Understanding & Reducing Air System Noise

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- Joined AMCA in February 2019
- Responsible for development of AMCA's education programs; staff liaison for the Education & Training Subcommittee
- Projects include webinars, online education modules, presentations at trade shows, AMCA Speakers Network and other duties as assigned.

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Canadian National Sales Manager – Commercial, Industrial & Environmental, AMCA Member Company

- Expertise in reducing mechanical HVAC noise through design & application of noise control products
- Extensive knowledge of sheet metal design & fabrication
- Bachelors of Engineering in Mechanical Systems Engineering

Understanding & Reducing Air System Noise

Purpose and Learning Objectives

The purpose of this presentation is to provide participants with an understanding of air system noise, proper methodology of performing in-duct and breakout acoustic analysis, and selecting and locating noise control products.

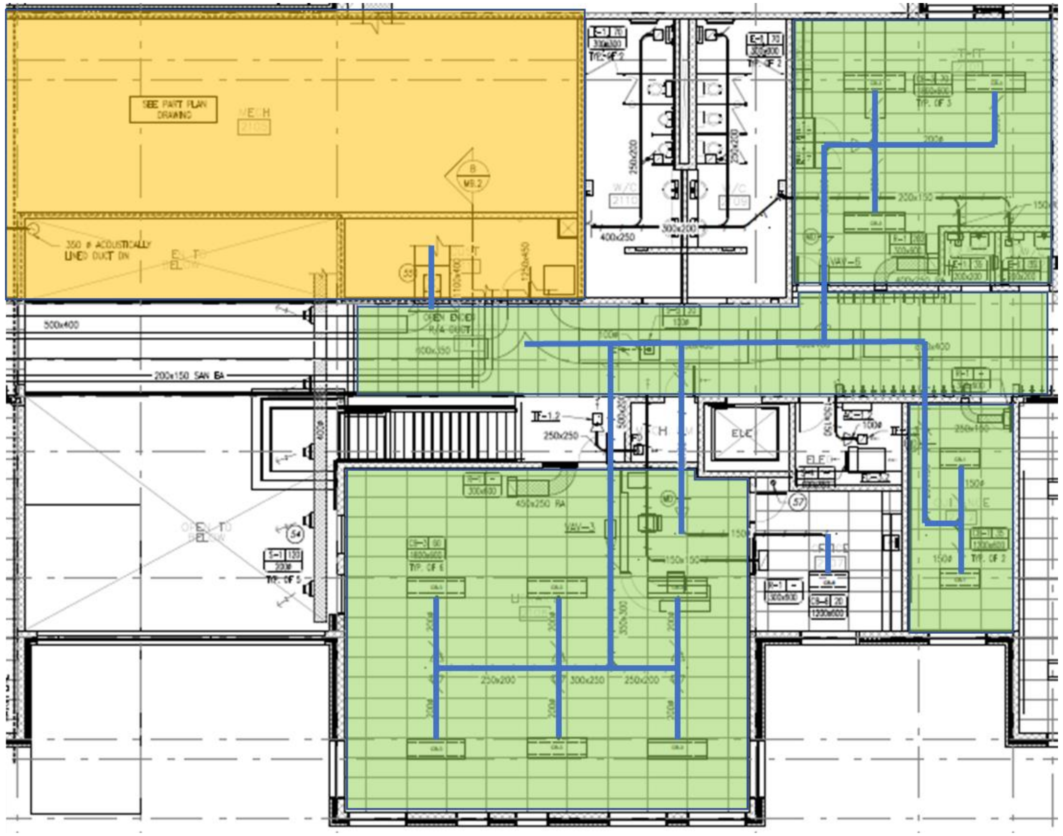
At the end of this presentation participants will be able to:

1. Explain the basic concepts of how sound power, sound pressure and frequency interact.
2. Investigate the components of a duct system and how they generate and naturally attenuate (silence) sound.
3. Identify the attenuation required for a duct system to meet desired sound levels in a critical space (office, etc.).
4. Describe how to select and locate sound attenuation products.

Overview

- Airborne noise and sound in an HVAC System
- Duct system acoustic analysis
- Introduction to duct silencers
- Locating silencers on an HVAC system
- Silencer Options

Noise and Sound



- Noise is unwanted sound
- Sound is a propagating disturbance (a wave) in a fluid or solid
- In a solid, this can be noise transmitted through building partitions
- In a fluid, this can be noise transmitted through the HVAC system
- Source, Path, and Receiver

Noise Source

- Airborne sound is generated by a vibrating surface or by a turbulent fluid stream.

- Sound waves in air are variations in pressure above and below atmospheric pressure.

- Sound levels measured by the rate at which acoustical energy is released referred to as: **Sound Power.**

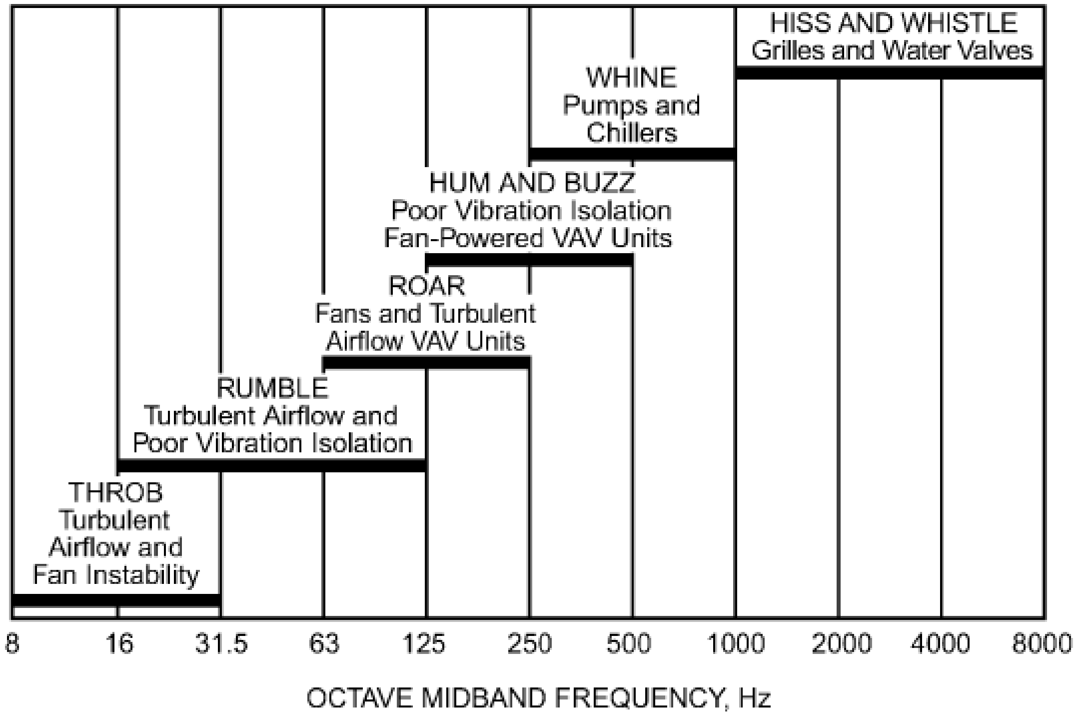
The Sound Spectrum

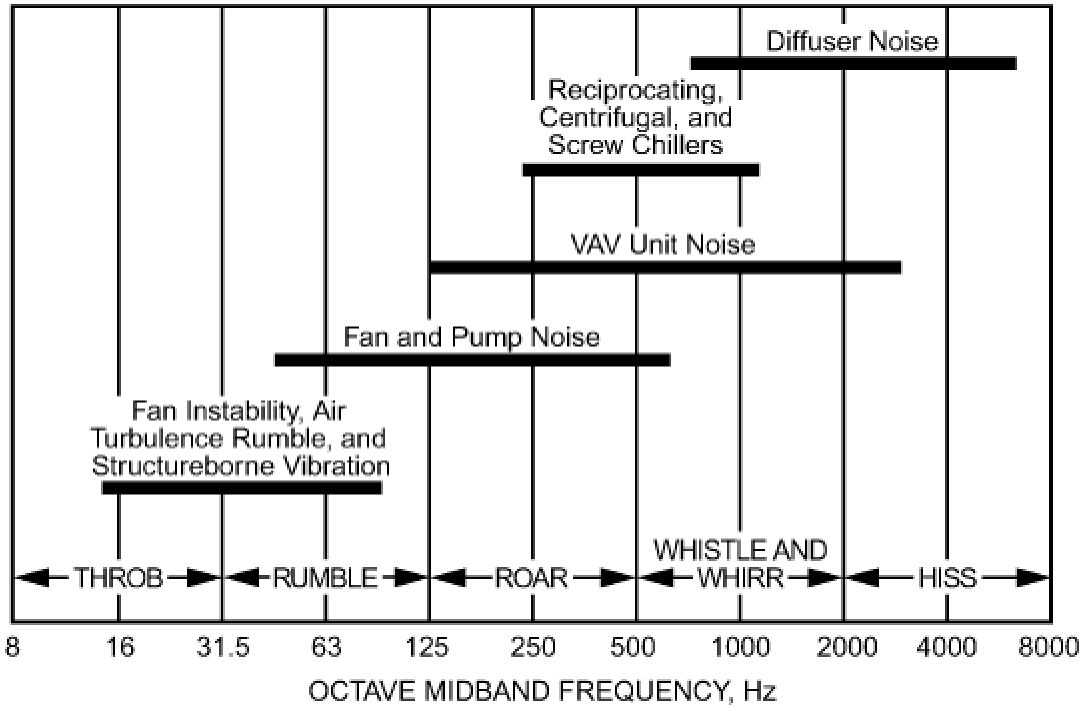
- Tonal sound
  - Simple wave
  - Acoustical energy located at only one frequency

- Broadband sound
  - Complex wave
  - Acoustical energy spread across multiple frequencies
  - Octave band spectrum:

    63 Hz / 125 Hz / 250 Hz / 500 Hz / 1000 Hz / 2000 Hz / 4000 Hz / 8000 Hz

The Sound Spectrum





Receiver

- Sound Levels in the rooms are dependent on the size, number of sources, and acoustic properties of the space.
- Measured as: **<u>Sound Pressure</u>**
- Sound pressure levels across the sound spectrum can be used to determine noise rating of the space.

Sound Power and Sound Pressure

Source	Sound Power, W
Human breath	10^{-11}
Space shuttle launch	10^{8}

Source	Sound Pressure, Pa
Threshold of hearing	2×10^{-6}
Military jet @ 100ft	2×10^{2}

The Log Scale

- Sound “Level”
  - Logarithmic ratio
  - Use to describe a physical property of great range in values

Level = 10 * log10 (A/Aref)

Where:

A = magnitude of the physical property
Aref = agreed upon reference value

A/ Aref Assigned the unit of bel

Sound Power and Sound Pressure Level

- Sound power level, Lw,:

$$Lw = 10 \log (w/wref)$$

  - wref = reference sound power, 10-12 W

- Sound pressure level, Lp:

$$Lw \propto Lp^2$$

$$Lp = 10 \log (p/pref)^2$$

$$Lp = 20 \log (p/pref)$$

  - Pref = reference sound pressure in air, 20-5 Pa

Sound Power and Sound Pressure Level

Source	Sound Power, W	Sound Power Level, dB
Human breath	10^{-11}	10
Space shuttle launch	10^{8}	200

Source	Sound Pressure, Pa	Sound Pressure Level, dB
Threshold of hearing	2×10^{-6}	0
Military jet @ 100ft	2×10^{2}	140

Subjective Reaction to Changes in L_p

Subjective Change	Objective Change in Sound Pressure Level (Broadband Sound)
Much louder	More than 10 dB
"Twice" as Loud	+10 dB
Louder	+5 dB
Just Perceptibly Louder	+3 dB
Just Perceptibly Quieter	-3 dB
Quieter	-5 dB
"Half" as Loud	-10 dB
Much Quieter	Less than -10 dB

< 3 difference in dB is not significant

Logarithmic Addition

Logarithmic addition of levels is non-linear:

Difference between levels to be combined, dB	**0 to 1**	**2 to 4**	**5 to 9**	**10 and more**
Number of dB to add to highest level	3	2	1	0

86 dB + 86 dB = 89 dB	86 dB + 78 dB = 87 dB
86 dB + 83 dB = 88 dB	86dB + 76 dB = 86 dB

Noise Criteria (NC) Level

- Quantify the spectrum into one number
  - Sound pressure levels at the receiver
  - Adjust for the human response to the sound spectrum

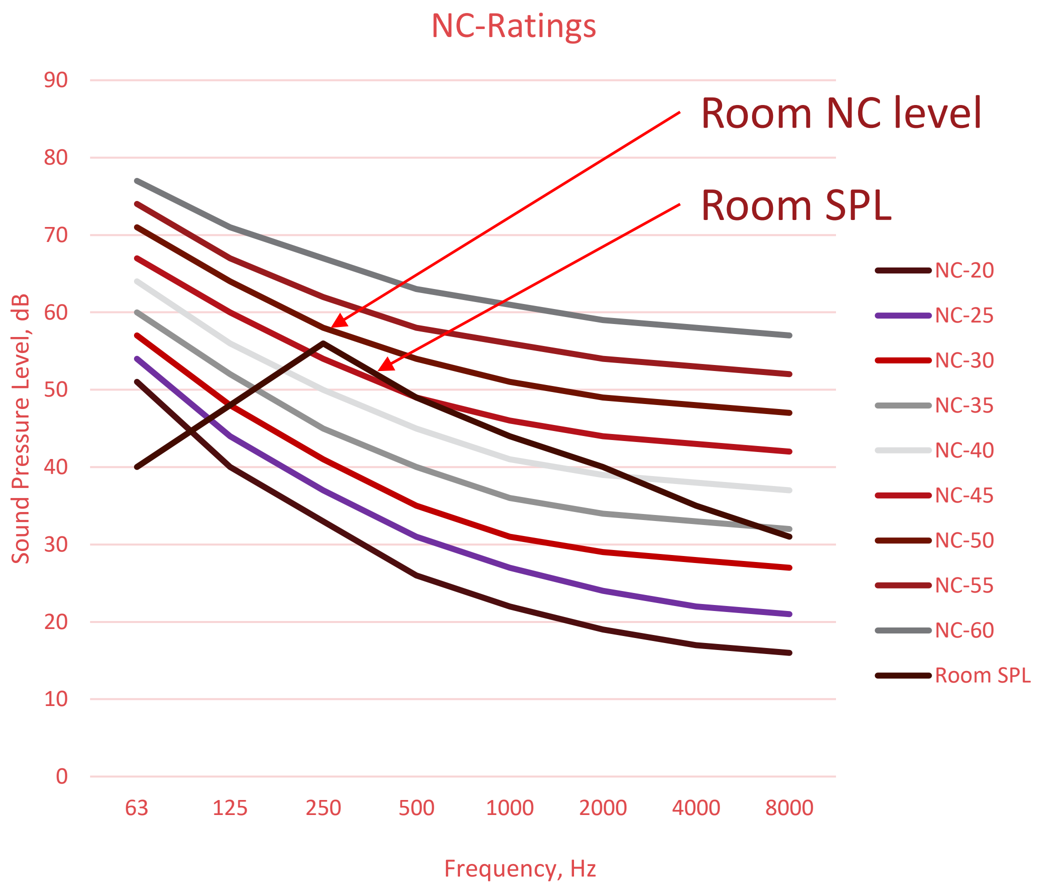
- NC Level
  - Indoor criteria

Noise Criteria (NC) Level

- Indoor acceptable noise levels are usually classified as an NC level.
  - Others include: NR, RC, RC Mark II

- Compares sound levels at all eight octave bands, the maximum allowable sound pressure at each frequency.

- The NC level is determined by the lowest curve that is not exceeded by the room SPL spectrum.



Sound Path

Sound Source Paths:

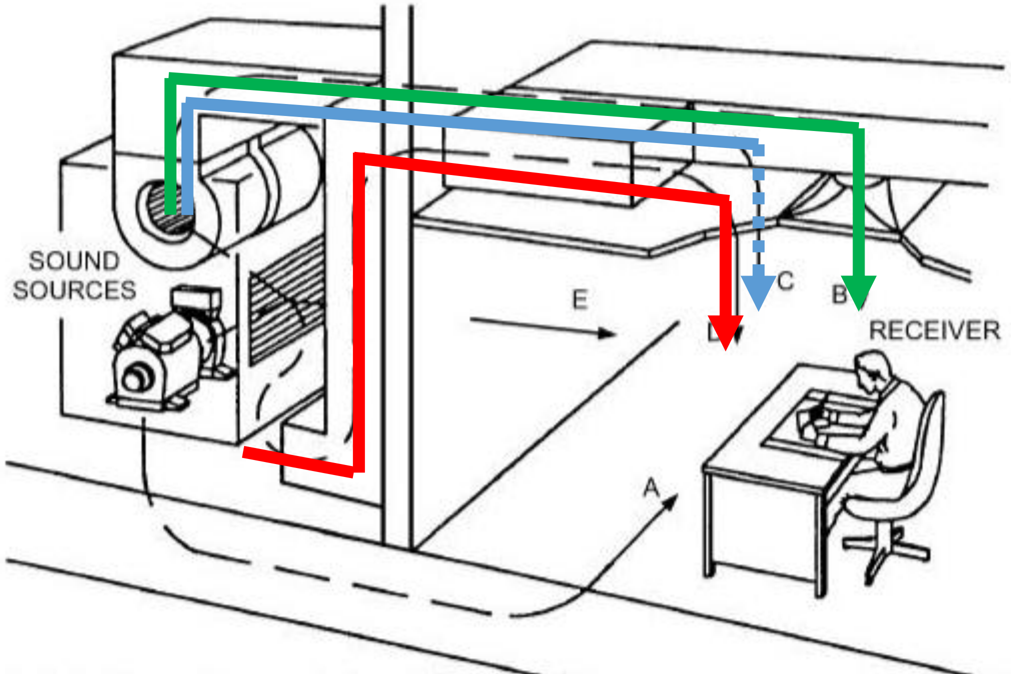
Path A – Structure borne path though floor

Path B – Airborne path through supply system

Path C – Duct breakout from supply air duct

Path D – Airborne path through return system

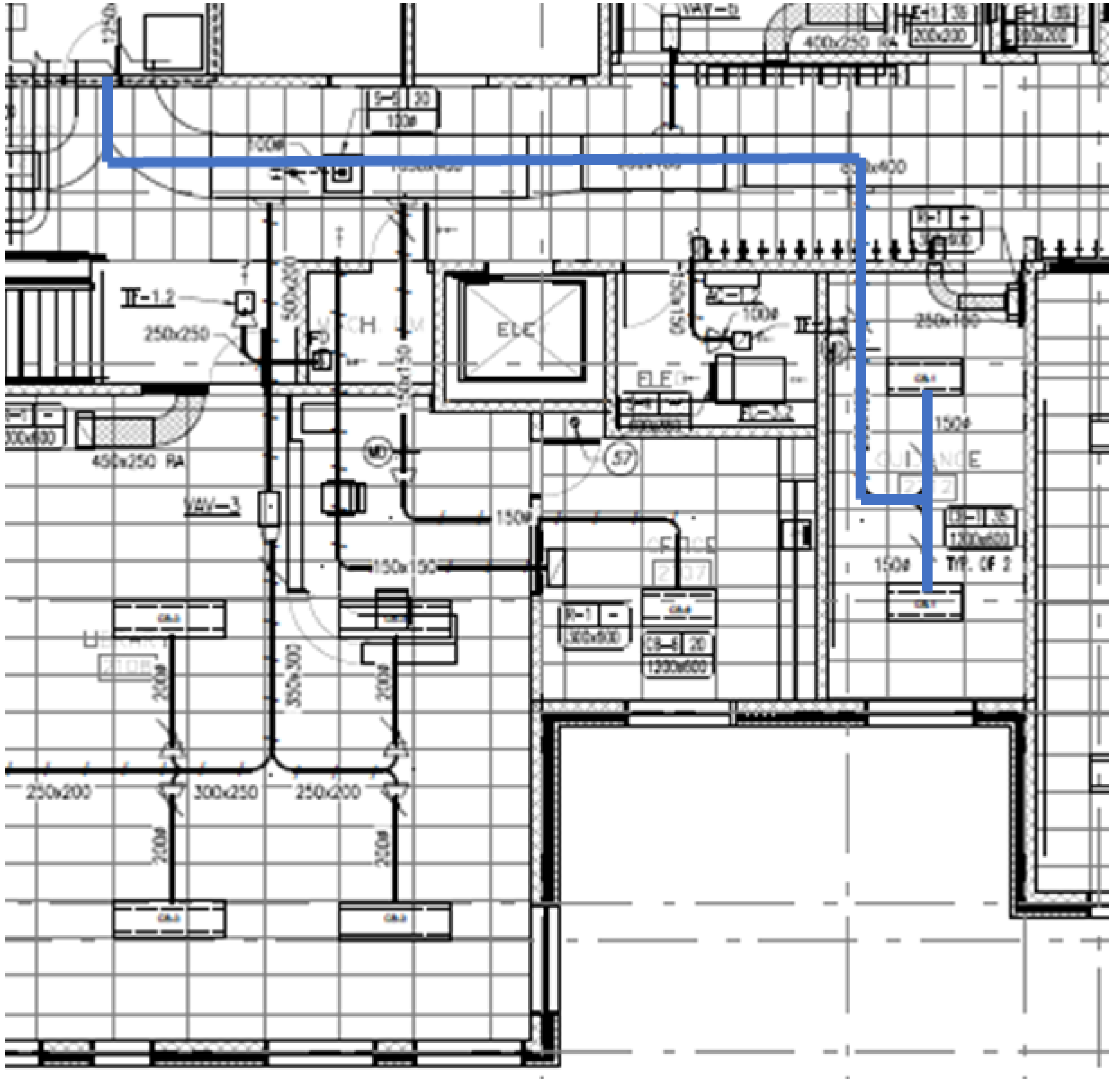
Path E – Airborne path through mechanical equipment room



Path A: Structureborne path through floor
Path B: Airborne path through supply air system
Path C: Duct breakout from supply air duct
Path D: Airborne path through return air system
Path E: Airborne path through mechanical equipment room wall

Natural Attenuation

- Duct elements in the HVAC System dissipate acoustic energy of the sound wave along the sound path.
- This is caused by:
  - Duct vibration
  - Sound wave reflections
  - Flow branching



Natural Attenuation: Unlined Ductwork

- In-duct sound energy transmitted to duct surface
- Can produce a significant amount of attenuation in long rectangular duct runs
- Function of duct shape and size

Duct Size (in x in)	Perimeter/ Area (1/ft.)	Attenuation in Unlined Rectangular Duct (dB/ft.) Octave Band Center Frequency (Hz)			
		63	125	250	> 250
6 x 6	8.0	0.30	0.20	0.10	0.10
12 x 12	4.0	0.35	0.20	0.10	0.06
12 x 24	3.0	0.40	0.20	0.10	0.05
24 x 24	2.0	0.25	0.20	0.10	0.03
48 x 48	1.0	0.15	0.10	0.07	0.02

Diameter	Attenuation in Unlined Round Duct (dB/ft.) Octave Band Center Frequency (Hz)						
	63	125	250	500	1K	2K	4K
D ≤ 7	0.03	0.03	0.05	0.05	0.10	0.10	0.10
7 < D ≤ 15	0.03	0.03	0.03	0.05	0.07	0.07	0.07
15 < D ≤ 30	0.02	0.02	0.02	0.03	0.05	0.05	0.05
30 < D ≤ 60	0.01	0.01	0.01	0.02	0.02	0.02	0.02

