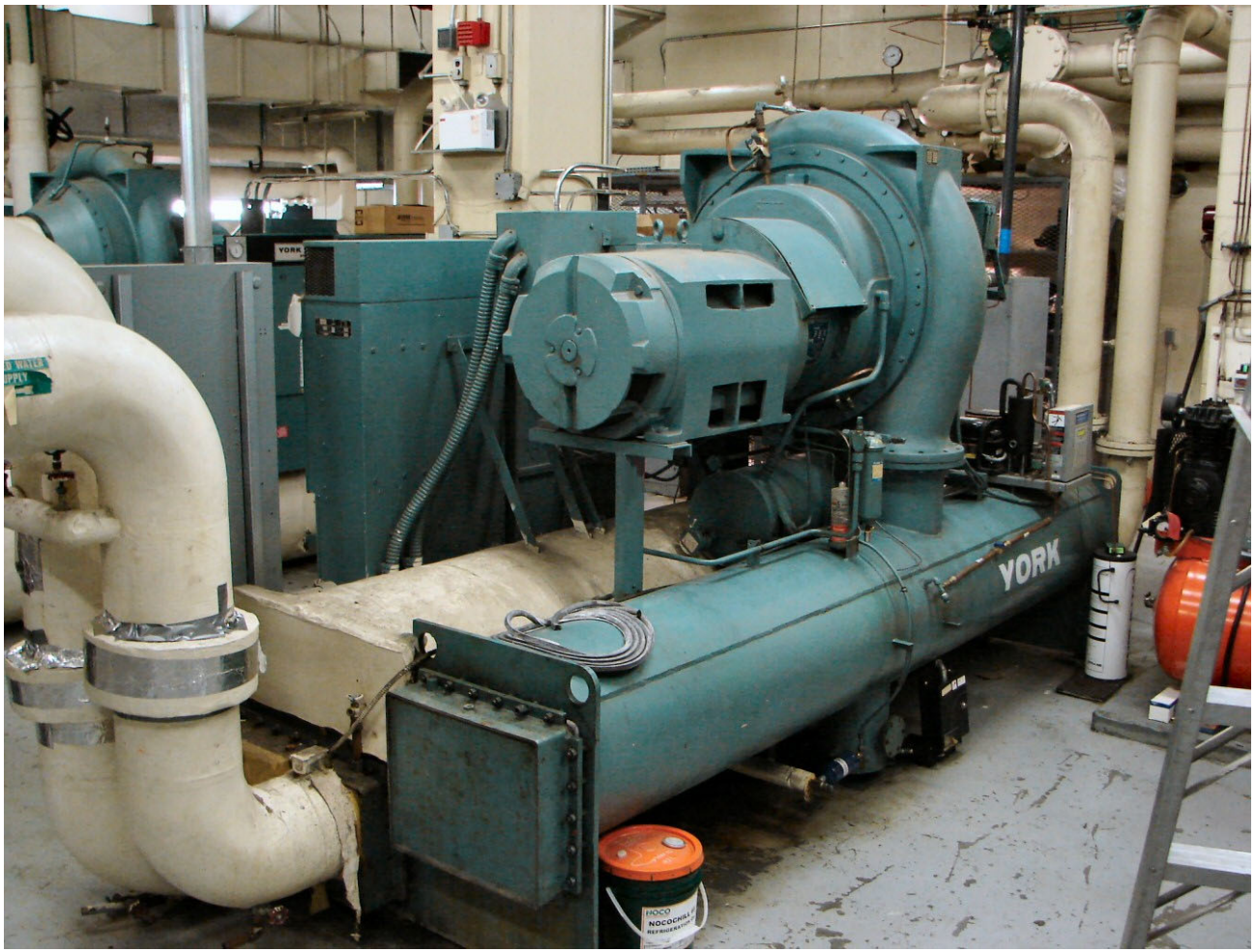
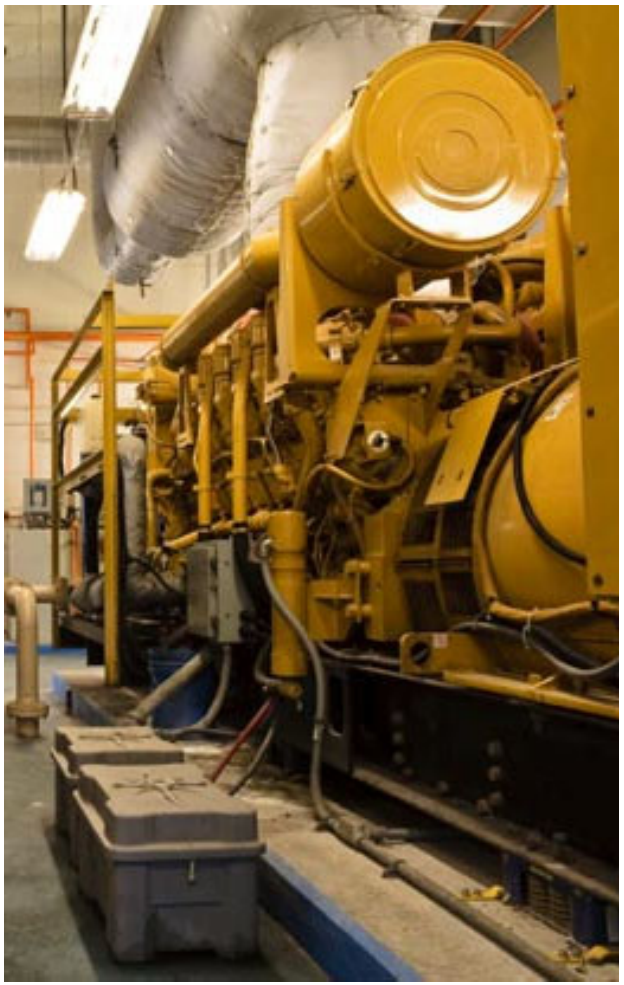
3 Main Aspects

Source





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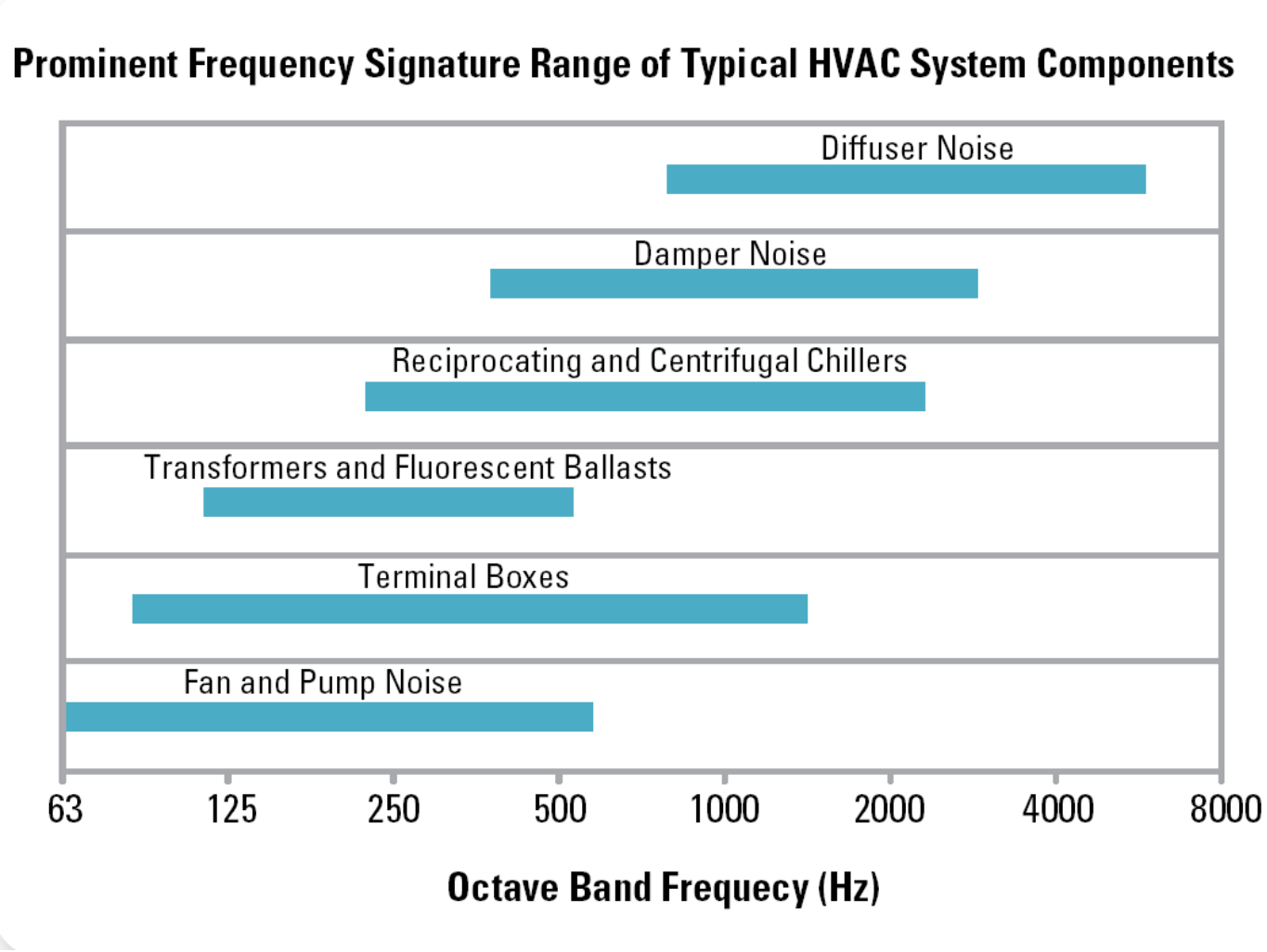
3 Main Aspects