Natural Attenuation: Lined Ductwork

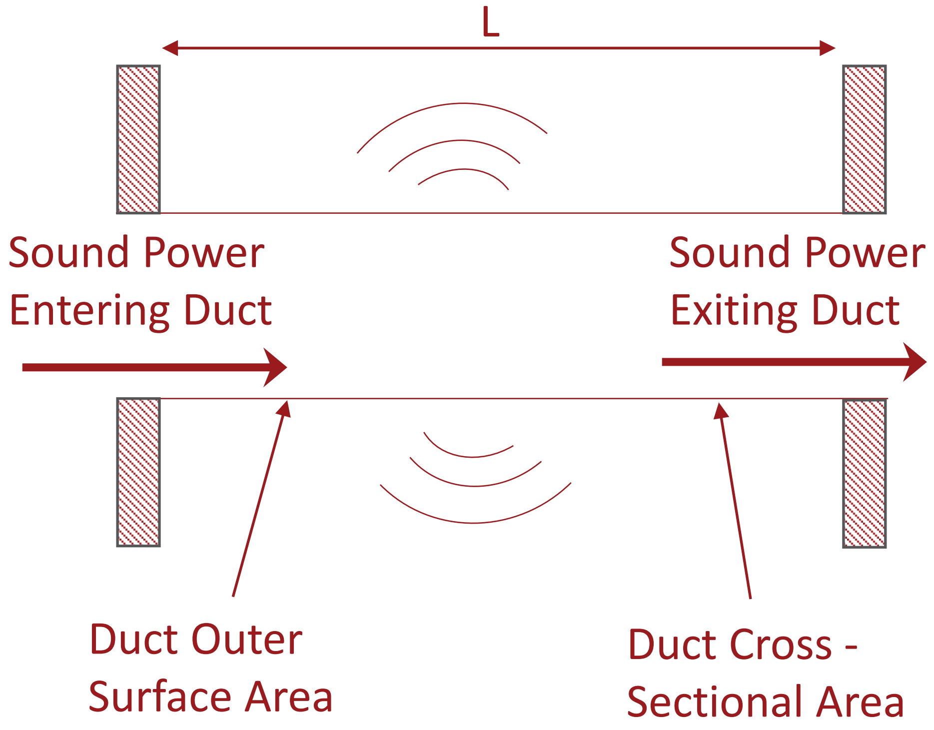
- Increase in attenuation in mid and high bands over unlined
- Typically, not enough attenuation in the 63 Hz and 125 Hz bands for mechanical noise.
- Useful for eliminating generated noise, noise from a VAV box or in-branch duct element.
- 1" or 2" lining thickness (common)

Diameter (in)	Attenuation in Lined Round Duct (dB/ft.)							
	Octave Band Center Frequency (Hz)							
	63	125	250	500	1K	2K	4K	8K
6	0.38	0.59	0.93	1.53	2.17	2.31	2.04	1.26
12	0.23	0.46	0.81	1.45	2.18	1.91	1.48	1.05
18	0.13	0.35	0.69	1.37	2.01	1.56	1.10	0.90
24	0.07	0.25	0.57	1.28	1.71	1.24	0.85	0.80

Duct Size (in x in)	Insertion Loss for Lined Rectangular Duct w/ 1-in. Fiberglass (dB/ft.)					
	Octave Band Center Frequency (Hz)					
	125	250	500	1K	2K	4K
6 x 6	0.6	1.5	2.7	5.8	7.4	4.3
6 x 18	0.5	1.0	2.2	4.7	5.2	3.3
8 x 8	0.5	1.2	2.3	5.0	5.8	3.6
8 x 24	0.4	0.8	1.9	4.0	4.1	2.8

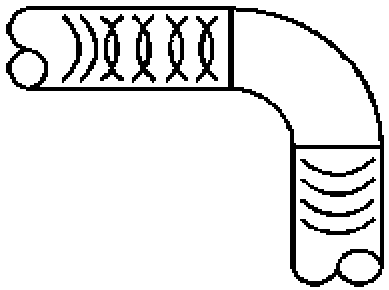
Duct Breakout

- When acoustic sound energy radiates through the duct walls into the surrounding area
- Increasing duct gauge and stiffness reduces breakout
- Reduce sound power level in duct



Natural Attenuation: Duct Elbows

- Acoustic energy loss due to reflection of the sound wave
- Can be a significant source of attenuation if multiple elbows are in the system.
- Unlined/lined, radius, mitered, with/without turning vanes, all have different attenuation levels.

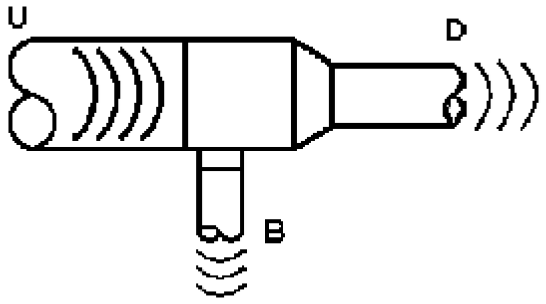


Insertion Loss of Radius Rectangular Elbows	
fw = f x w (f = center frequency, kHz and w = width, inches)	Insertion Loss (dB)
fw < 1.9	0
1.9 ≤ fw < 3.8	1
3.8 ≤ fw < 7.5	2
Fw > 7.5	3

Insertion Loss of Unlined and Lined, Mitered Elbows with Turning Vanes		
fw = f x w (f = center frequency, kHz and w = width, inches)	Insertion Loss (dB)	
	unlined	lined
fw < 1.9	0	0
1.9 ≤ fw < 3.8	1	1
3.8 ≤ fw < 7.5	4	4
7.5 ≤ fw < 15	6	7

Natural Attenuation: Branching

- Most significant mechanism of natural attenuation
- Energy In = Energy Out
- Energy division is according to the ratio areas
- Typical HVAC design equates flow ratio and area ratio



$\Delta\, Lwu - b = 10 \log [Ab/(Au + Ab)]$

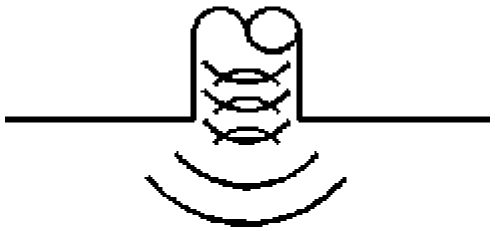
$\Delta\, Lwu - d = 10 \log [Ad/(Au + Ad)]$

$A = ft^2$

$\Delta\, Lw = dB$

Natural Attenuation: End Reflection

- Incident sound energy is reflected when the sound wave expands into a large space.
- Good low frequency attenuation
- If rectangular duct, use equivalent diameter



Diameter in)	Duct End Reflection Loss – Duct Terminated Flush with Wall (dB)				
	Octave Band Center Frequency (Hz)				
	63	125	250	500	1K
6	18	12	7	3	1
12	12	7	3	1	0
24	7	3	1	0	0
36	4	2	0	0	0
48	3	1	0	0	0

Natural Attenuation: Room Effect

- The room effect considers the environment that the sound power level (Lw) is in.
- This equation is for normal rooms with some level of sound absorption within the space including furnishings.
- The result is the sound pressure level in the space.

$$Lp = Lw - 5\ \mathrm{Log}\ (V) - 3\ \mathrm{Log}\ (f) - 10\ \mathrm{Log}\ (r) + 25\ \mathrm{dB}$$

$Lp\ = room\ sound\ pressure\ (dB\ re\ 20\ x\ 10 - 5\ Pa)$

$Lw = source\ sound\ power\ (dB\ re\ 1\ x\ 10 - 12\ \ watts)$

$V = \ room\ volume\ (ft.^3)$

$f = \ octave\ band\ center\ frequency\ (Hz)$

$r = \ reference\ distance\ from\ diffuser\ (ft.)$

Duct System Acoustic Analysis

- Determine the most sensitive space on the HVAC system.
- Start with the sound power level of the sound source.
- Deduct the natural attenuation of the HVAC system.
- Calculate the sound pressure spectrum and compare against NC Curves.

Job Information

Job Name:	*WECDSB - New Catholic School*
Job Number:	*2132223*
Site Altitude:	*0 ft*
Refrigerant	*R-410A*

Unit Information

Approx. Op./Ship Weights:	*1151 / 1151 lbs.*
Supply CFM/ESP:	*3500 / 0.75 in. wg.*
Final-Filter FV / Qty:	*393.75 fpm / 4*
Outside CFM:	*525*
Ambient Temperature:	*93 °F DB / 75 °F WB*
Return Temperature:	*75 °F DB / 62.5 °F WB*

Static Pressure

External:	*0.75 in. wg.*	Economizer:	*0.08 in. wg.*
Evaporator:	*0.32 in. wg.*	Heating:	*0.11 in. wg.*
Filters Clean:	*0.17 in. wg.*	Cabinet:	*0.12 in. wg.*
Dirt Allowance	*0.35 in. wg.*	Total:	*1.90 in. wg.*

Cabinet Sound Power Levels*

Octave Bands:	63	125	250	500	1000	2000	4000	8000
Discharge LW(dB):	84	83	86	81	74	72	68	62
Return LW(dB):	79	78	76	68	65	62	56	47

**Sound power levels are given for informational purposes only. The sound levels are not guaranteed.*

Rated in accordance with AHRI 340/360

Application EER @ Op. Conditions: *9.8*

Electrical Data

Rating:	*575/3/60*	Minimum Circuit Amp:	*17*
Unit FLA:	*15*	Maximum Overcurrent:	*25*

	Qty	HP	VAC	Phase	RPM	FLA	RLA
Compressor 1:	1		575	3			9.9
Condenser Fans:	1	0.75	460	1	1075	2.3	
Supply Fan:	1	2.00	575	3	1760	2.7	
Combustion:	1	0.09	460	1	3000	0.7	

Cabinet Sound Power Levels*

Octave Bands:	63	125	250	500	1000	2000	4000	8000
Discharge LW(dB):	84	83	86	81	74	72	68	62
Return LW(dB):	79	78	76	68	65	62	56	47

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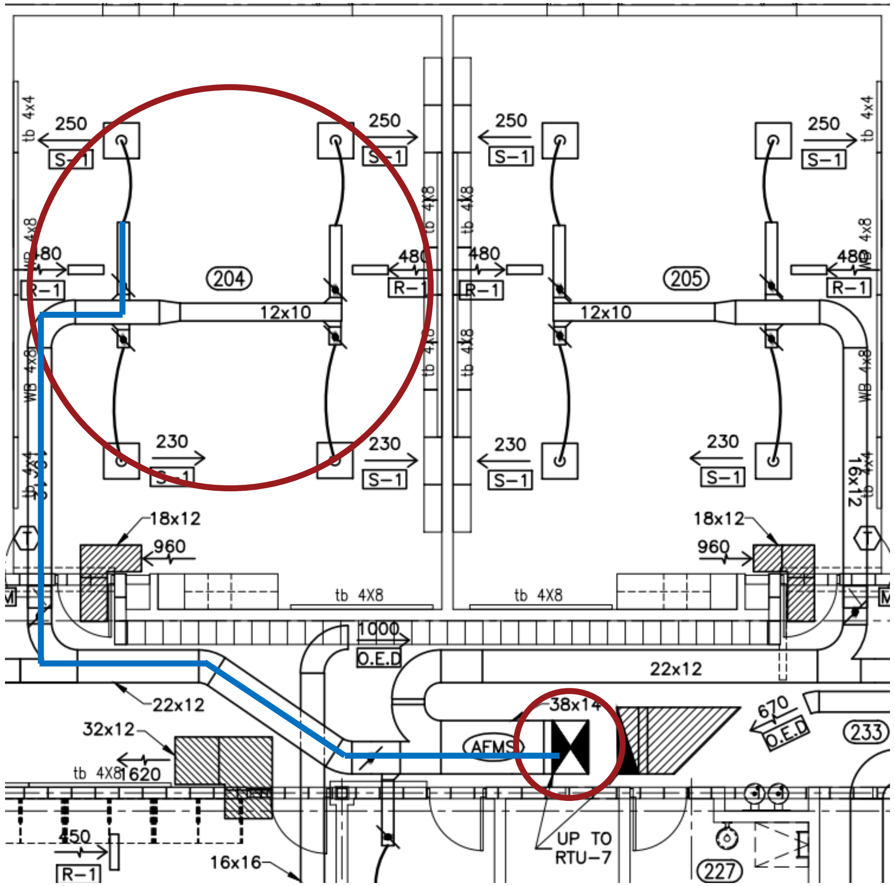
Duct System Acoustic Analysis: Supply System



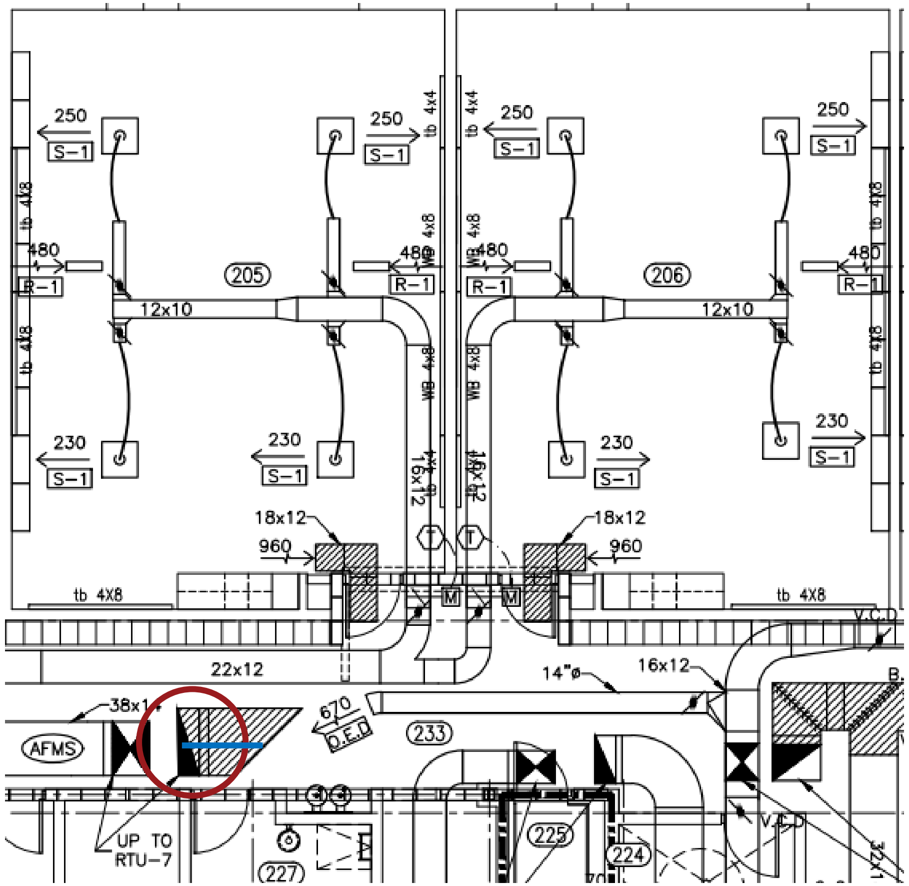
- Lw for RTU-7 Discharge
  - 82/ 83/ 84/ 79/ 72/ 70/ 66/ 60
- Duct:
  - 38x14”, 5’
  - 22x12”, 15’
  - 16x12”, 15’
  - 8” ∅, 4’
- Elbows:
  - 14”, 22”, 16”, 16”
- End Reflection:
  - 8” ∅
- Power Split:
  - 230/3350 CFM = 7%
- Room Effect:
  - 20x30x9’, 4-diffuser array, NC-35

Duct System Acoustic Analysis: Supply System

HVAC ACOUSTIC ANALYSIS END NOISE									
Octave Band Center Frequency, Hz:	63	125	250	500	1 k	2 k	4 k	8 k	Description:
Fan PWL:	82	83	84	79	72	70	66	60	No Prediction, Flow Volume (cfm) : 3350, Fan Operating Pressure (in. wg) : 0.75 Efficiency (%): 58.7
Duct 38x14:	1	1	1	0	0	0	0	0	38 x 14 - (in) duct, 5 (ft) long, Unlined
Duct 22x12:	6	3	2	1	1	1	1	1	22 x 12 - (in) duct, 15 (ft) long, Unlined
Duct 16x12:	6	3	2	1	1	1	1	1	16 x 12 - (in) duct, 15 (ft) long, Unlined
Duct 8dia:	0	0	0	0	0	0	0	0	8 - (in) dia duct, 4 (ft) long, Unlined
Total Duct Attenuation:	**13**	**7**	**5**	**2**	**2**	**2**	**2**	**2**	Total Duct Attenuation
Elbow Duct 14:	0	0	1	5	8	4	3	3	Width (in) : 14, Qty : 1, Square Unlined
Elbow Duct 22:	0	1	2	3	3	3	3	3	Width (in) : 22, Qty : 1, Radiused Unlined
Elbow Duct 16:	0	2	4	6	6	6	6	6	Width (in) : 16, Qty : 2, Radiused Unlined
Total Elbow Duct Attenuation:	**0**	**3**	**7**	**14**	**17**	**13**	**12**	**12**	Total Elbow Duct Attenuation
End Reflection:	16	10	6	2	1	0	0	0	Duct Terminated Flush with a Wall, 8 (in) Dia
Branch SP division:	12	12	12	12	12	12	12	12	Branch Flow (cfm) : 230
PWL in Room:	**41**	**51**	**54**	**49**	**40**	**43**	**40**	**34**	PWL in Room
PWL to SPL:	5	6	7	8	9	10	11	12	Room Correction - Normal Office / Classroom, Width (ft) : 30, Height (ft) : 9, Length (ft) : 20
Multi-Terminal Correction:	6	6	6	6	6	6	6	6	
Room SPL	**42**	**51**	**53**	**47**	**37**	**39**	**35**	**28**	Room SPL = 48 dBA
A-weighted values :	15	34	44	43	37	40	36	26	A-weighted values
Design Level:	60	52	45	40	36	34	33	32	**NC - 35**
Required Attenuation:	**0**	**0**	**8**	**7**	**1**	**5**	**2**	**0**	Required Attenuation

Notes: In general, Predictions are based on ASHRAE HVAC APPLICATIONS, 2007.
The accuracy of this evaluation is dependent upon the accuracy of the Fan Sound Power Levels, and ASHRAE Data and Calculations Methods.

Duct System Acoustic Analysis: Return System



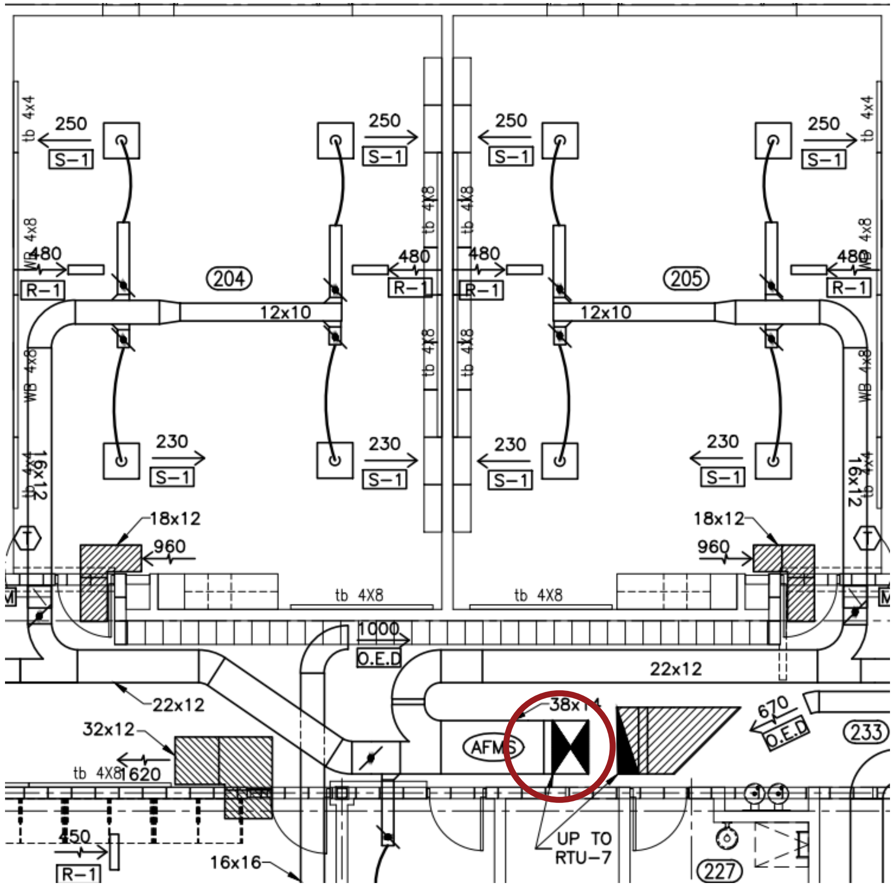
- Lw for RTU-7 Return
  - 74/ 71/ 72/ 63/ 60/ 56/ 50/ 39
- Duct:
  - 44.5x13.5”, 1’
- Elbow:
  - 13.5”
- Ceiling Tile IL:
  - Glass Fiber Tile: 3/6/5/7/7/8/9/9
  - Gypsum: 8/11/15/15/17/17/18/18
- End Reflection:
  - 44.5x13.5”
- Room Effect:
  - 8x30x12’, single source, NC-40

Duct System Acoustic Analysis: Return System

HVAC ACOUSTIC ANALYSIS END NOISE									
Octave Band Center Frequency, Hz:	**63**	**125**	**250**	**500**	**1 k**	**2 k**	**4 k**	**8 k**	**Description:**
Fan PWL:	**74**	**71**	**72**	**63**	**60**	**56**	**50**	**39**	No Prediction, Flow Volume (cfm) : 3350, Fan Operating Pressure (in. wg) : 0.75 Efficiency (%): 58.7
Duct 44.5x13.5:	0	0	0	0	0	0	0	0	44.5 x 13.5 - (in) duct, 1 (ft) long, Unlined
Total Duct Attenuation:	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	Total Duct Attenuation
Elbow Duct 13.5:	0	0	1	5	8	4	3	3	Width (in) : 13.5, Qty : 1, Square Unlined
Total Elbow Duct Attenuation:	**0**	**0**	**1**	**5**	**8**	**4**	**3**	**3**	Total Elbow Duct Attenuation
End Reflection:	4	2	1	0	0	0	0	0	Duct Terminated in Free Space, 44.5 (in) Maximum Duct Dimension
Other attenuation:	3	6	5	7	7	8	9	9	Glass Fiber Tile IL
PWL in Room:	**67**	**63**	**65**	**51**	**45**	**44**	**38**	**27**	PWL in Room
PWL to SPL:	6	7	8	9	10	11	12	13	Room Correction - Normal Office / Classroom, Width (ft) : 30, Height (ft) : 12, Length (ft) : 8
Room SPL	**61**	**56**	**57**	**42**	**35**	**33**	**26**	**14**	Room SPL = 49 dBA
A-weighted values :	34	39	48	38	35	34	27	12	A-weighted values
Design Level:	64	56	50	45	41	39	38	37	**NC - 40**
Required Attenuation:	**0**	**0**	**7**	**0**	**0**	**0**	**0**	**0**	Required Attenuation

Notes: In general, Predictions are based on ASHRAE HVAC APPLICATIONS, 2007.
The accuracy of this evaluation is dependent upon the accuracy of the Fan Sound Power Levels, and ASHRAE Data and Calculations Methods.