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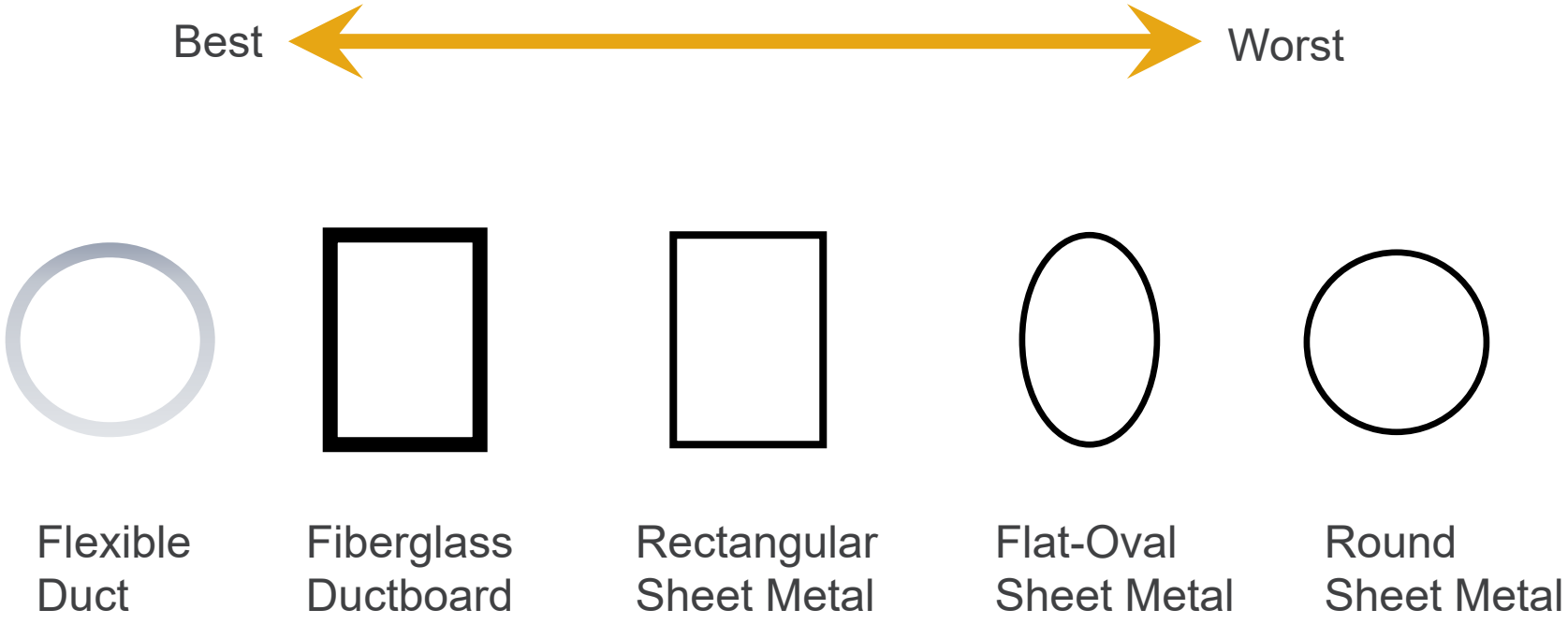
3 Main Aspects

Ductwork absorption potential



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3 Main Aspects

Ductwork vs. Silencers

24” x 24” ductwork comparison…

Path	125	250	500	1000	2000	4000
10ft duct w/o lining	2	1	0.3	0.3	0.3	0.3
10ft duct w/ 1” lining	2	5	14	28	22	18
10ft duct w/ 2” lining	3	9	25	35	22	18
3ft rectangular silencer	5	9	20	28	24	18
5ft rectangular silencer	8	16	29	41	30	23

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3 Main Aspects

Duct Silencers

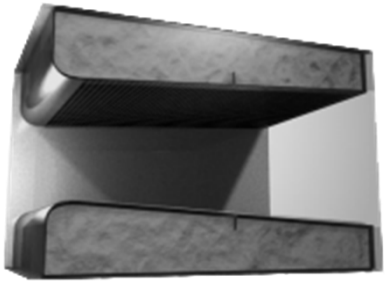
Rectangular

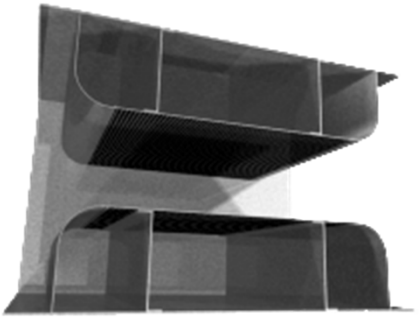
Elbow

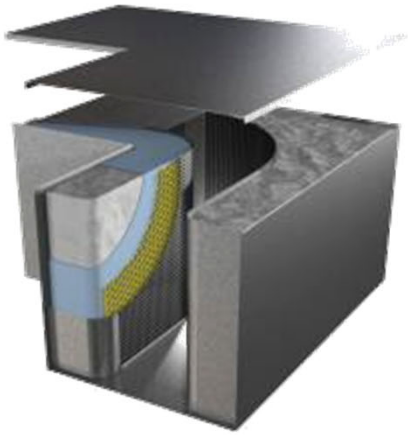
Circular

Polymer Lined

Packless







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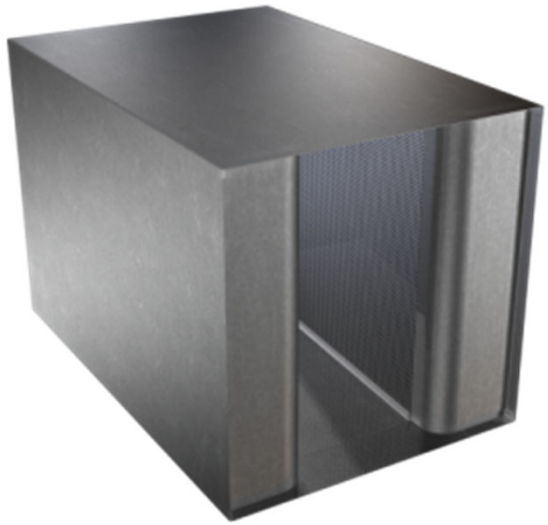
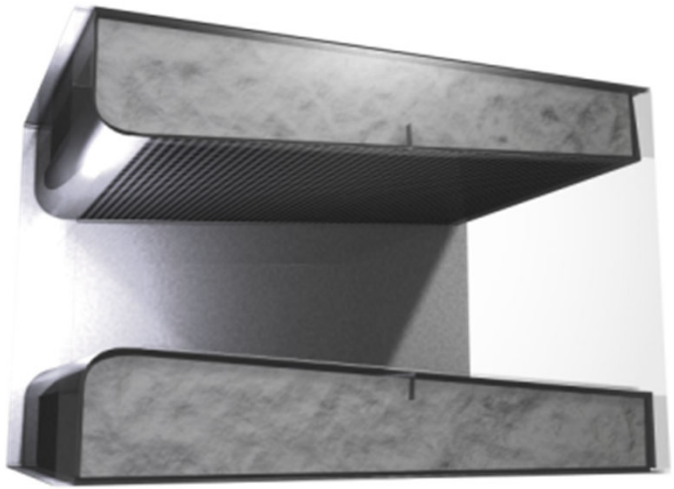
3 Main Aspects

Rectangular Silencers

- Most common type of silencer
- Lowest cost
- Breakout noise reduced using HTL casing





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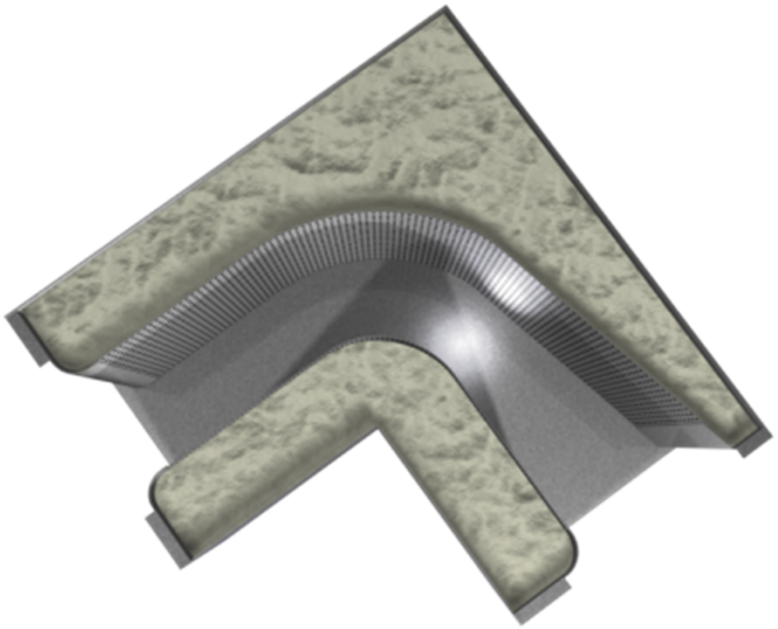
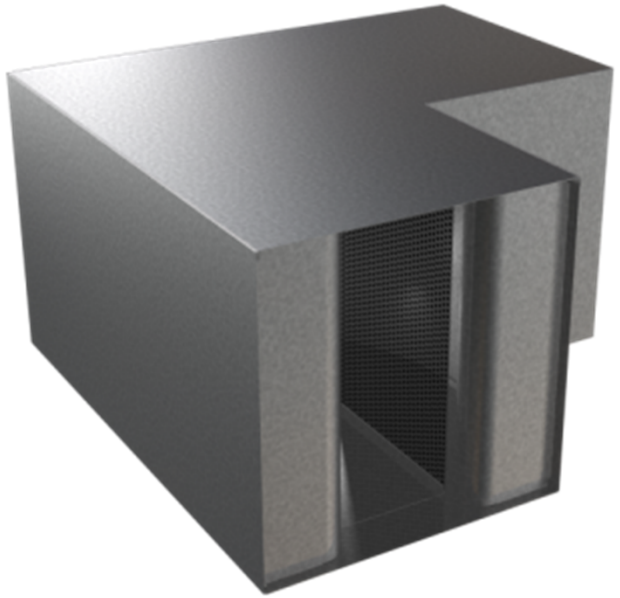
3 Main Aspects

Elbow Silencers

- Where standard rectangular silencers will not fit
- Generated noise should be considered
- Recommended velocity below 1500 fpm





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3 Main Aspects

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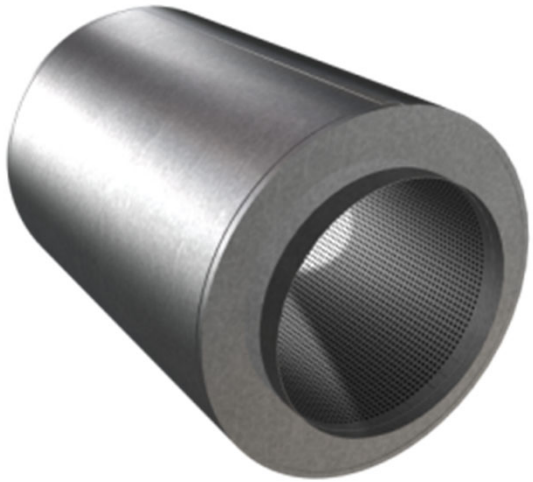
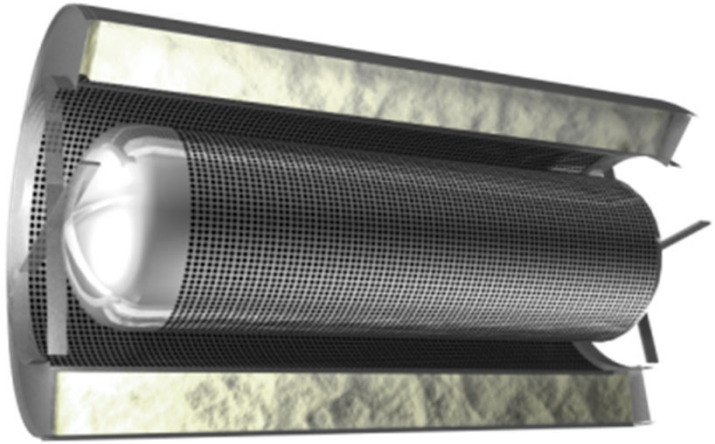
3 Main Aspects

Circular Silencers

- Round duct applications
- Higher velocity up to 8000 fpm
- HTL casing at low frequencies





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3 Main Aspects

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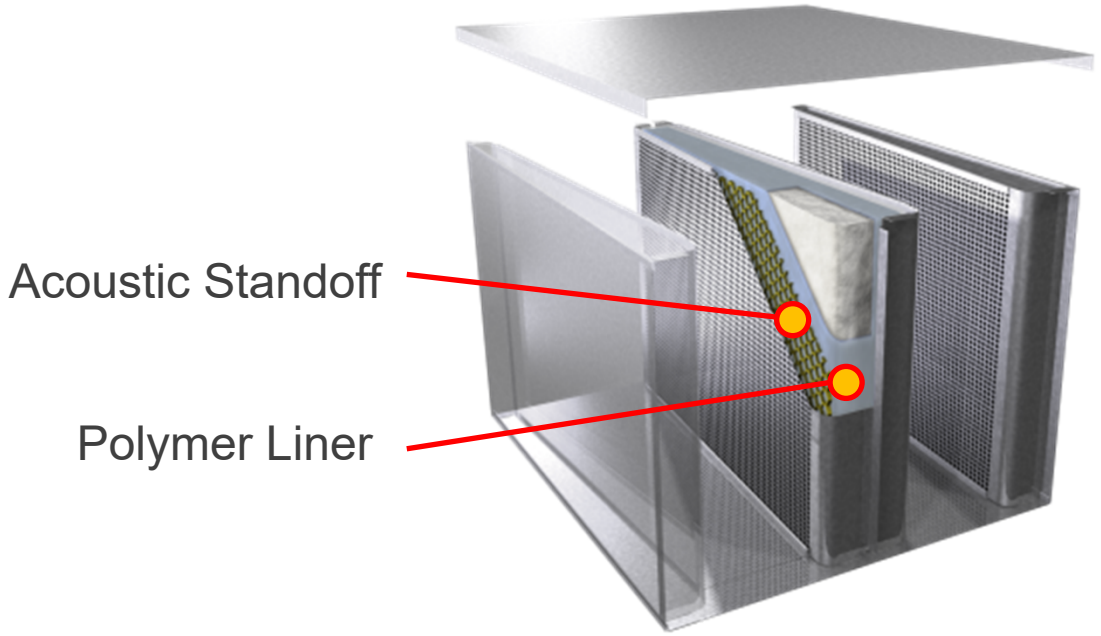
3 Main Aspects

Film Lined Silencers

- Polymer liner + acoustic standoff
- Applications requiring contaminant free environment
- Hospital grade



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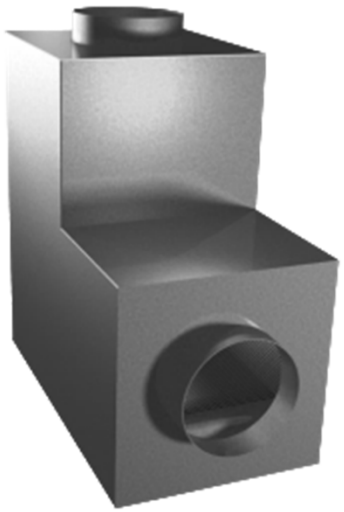
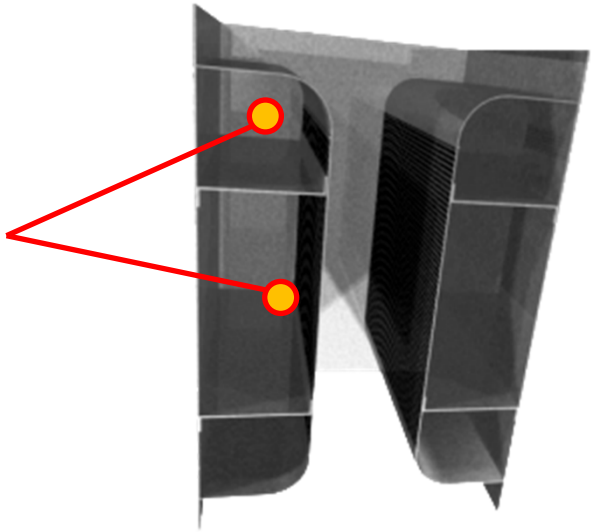
3 Main Aspects

Packless

- No acoustic media
- Applications requiring contaminant free environment
- Cleanable / Hospital grade
- For applications with extremely high air quality standards



Tuned chambers



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3 Main Aspects

- Silencer Location

Locate as close to the source as possible or within Mechanical Spaces

Place on the rooftop for rooftop units…

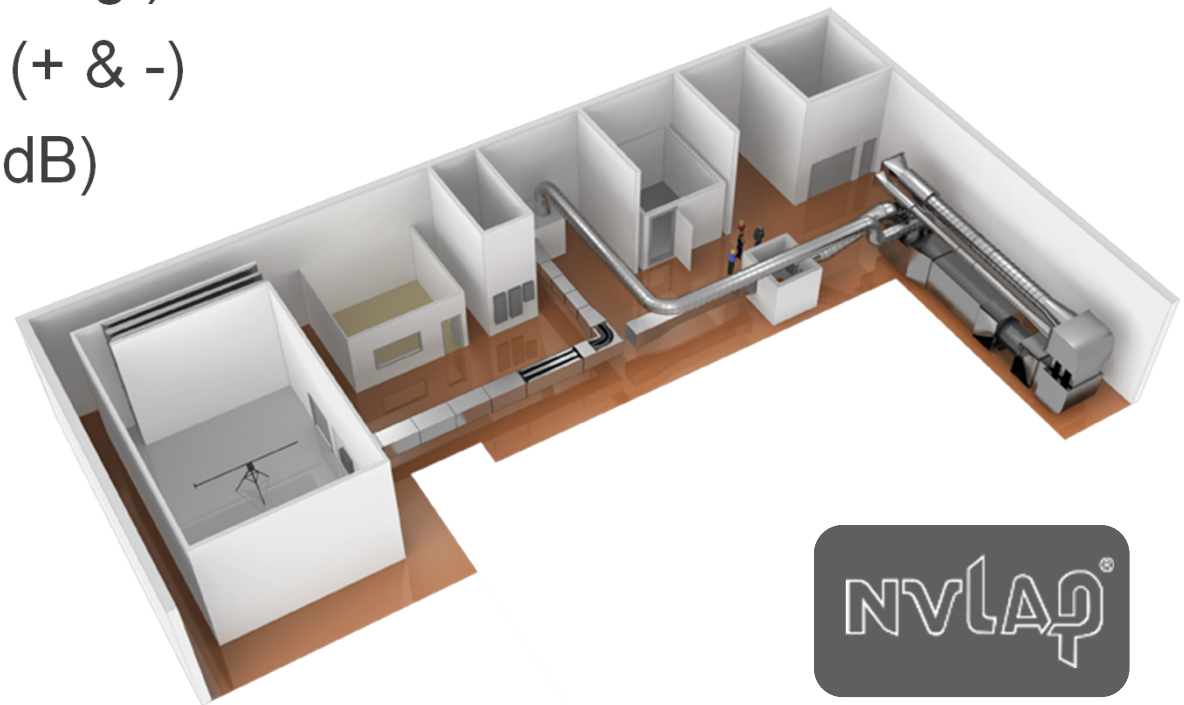
…or in vertical shafts

Acoustical Considerations for Building Design

3 Main Aspects

Testing:

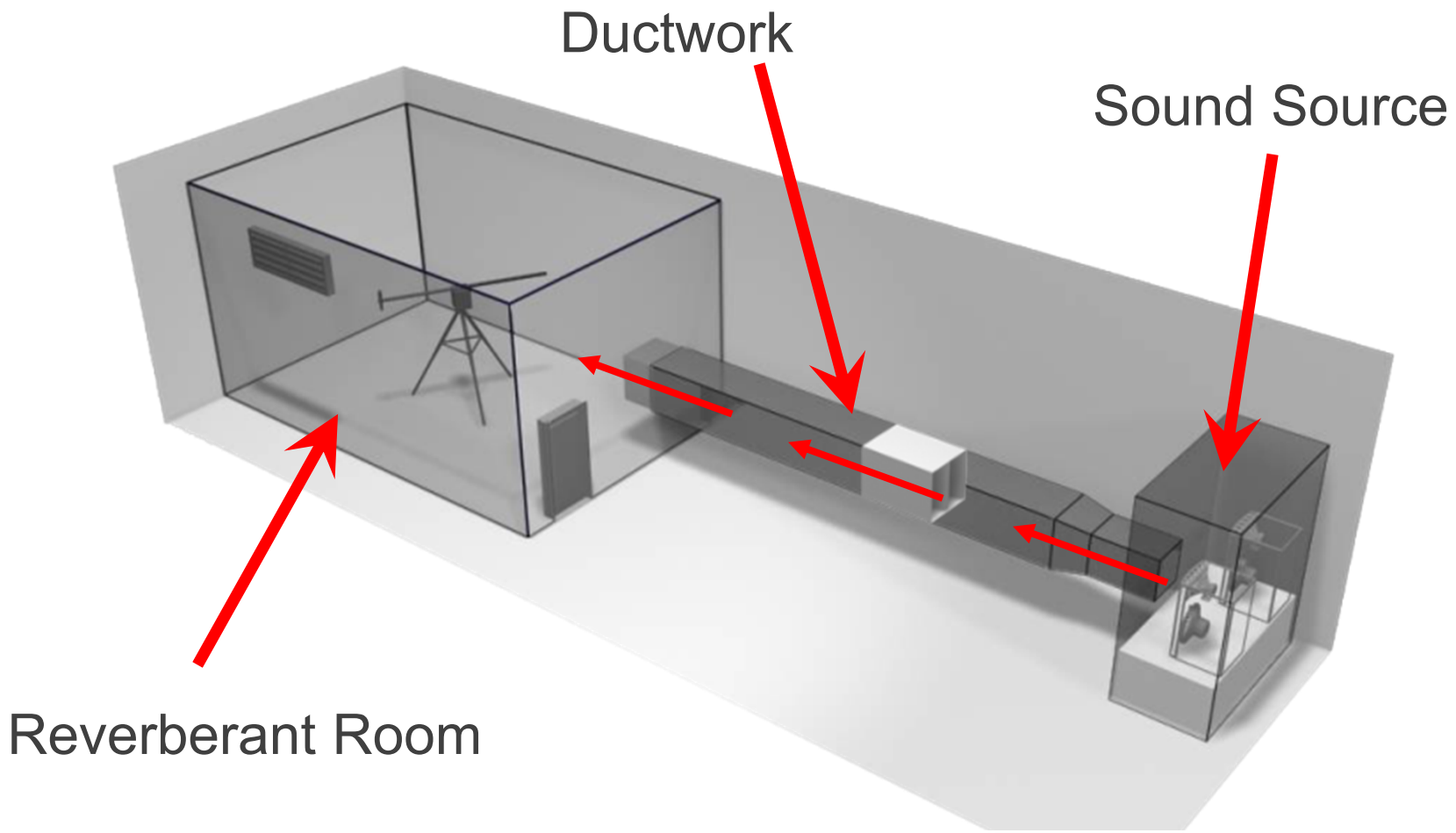
- Ensure data derived from ASTM E477-13
- Dynamic Insertion Loss (dB)
- Pressure drops (in.w.g.)
- Air flow directions (+ & -)
- Generated noise (dB)