Duct System Acoustic Analysis: Break-Out



- Lw for RTU-7 Discharge
  - 82/ 83/ 84/ 79/ 72/ 70/ 66/ 60
- Duct:
  - 38x14”
- Ceiling:
  - FG Ceiling Tile
- Room Criteria:
  - NC-40

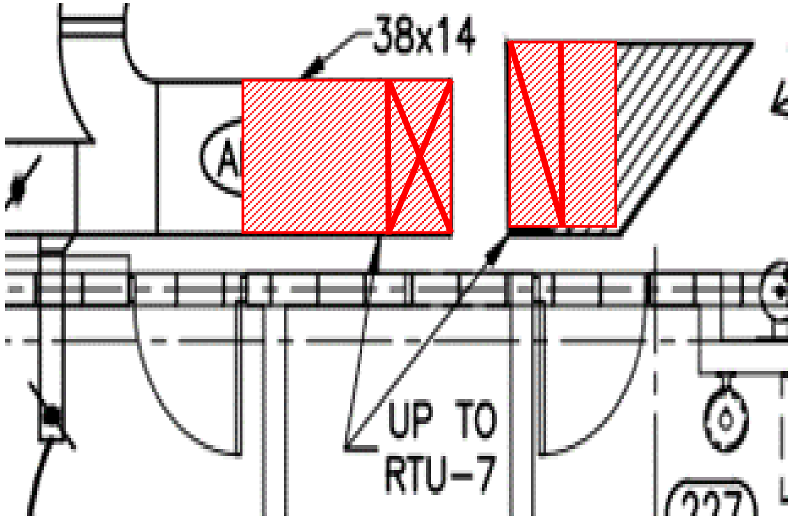
Duct System Acoustic Analysis: Break-Out

HVAC ACOUSTIC ANALYSIS BREAKOUT NOISE									
Octave Band Center Frequency, Hz:	63	125	250	500	1 k	2 k	4 k	8 k	Description:
Fan PWL:	**82**	**83**	**84**	**79**	**72**	**70**	**66**	**60**	No Prediction, Flow Volume (cfm) : 3350, Fan Operating Pressure (in. wg) : 0.75, Efficiency (%): 58.7
Breakout TLout:	23	26	29	32	32	38	44	45	44.5 x 13.5 (in) x 18 ga - Rectangular Duct
10 Log(S/A):	14	14	14	14	14	14	14	14	10 Log(S/A)
Breakout PWL:	**73**	**71**	**69**	**61**	**54**	**46**	**36**	**29**	Breakout PWL
Ceiling / Plenum / Room Effect :	3	6	5	7	7	8	9	9	Glass Fiber, 1.0 lb/ft2,
Duct Breakout Room Effect:	12	12	12	12	12	12	12	12	
Room SPL	**58**	**53**	**52**	**42**	**35**	**26**	**15**	**8**	Room SPL = 45 dBA
A-weighted values :	31	36	43	38	35	27	16	6	A-weighted values
Design Level:	64	56	50	45	41	39	38	37	**NC - 40**
Required Attenuation:	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	Required Attenuation

Notes: In general, Predictions are based on ASHRAE HVAC APPLICATIONS, 2007.
The accuracy of this evaluation is dependent upon the accuracy of the Fan Sound Power Levels, and ASHRAE Data and Calculations Methods.

- 2 dB is not significant and can be overlooked

Duct System Acoustic Analysis



The Requirements:

- Supply System:
  - Required Attenuation:
    - 0/0/8/7/1/5/2/0
  - Required Casing Gauge:
    - 18 Ga.
- Return System:
  - Required Attenuation:
    - 0/0/7/0/0/0/0/0
- Select Silencer:
  - Equal to, or greater than, required attenuation
  - Note the pressure drop of the silencer

The Silencer/Attenuator/Sound Trap

- Ducted, replaces section of ductwork
- Standard configurations:
  - Rectangular
  - Elbow
  - Circular
- Can be fabricated to match any sheet metal shape and size
- Three performance characteristics:
  - Insertion Loss
  - Pressure Drop
  - Generated Noise

Silencer Performance

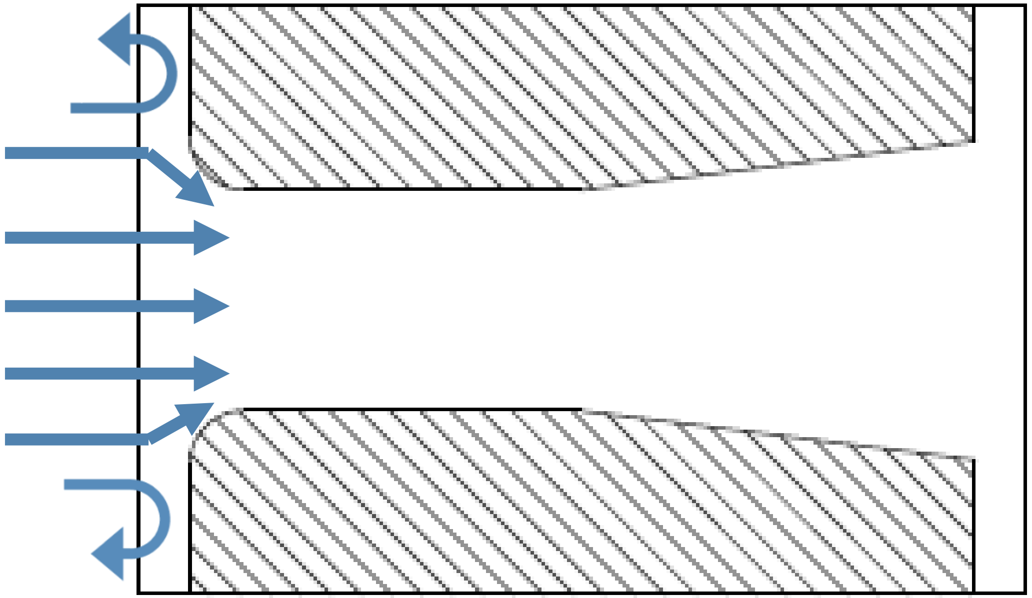
- Insertion loss
  - The difference in sound power level of a system with and without a silencer.
  - Measured across 8 octave bands:

    63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz
- Pressure drop
  - Consequence of creating obstruction in airstream: “You don’t get something for nothing.”
- Generated noise
  - Noise generated when air flows through a silencer air passage.

The Silencer: How it Works

Inlet

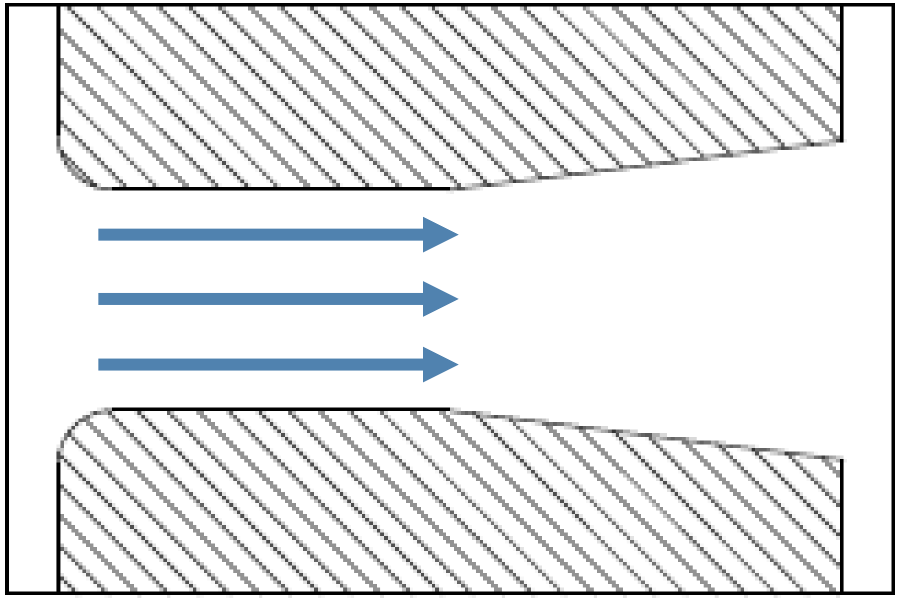
- Turbulent air flow from baffle obstruction
- Air is compressed and velocity increases
- Small amount of high frequency insertion loss due to sound wave reflection
- Some pressure drop due to turbulence and compressing air flow



The Silencer: How it Works

Passage

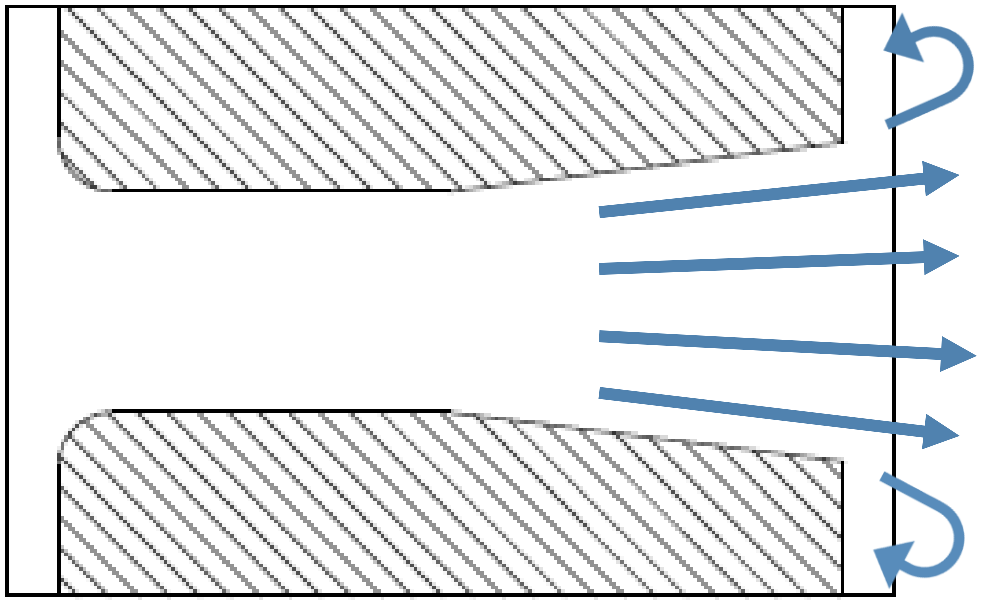
- Sound energy enters the baffles
- Air is compressed and accelerates
- Sound energy is transferred to small amount of heat energy in the baffle; majority of the insertion loss
- Small pressure drop attributed to friction



The Silencer: How it Works

Outlet

- Air redistributes back to the duct size
- Small amount of low frequency insertion loss due to reflection as sound wave expands
- Largest contributor to pressure drop due to sudden expansion



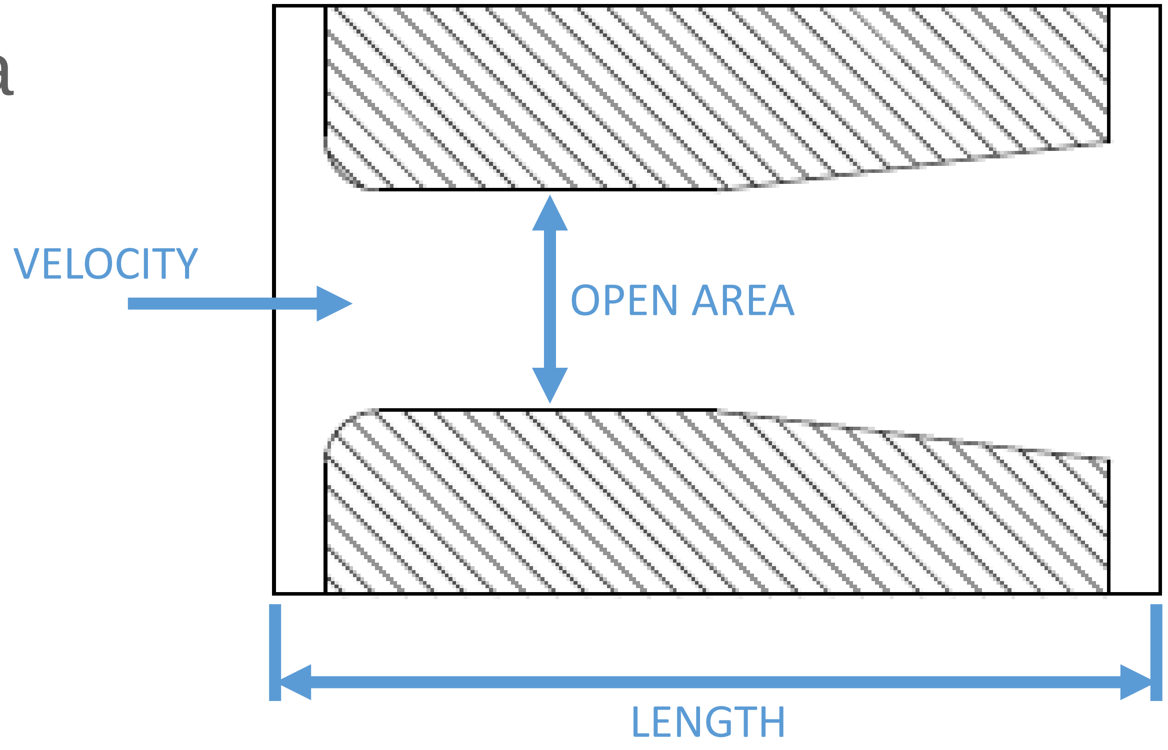
Generated Noise

- Noise generated when air flows through a silencer air passage
- GN is an absolute sound power level added to the system (logarithmic addition)
- GN is typically of note for quiet HVAC systems (< NC 25)
- GN is typically not important when flow velocity is properly selected