Acoustical Considerations for Building Design

3 Main Aspects

Test Method – ASTM-E477-13

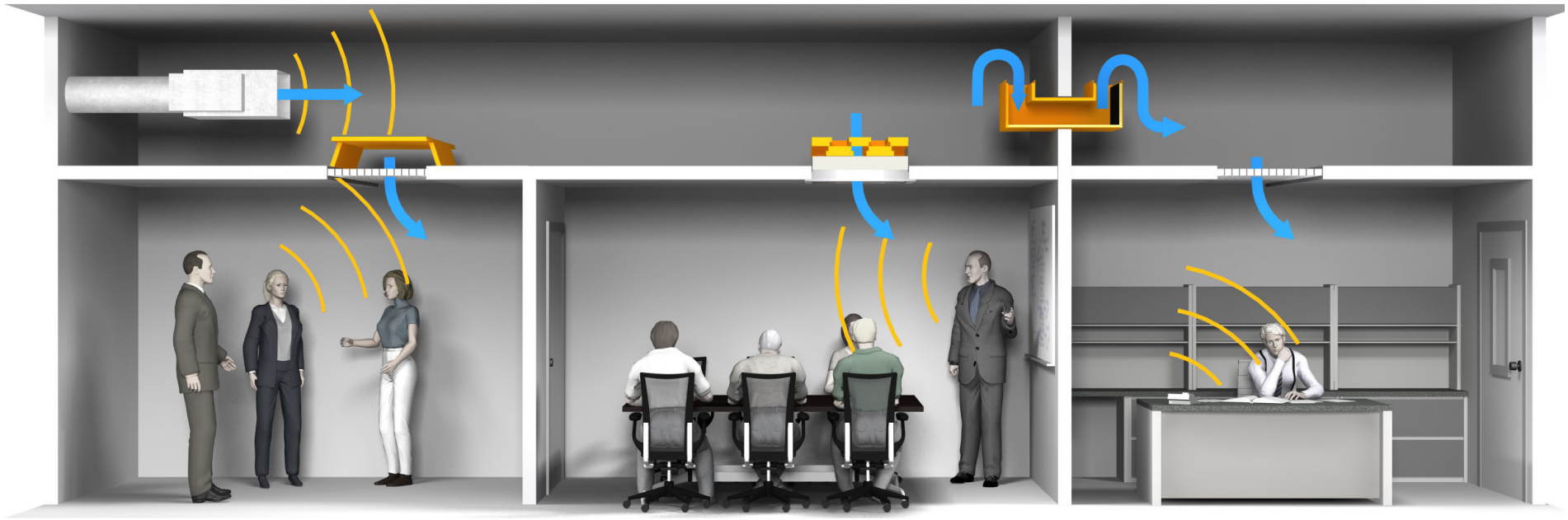


Acoustical Considerations for Building Design

3 Main Aspects

Radiated sound is most often associated with sound energy traveling through **air** to a **receiver**

Mechanical equipment's casing radiated sound or ductwork and flex connection break-out noise



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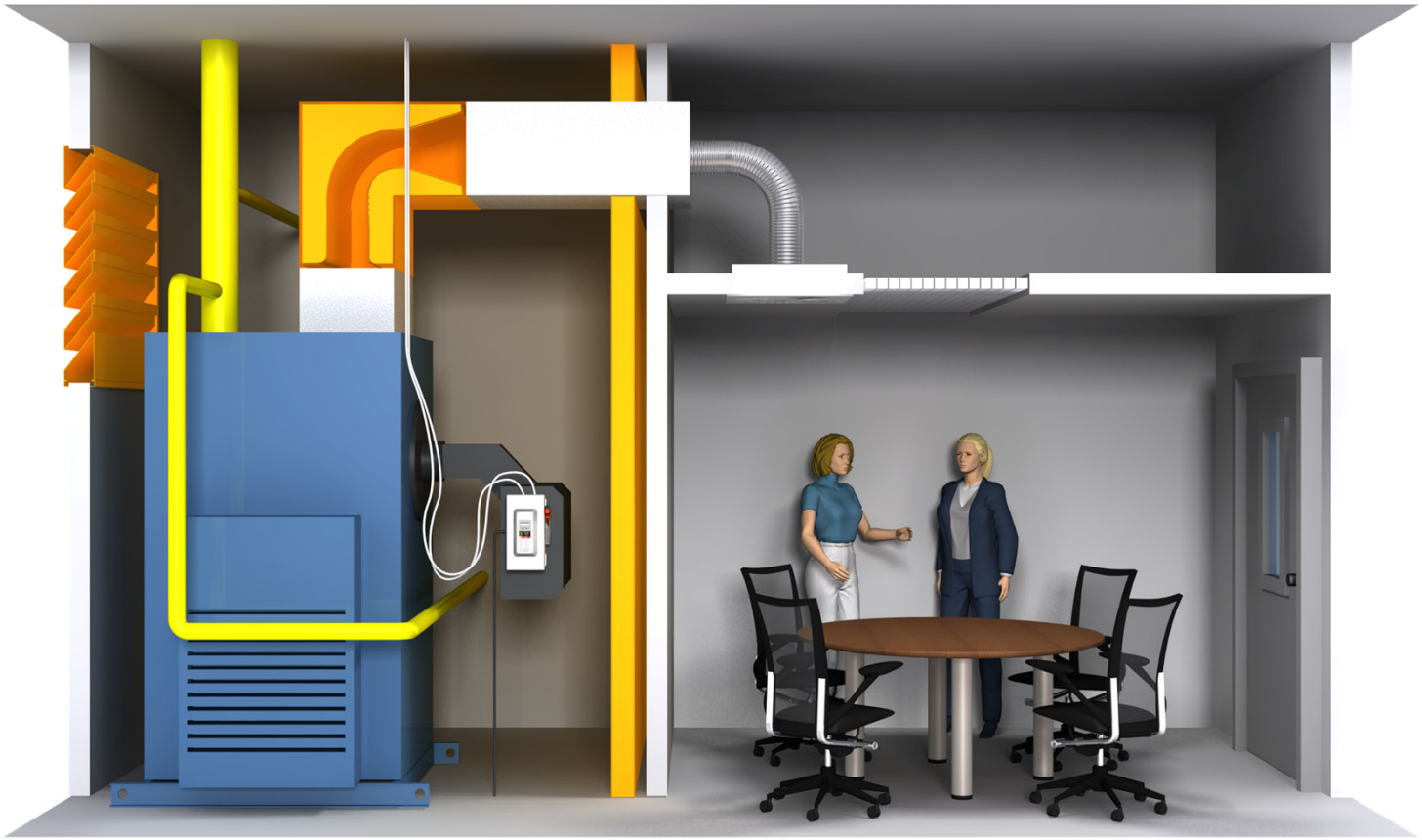
3 Main Aspects

Noise Control products can be utilized to address Radiated Sound Energy by adding sound blocking (**STC**) and sound absorption (**NRC**) to a mechanical space



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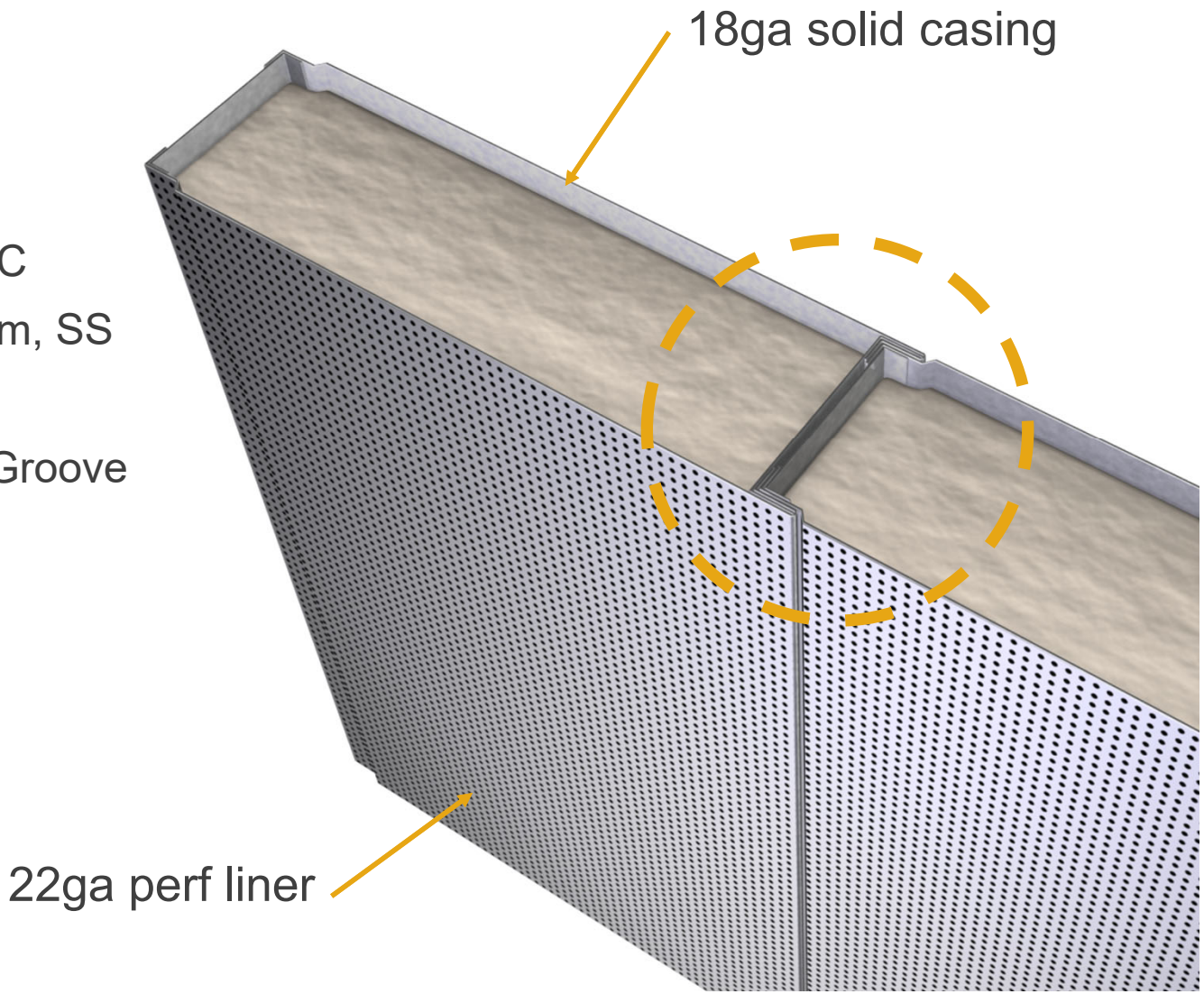
3 Main Aspects

Acoustic Panels

- Lab rated STC & NRC
- Galvanized, Aluminum, SS
- Painted finishes
- Insulated Tongue & Groove
- H-Channel



Acoustical Considerations for Building Design

3 Main Aspects

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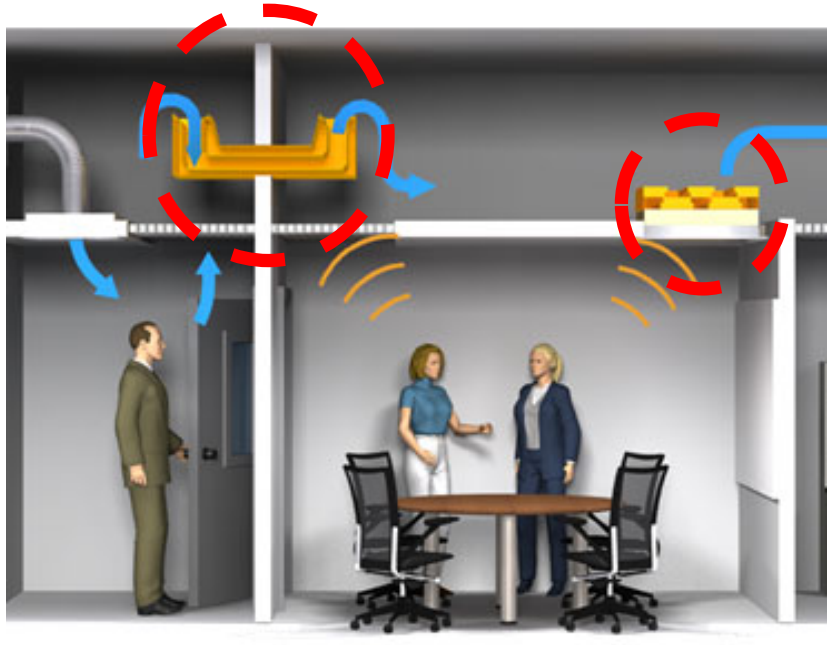
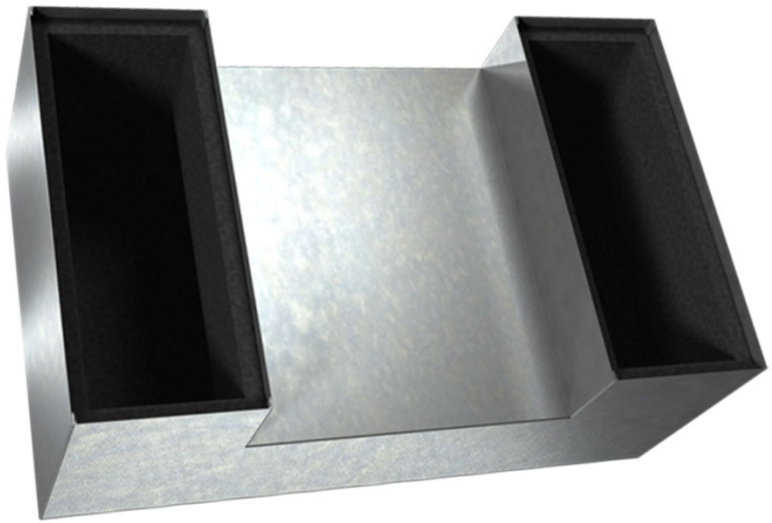
3 Main Aspects

Air Transfer Noise

Reduce Noise Flanking

- Common return air plenum
- Often between private & open plan spaces





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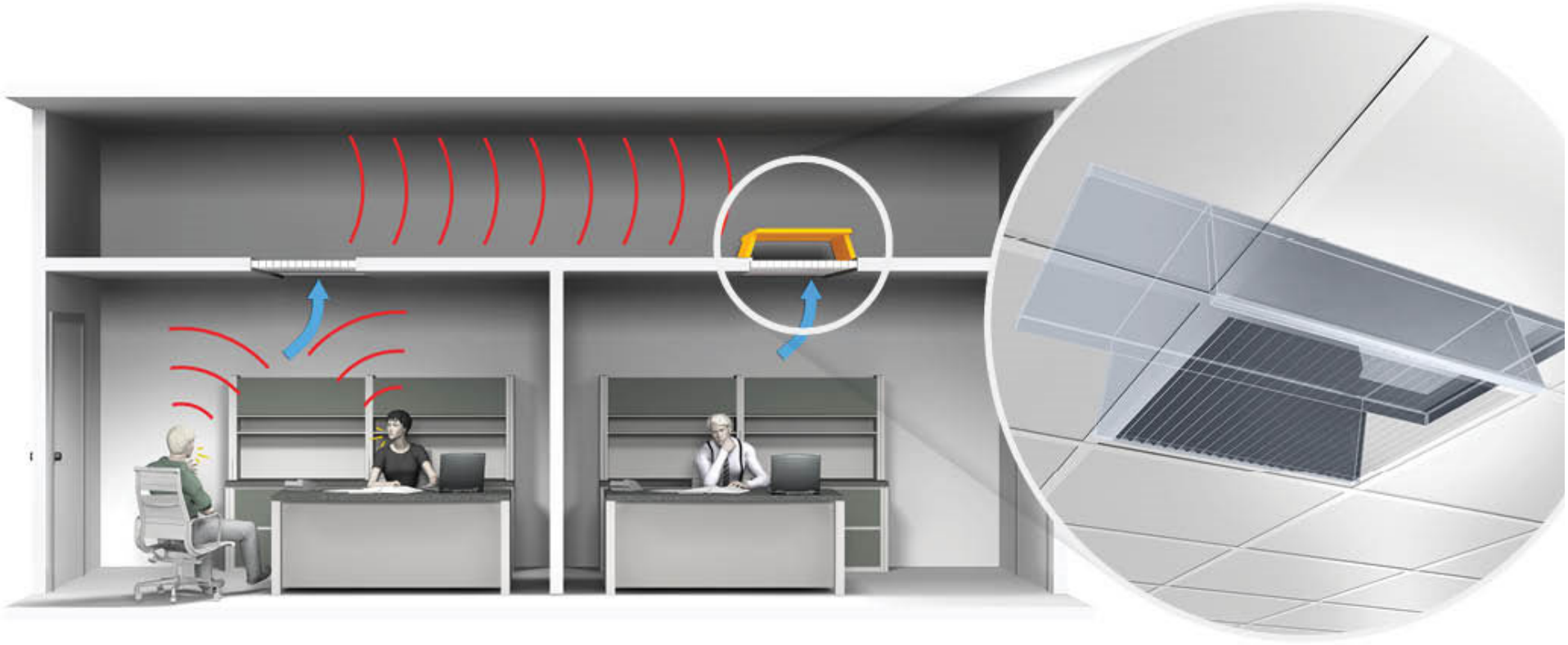
3 Main Aspects