Noise Criteria	Max. Duct Velocity (fpm)
NC-40	1300
NC-35	1000
NC-30	800
NC-25	700

Controlling Performance

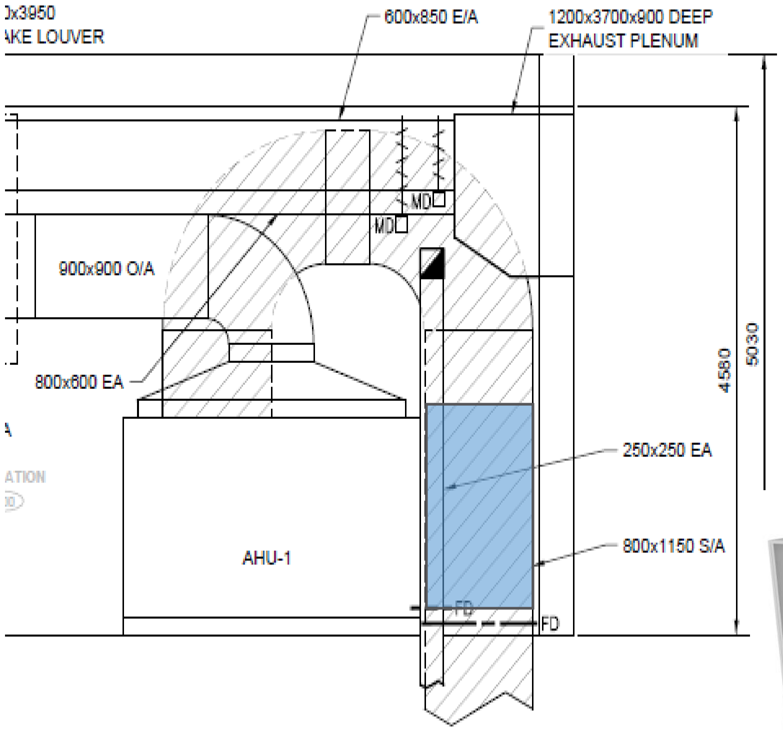
- The acoustic and aerodynamic performance of a silencer is dictated by:
  - The open area of the silencer
  - The length of the silencer
  - The velocity of the air



Silencer Configurations: Rectangular

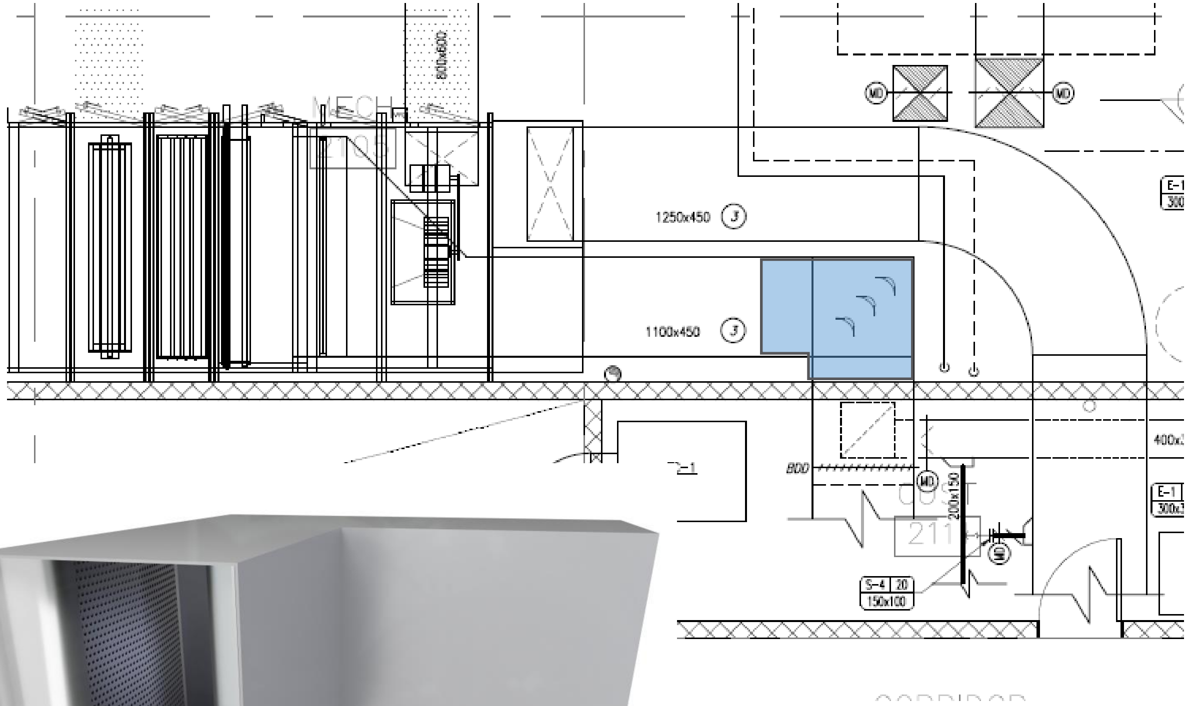
- Best for:
  - Low, medium, and high velocity applications
  - Long duct runs or chases

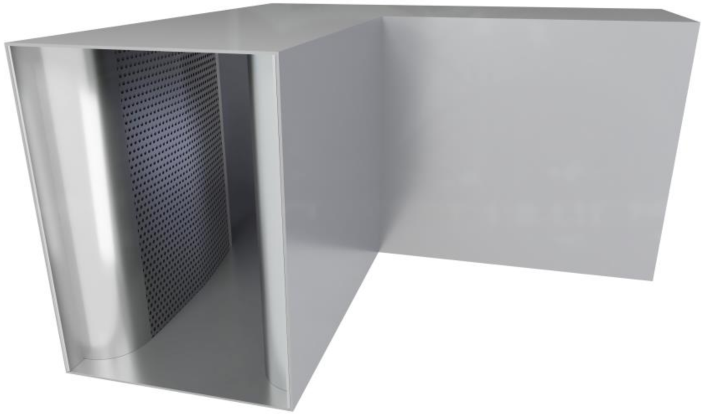
- Can have many variations of baffle sizes and configurations



Silencer Configurations: Elbow

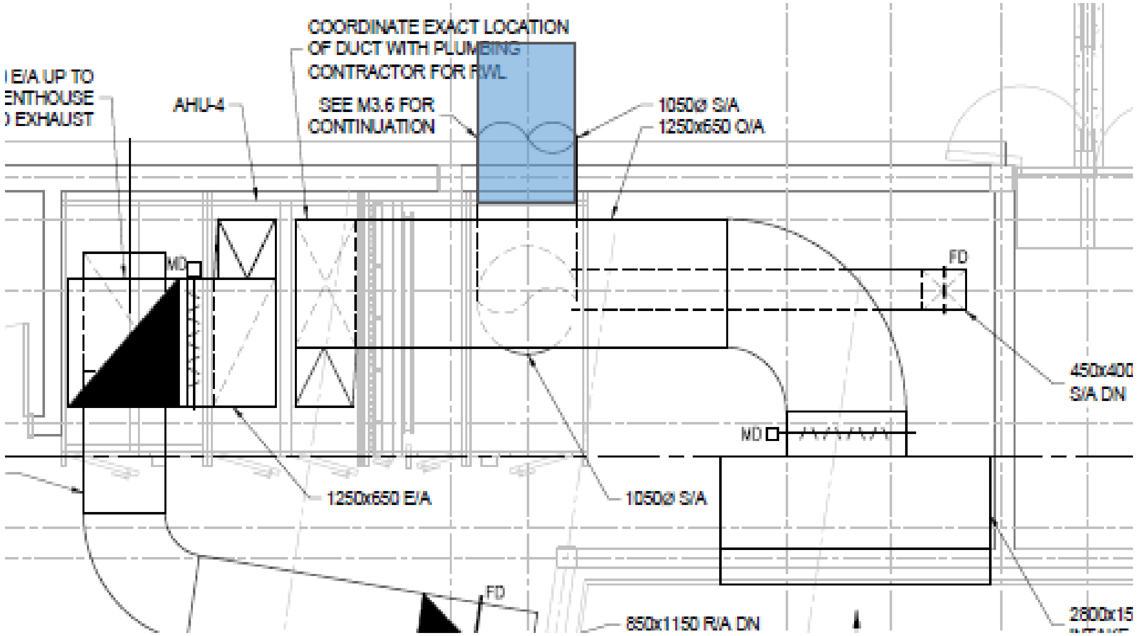
- Best for:
  - Lower Velocity applications (<1,500 fpm)
  - Space Saving Applications
  - Replacing duct elbow to reduce system effects
- Not suggested for when a straight silencer will suffice