Return Air Noise

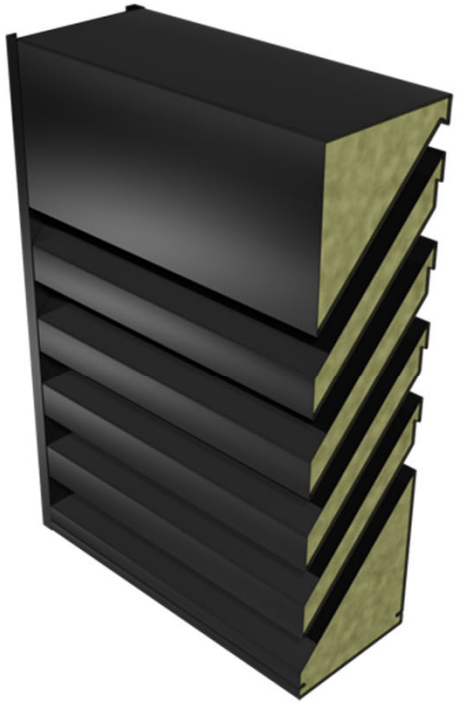


Acoustical Considerations for Building Design

3 Main Aspects

Acoustic Louvers

- Control Noise at the façade of building



Blade

Airfoil

Acoustical Considerations for Building Design

3 Main Aspects

Quiet HVAC Systems

Acoustical Considerations for Building Design

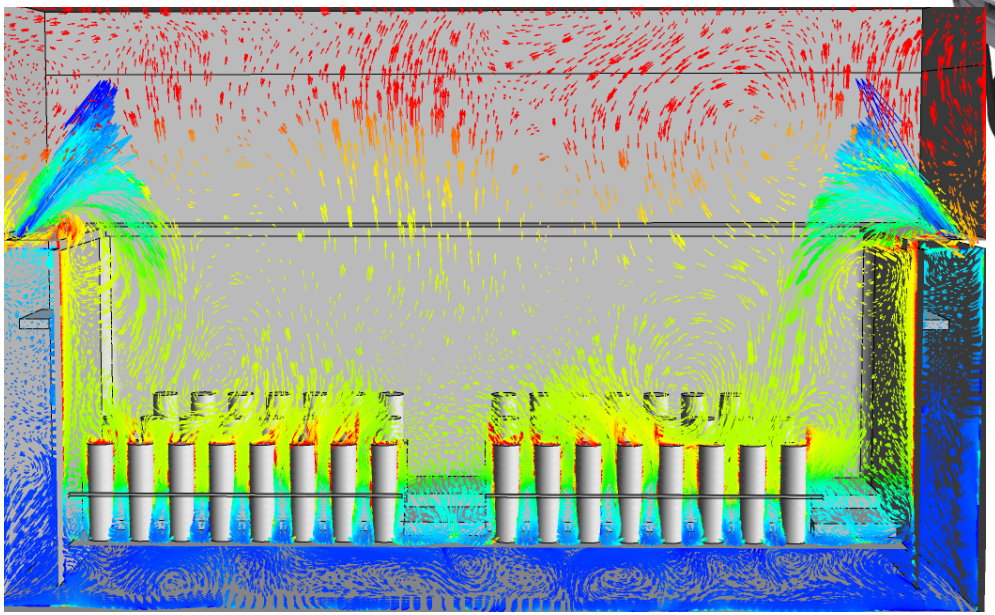
Quiet HVAC Systems

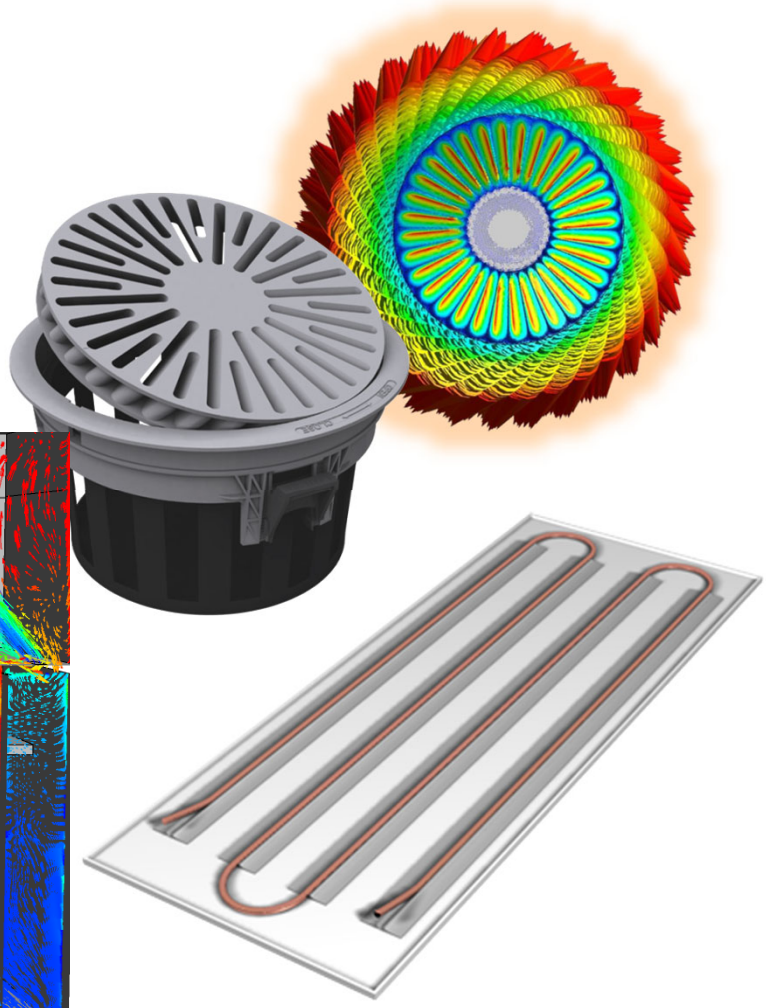
Quiet Terminals/VAV

Underfloor Air Distribution

Displacement Ventilation

Hydronic Systems





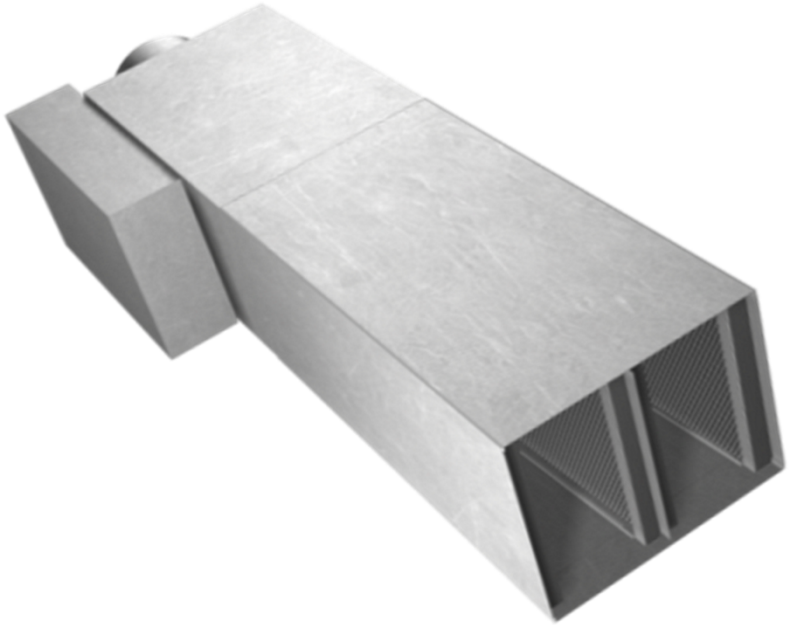
Acoustical Considerations for Building Design

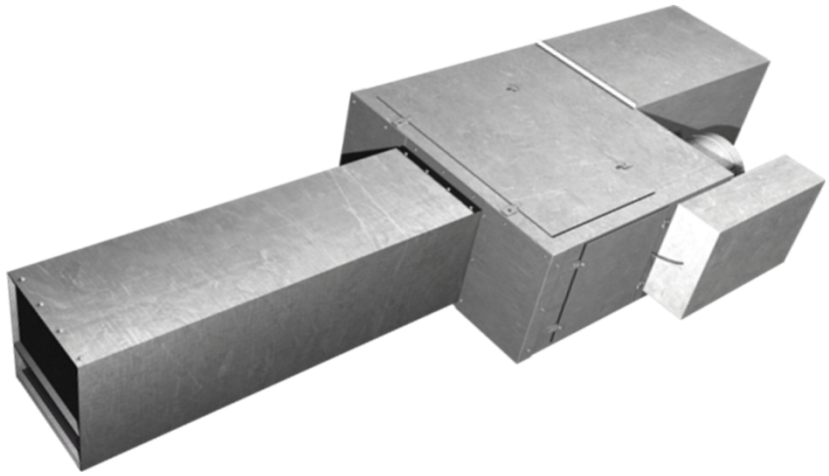
Quiet HVAC Systems

Quiet Terminal Units

Fully certified terminal / silencer assembly

Great for sound sensitive spaces (NC40 and below)

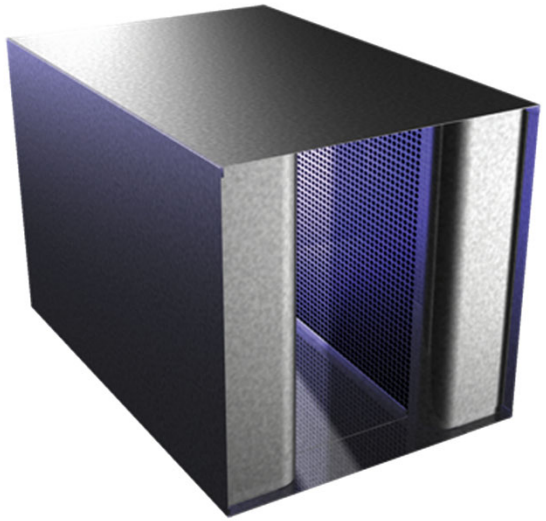




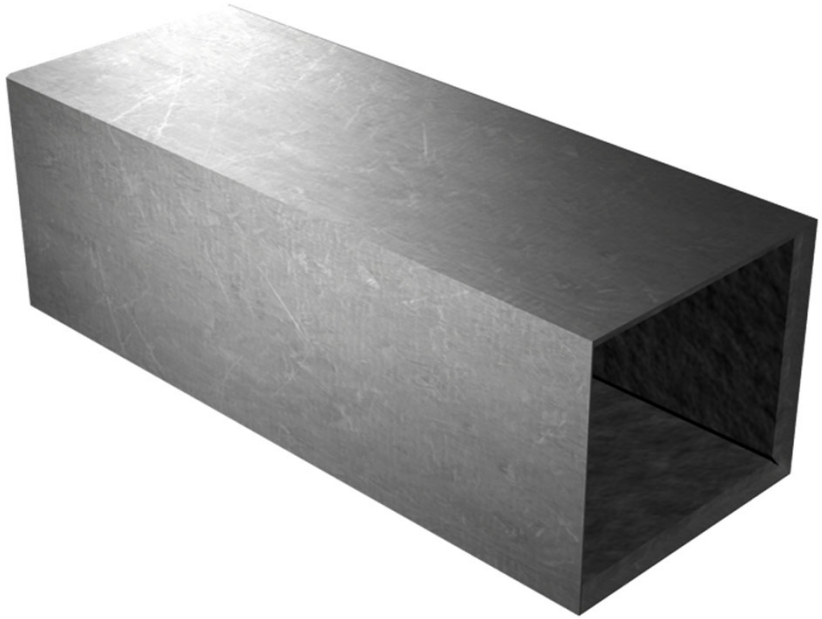
Acoustical Considerations for Building Design

Quiet HVAC Systems

Silencers vs. Attenuators



Silencer

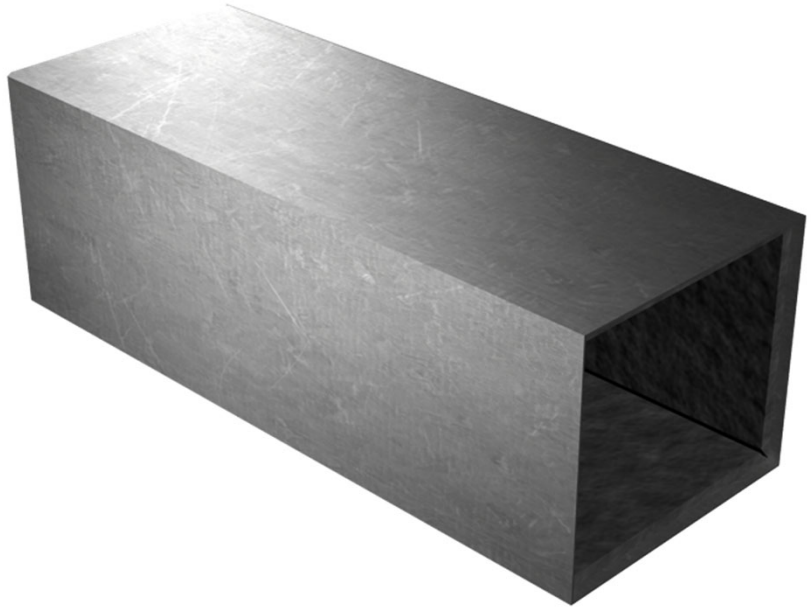


Attenuator

Acoustical Considerations for Building Design

Quiet HVAC Systems

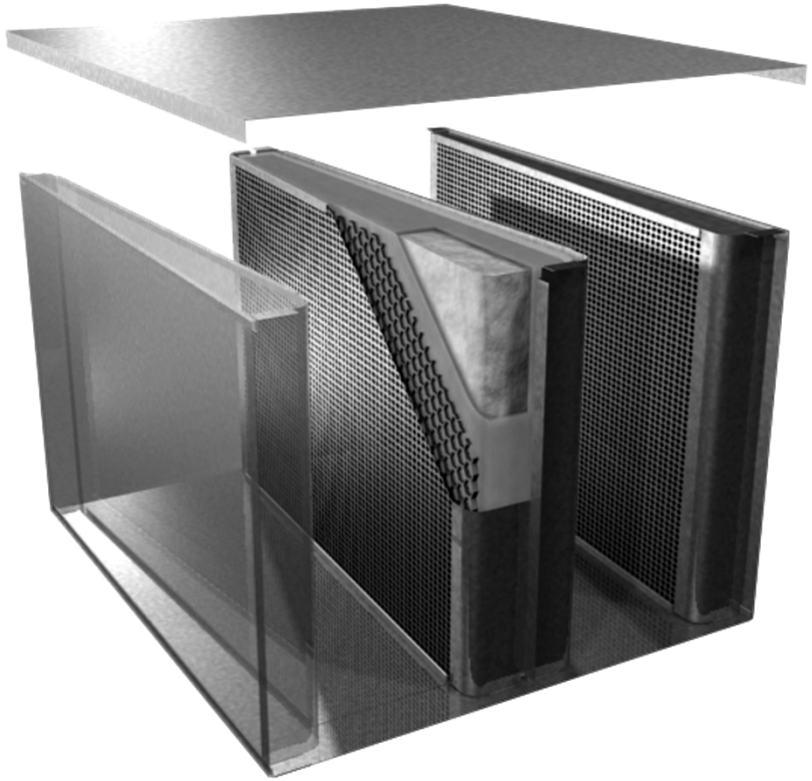
- Attenuator
  - Lined Duct Section
  - Duct Liner Matches Terminal Unit Liner
  - 3 or 5 ft. Long



Acoustical Considerations for Building Design

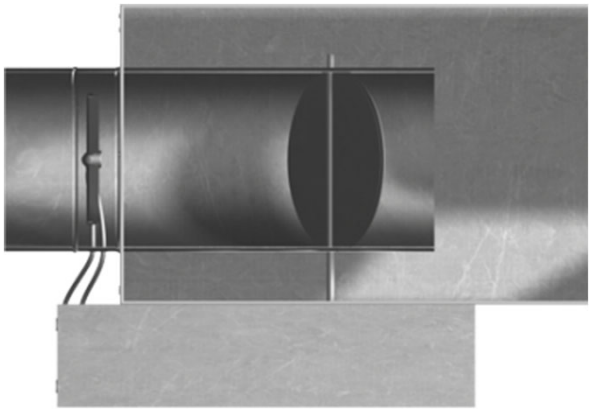
Quiet HVAC Systems

- Silencer
  - 3 to 5 ft. Long
  - Acoustic Baffles
  - Fiberglass Acoustic Media
  - Optional Polymer or Fiberglass Cloth Liners



Acoustical Considerations for Building Design

Quiet HVAC Systems



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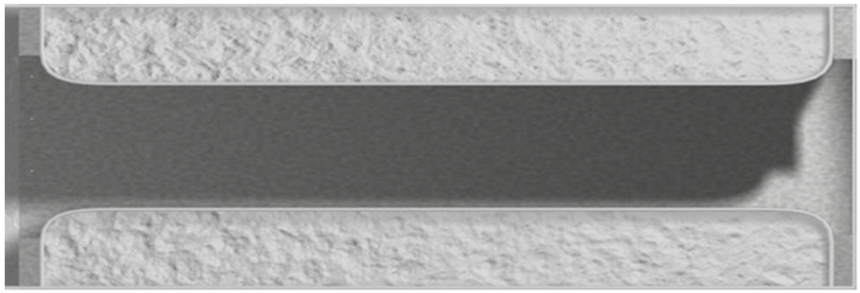


Terminal
(ASHRAE 130)

Silencer
(ASTM E477)

Can be unpredictable…

Acoustical Considerations for Building Design

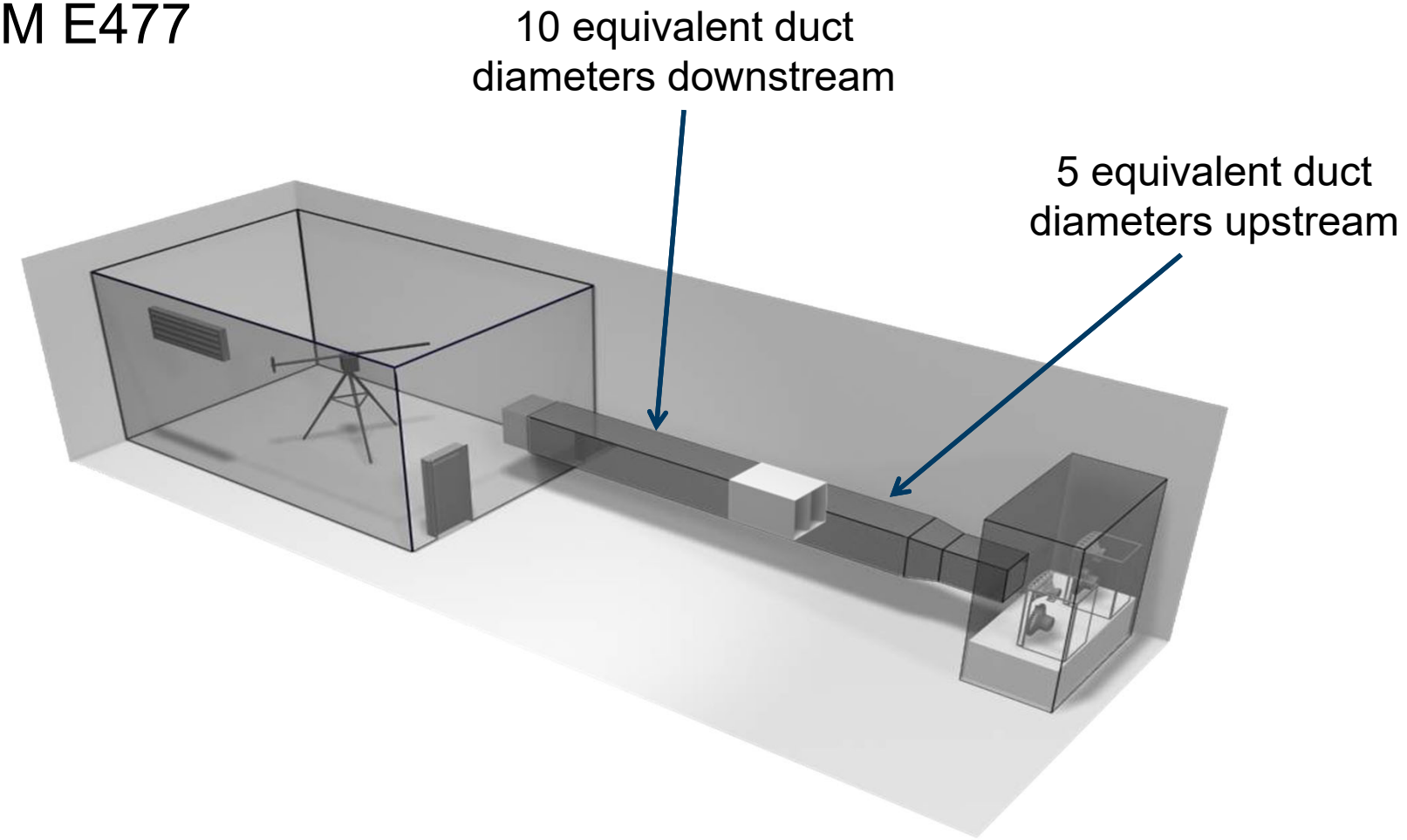
Quiet HVAC Systems

	Discharge Sound Power Octave Bands Mid Frequency						
Octave Band	**125**	**250**	**500**	**1000**	**2000**	**4000**	**NC**
Size 10 Terminal	73	74	71	66	64	63	**38**
Silencer IL	5	11	22	29	25	18	
Predicted Values	68	63	49	39	41	45	**24**
Standard Terminal & Silencer Test Results	72	61	51	43	49	51	**35**