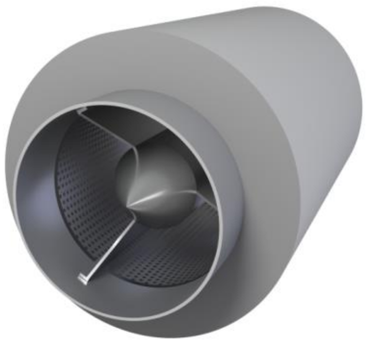


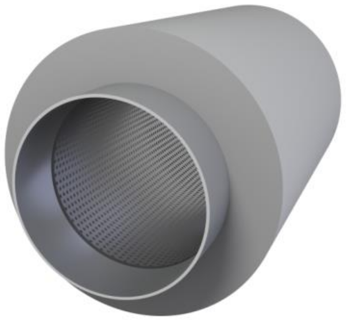


Silencer Configurations: Circular

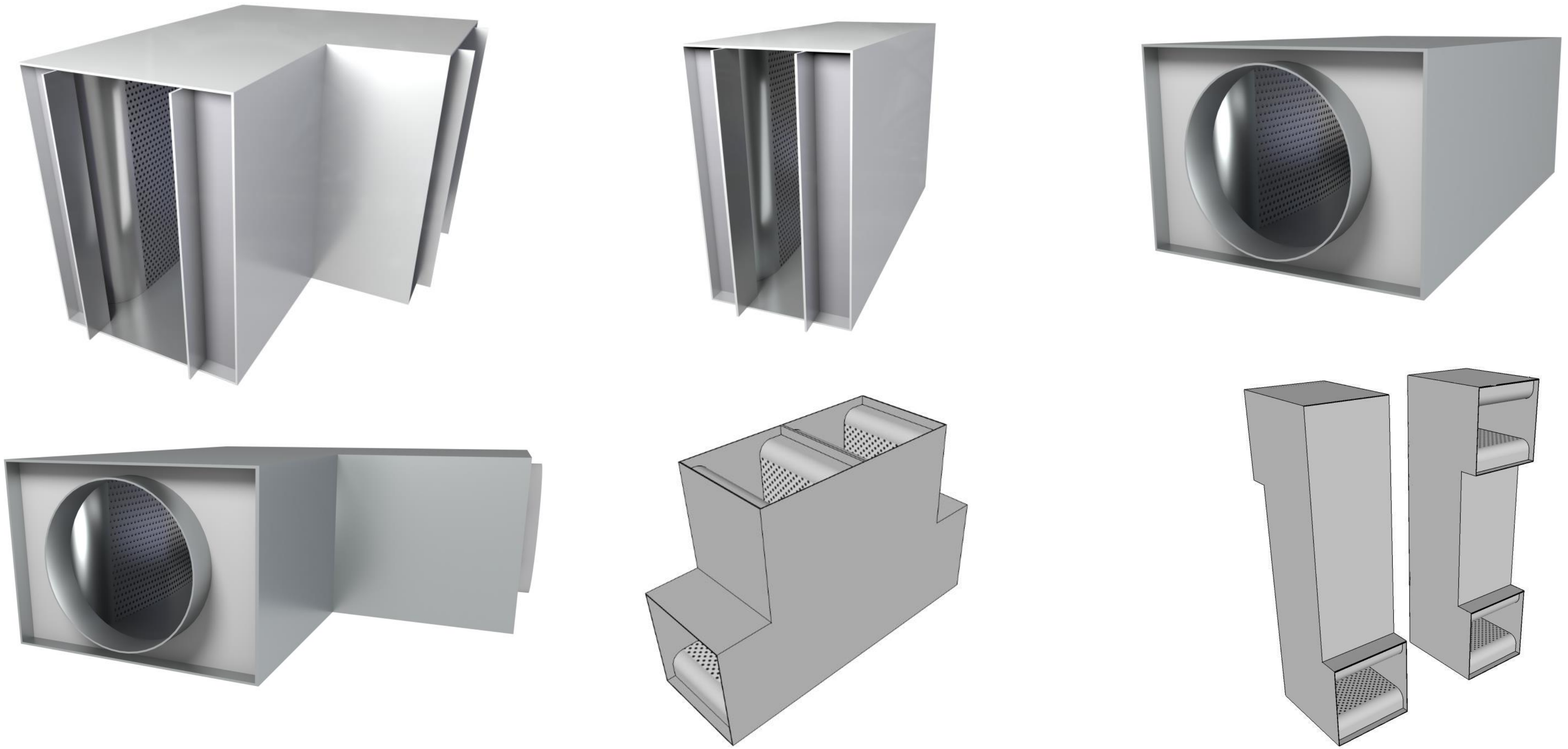
- Best for:
  - High velocity applications (>2,000 fpm)
  - Use with circular ductwork
- Available with and without a center bullet







Silencer Configurations: Other Types



Locating Silencers

- The factors which determine where a silencer is placed in the HVAC system:
  - **Acoustics** – placement to prevent any break-in or break-out noise
  - **Aerodynamics** – How the HVAC elements will affect pressure drop (system effects)

- Locate for acoustics and verify the aerodynamics are acceptable

System Effects

- Duct conditions upstream and downstream of the silencer affect the installed pressure drop

- Pressure drop ≤0.35”wg (87 Pa), including System Effects

- Pressure drop ≤ 0.2”wg (50 Pa) if System Effects are unknown

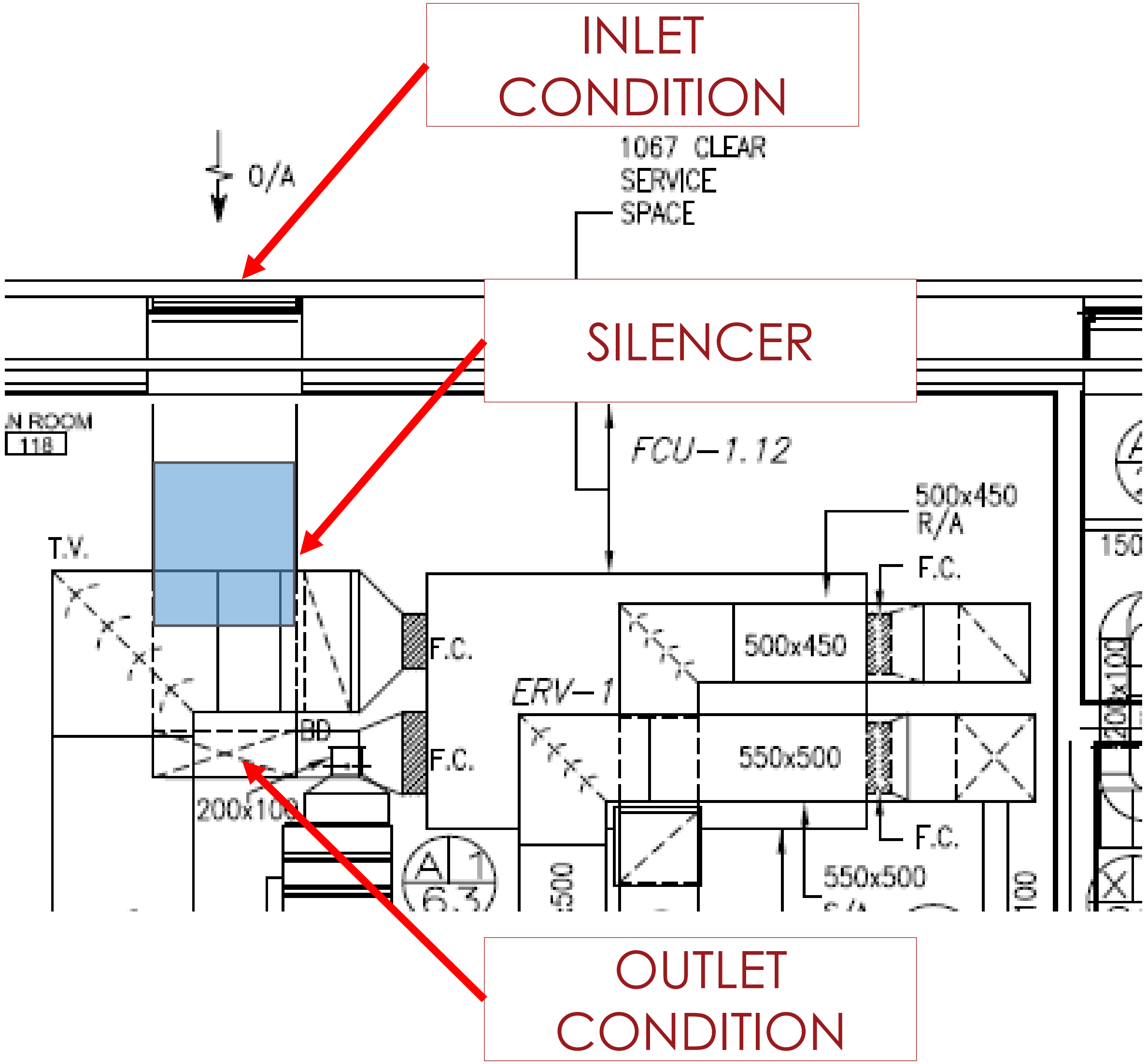
Silencer Condition	Pressure Drop Factor*
Inlet (within 3 to 4 duct diameters)	
Straight unobstructed duct	1.0
Free air/plenum with smooth inlet	1.05
Radiused elbow, with turning vanes	1.05
no turning vanes	1.1
Miter elbow	1.3
Free air/plenum with sharp inlet	1.1 to 1.30
Fan	1.1 to 1.3
Outlet (within 3 to 4 duct diameters)	
Straight unobstructed duct	1.0
Duct doubles area abruptly	1.4
Radiused elbow, with turning vanes	1.5
no turning vanes	1.9
Miter elbow	2.0
Abrupt expansion/plenum	2.0
Fan	1.2 to 1.4

*Silencer pressure drop (including system effects) = silencer pressure drop per test code × pressure drop factor (inlet) × pressure drop factor (outlet).

Above chart courtesy of ASHRAE

System Effects

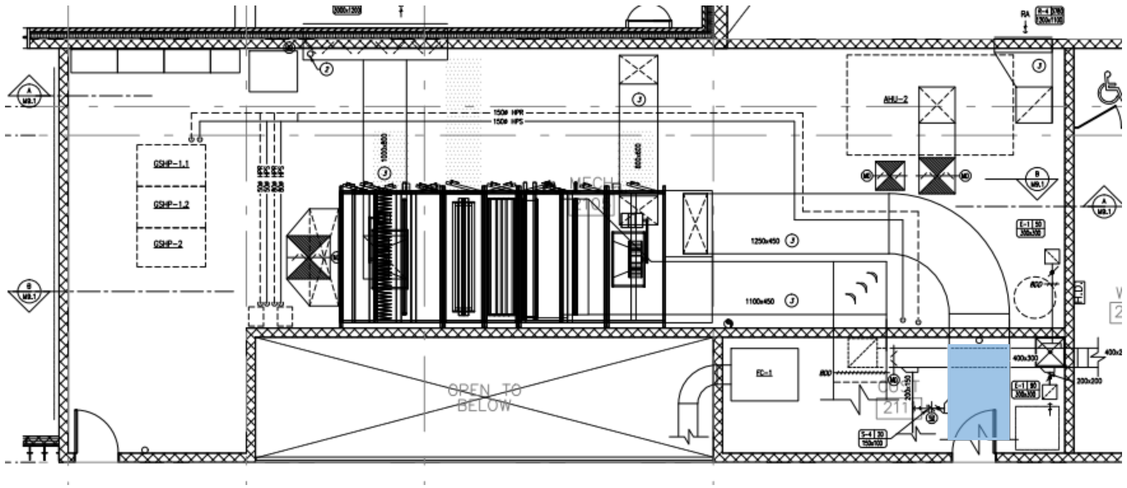
- Silencer PD: 0.25” w.g.
- Up-stream condition:
  - Sharp abrupt entry, 1D
  - Factor: 1.1
- Down-stream condition:
  - Radius elbow, 1D
  - Factor: 1.2
- Total PD = 0.25 x 1.1 x 1.2 = **0.33”w.g**



Locating Silencers

Location: Inside mechanical room

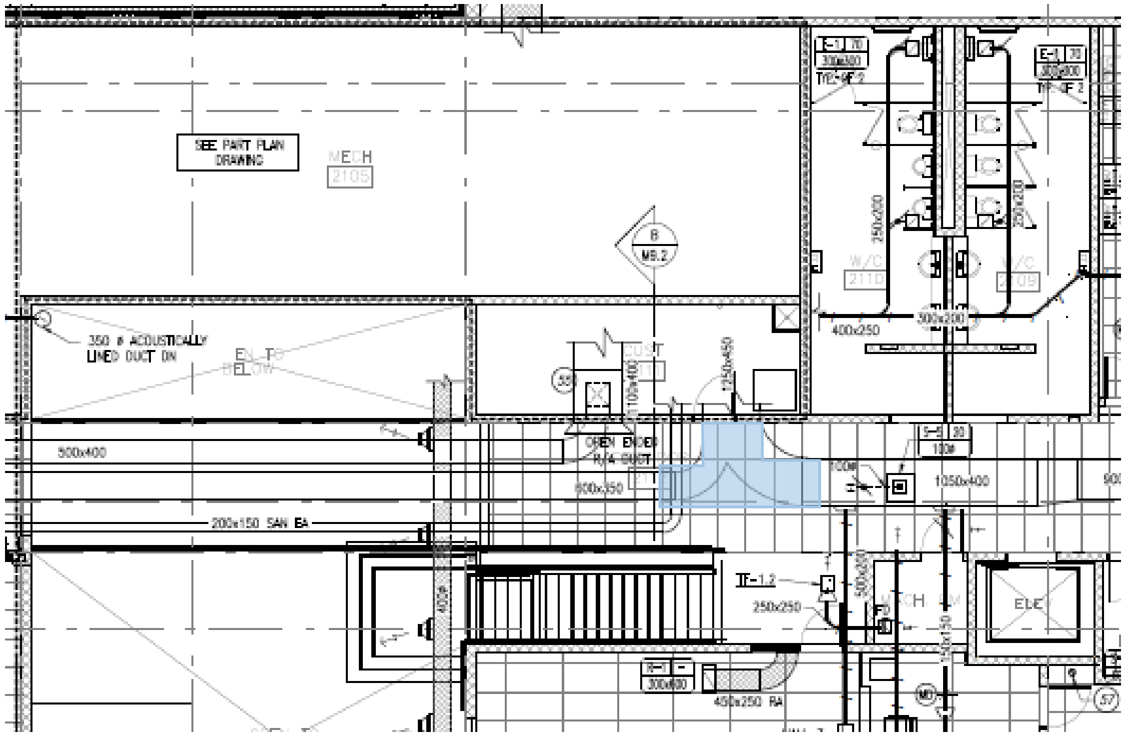
- Generally better system effects
- Guards against break-in noise
- Use standard rectangular silencer