Acoustical Considerations for Building Design

Terminal Unit Silencer – Silencer Test Standard

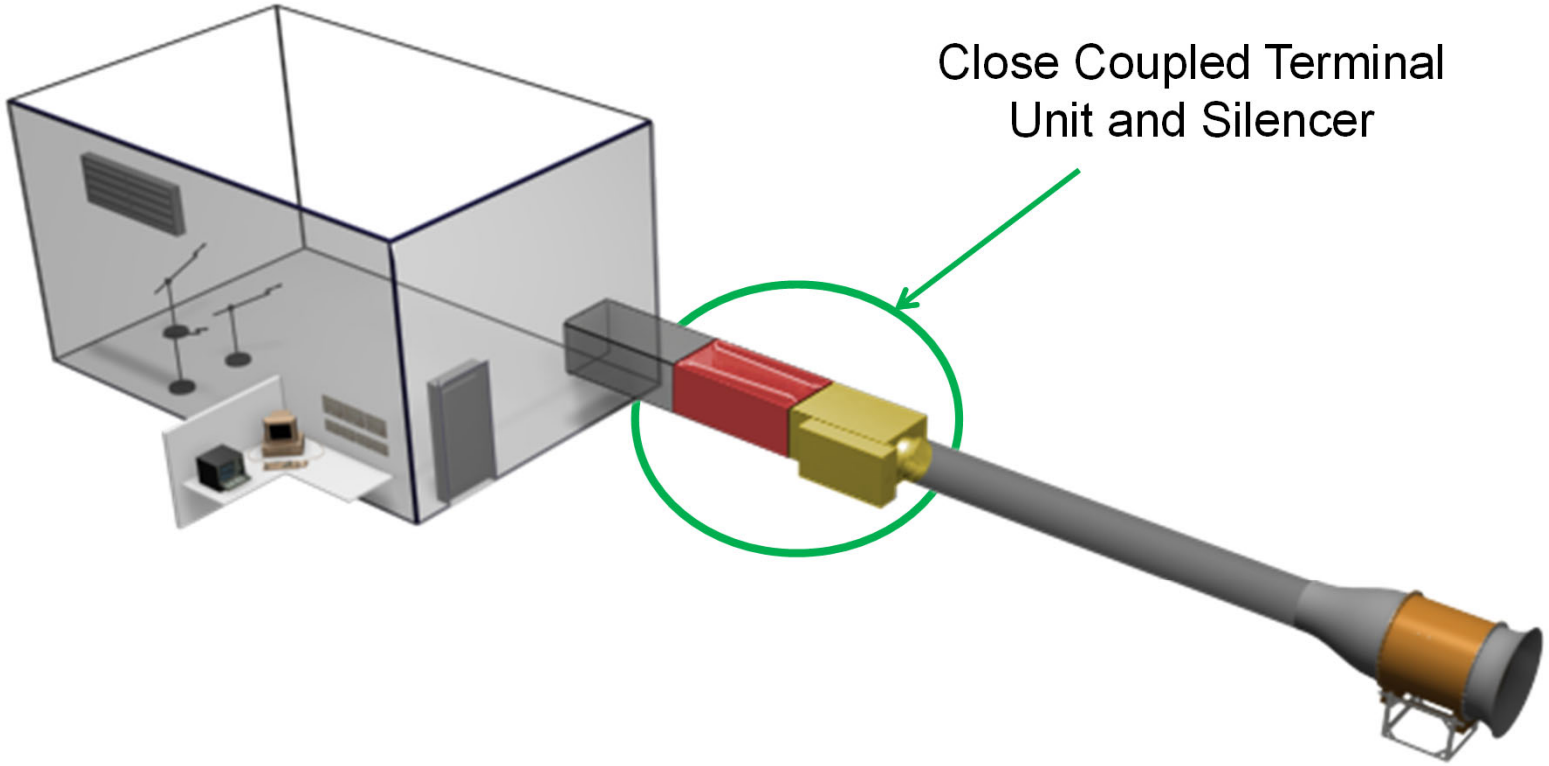
ASTM E477



Acoustical Considerations for Building Design

Terminal Unit Silencers - Terminal Units Test Standard

ASHRAE 130

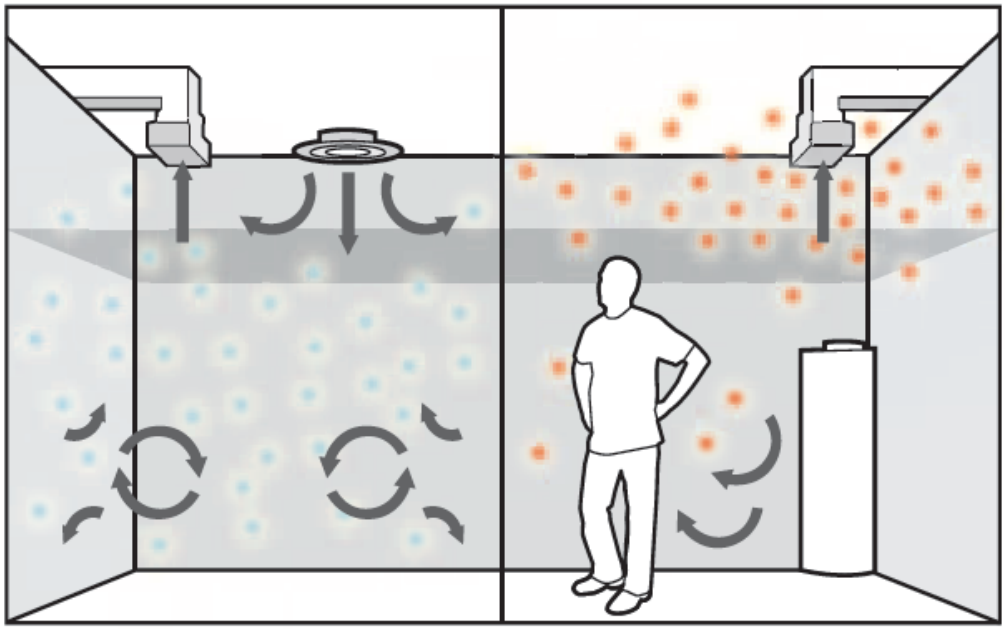


Acoustical Considerations for Building Design

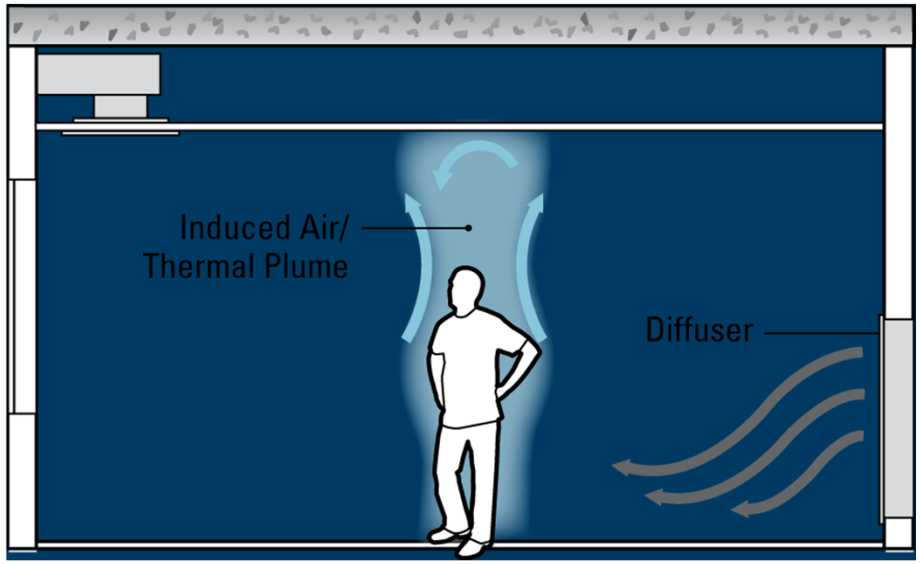
Quiet HVAC Systems

Displacement Ventilation

- Temperature Stratification
- Carry contaminants from breathing zone
- Improve Air Quality



Mixing Ventilation



Displacement Ventilation

Acoustical Considerations for Building Design

Quiet HVAC Systems

Displacement Ventilation

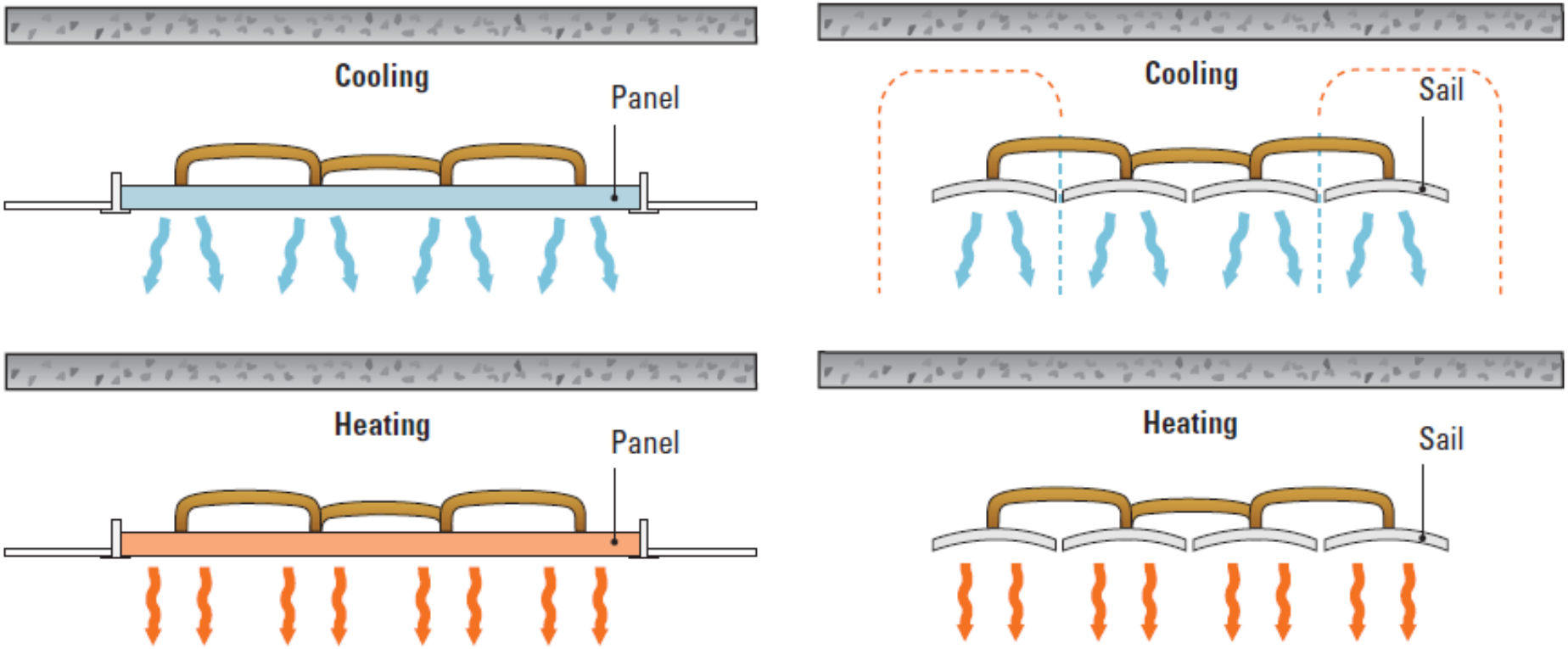
Acoustical Considerations for Building Design

Quiet HVAC Systems

Hydronic Systems

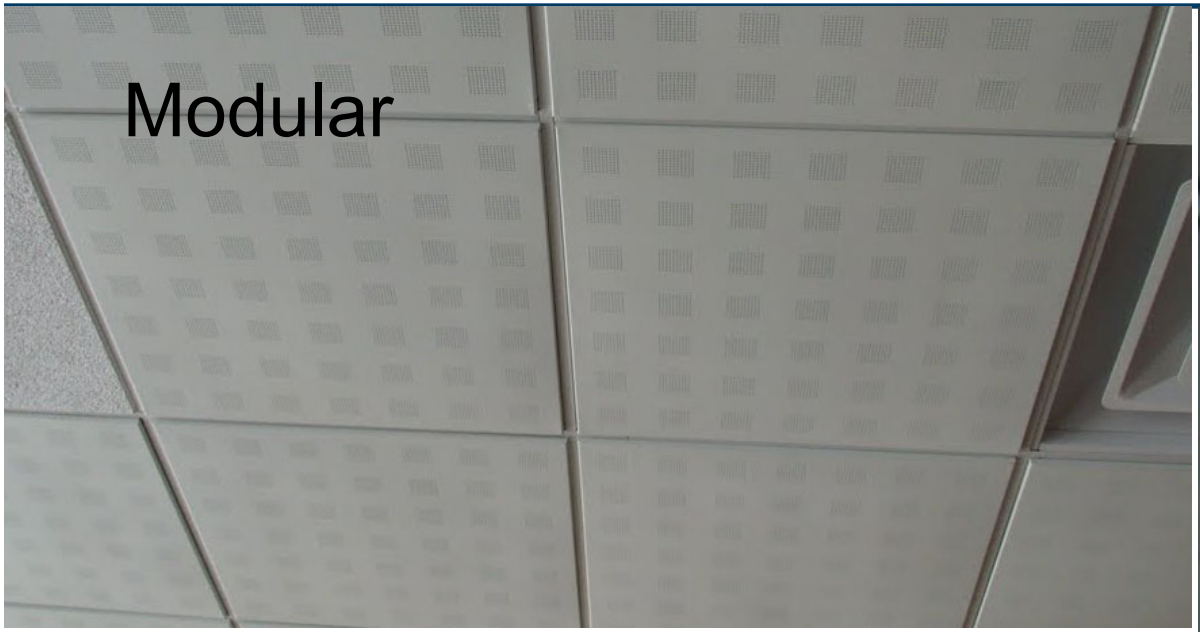
Panels fit in standard ceiling grid

Sails = higher capacity panel



Acoustical Considerations for Building Design

Quiet HVAC Systems

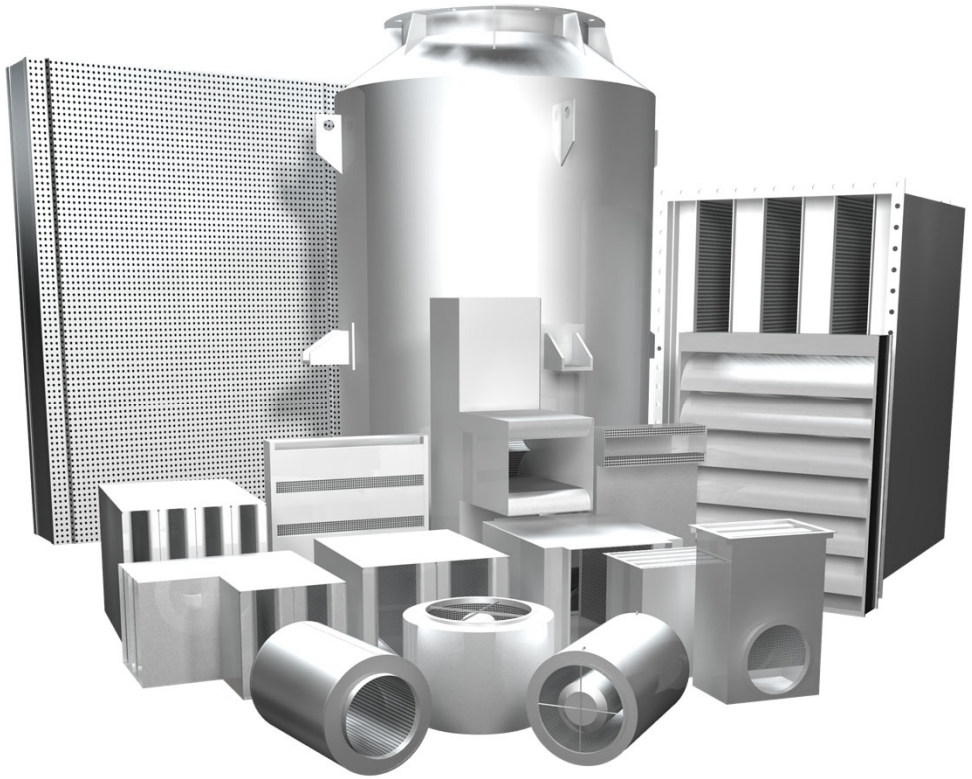


Summary

Acoustical Considerations for Building Design

Summary

- Importance?
- Relevant Terminology
- 3 Main Aspects
  - Source
  - Path
  - Receiver
- Quiet HVAC Systems



Acoustical Considerations for Building Design

Summary

QUESTIONS?

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