Locating Silencer

Location: Outside mechanical room

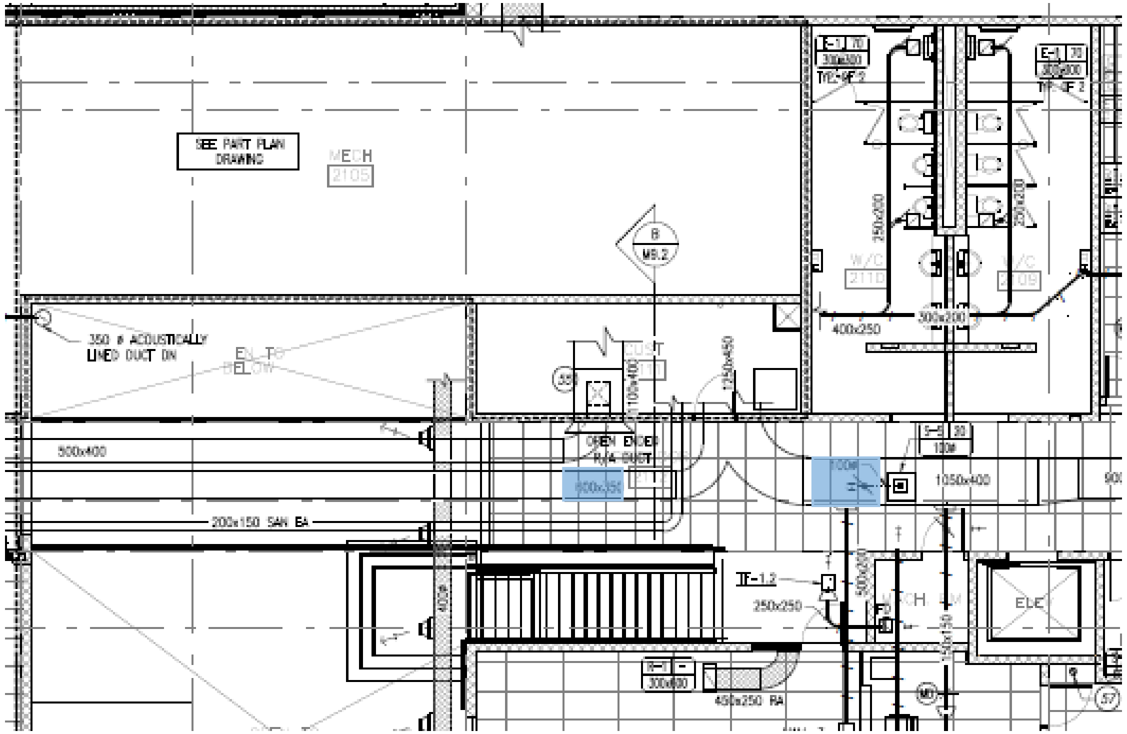
- May require a transitional configuration
- Breakout noise could be a concern



Locating Silencer

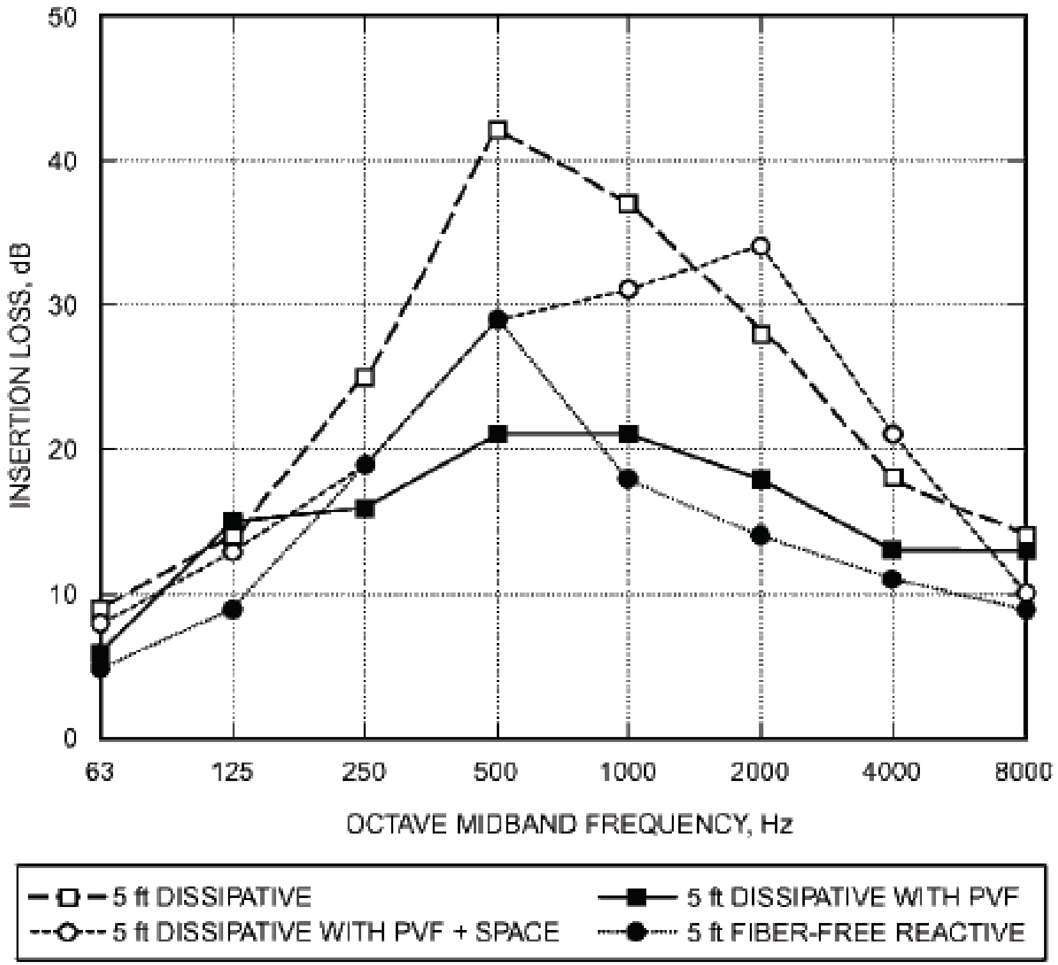
Location: In-branch

- Used when duct elements make placing a silencer difficult
- Locate smaller silencers in branches close to sound source
- Breakout noise could be a concern



Acoustic Media

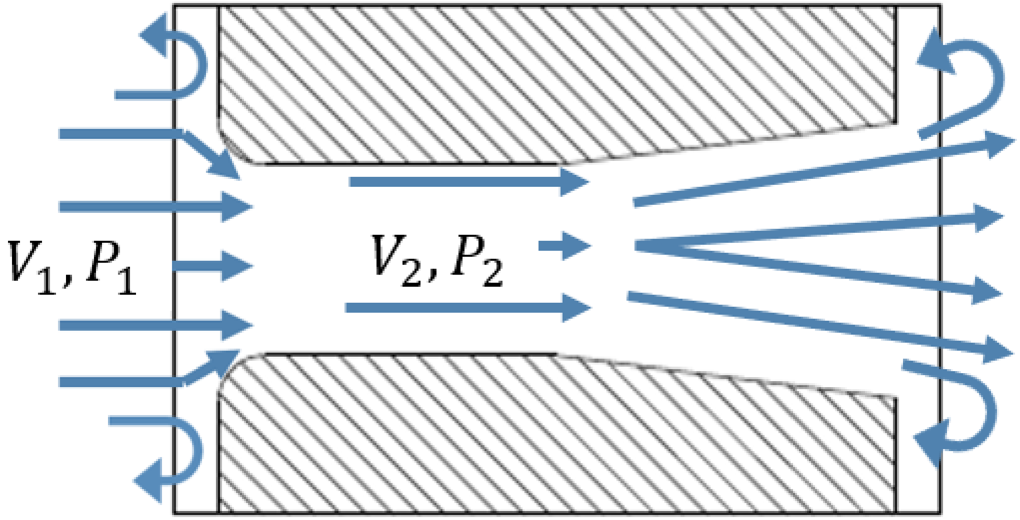
- Most common media types:
  - Fiberglass/Mineral wool
  - Cotton Media
  - No media (Reactive)



Media Type	Applications	IL's	Cost
Fiberglass (Dissipative)	Commercial, industrial, institutional - Schools - Courthouses - Shopping malls/office buildings - Industrial fans		$
Cotton Media	Commercial, industrial, institutional - Schools - Courthouses - Shopping malls/office buildings - Industrial fans - Not to be used in humid settings		$$$
Packless/No media (Reactive)	- Operating rooms - Fume hood exhaust - Clean rooms		$$$$

Media Covering

- As air enters the silencer flow is compressed
- Area of low pressure through passage
- Low pressure can pull fibers into the air stream



$$V_1 < V_2$$

$$P_1 > P_2$$

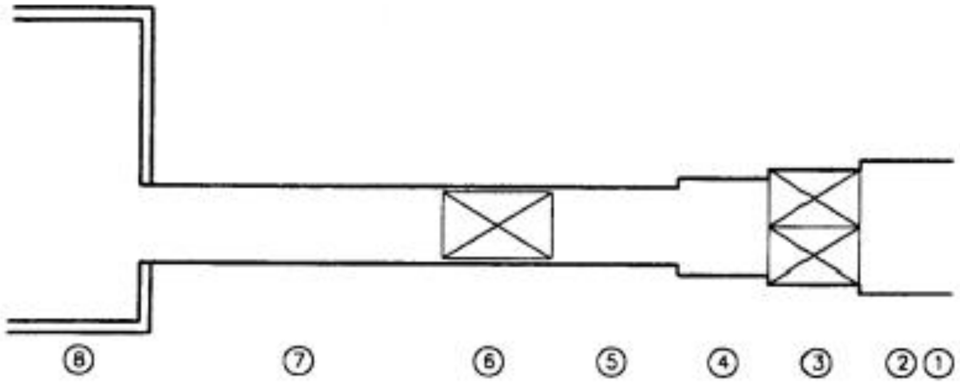
Media Type	Applications	IL's	Cost
No Lining	Commercial, industrial, institutional - Schools - Courthouses - Shopping malls/office buildings - Industrial fans		$
Fiberglass Cloth	- Applications with high velocities (> 2,200 fpm) - Industrial fans		$$
Film Lining	Healthcare, not including operating rooms - Hospitals - Medical offices - Healthcare facilities - Clean rooms		$$$

LOW
INSERTION LOSS

HIGH
INSERTION LOSS

Performance Testing

- Test Standard ASTM E477
- Impartial 3rd party testing or in-house
- Measured insertion loss, generated noise and pressure drop
- Pressure Drop is measured under ideal flow conditions



1 – Airflow measurement station
2 – System fan
3 – System silencer
4 – Signal source chamber
5 – Upstream pressure test station for forward (+ve) airflow and downstream pressure test station for reverse (–ve) airflow
6 – Straight silencer under test
7 – Downstream pressure test station for forward (+ve) airflow and upstream pressure test station for reverse (–ve) airflow
8 – Reverberation room

FIG. 1 Typical Facility for Rating Straight Duct Silencers With or Without Airflow

Resources

- **AMCA International**: www.amca.org
- **AMCA Publication:** www.amca.org/store

  > 202-17: Troubleshooting *(Available for purchase)*

  > 1011-03 (R2010): Certified Ratings Program - Product Rating Manual for Acoustical Duct Silencers ***(FREE PDF download)***

- **ASHRAE Fundamentals Handbook** – 2017, Chapter 8
- **ASHRAE HVAC Applications Handbook** – 2019, Chapter 49
- **Noise Control for Buildings and Manufacturing Plants** – Hoover & Keith, 2001
- **SMACNA - HVAC Systems Duct Design Manual** - 2006, 4th Edition

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