A PRACTICAL GUIDE TO INDUSTRIAL SOUND CONTROL

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NIA | National Insulation Association®

THE VOICE OF THE INSULATION INDUSTRY™

Agenda

- Why Do We Care about Sound?
- Science of Sound
- Measurements
- Insertion Loss
- ISO 15665
- E1222
- E477
- Duct Wrap

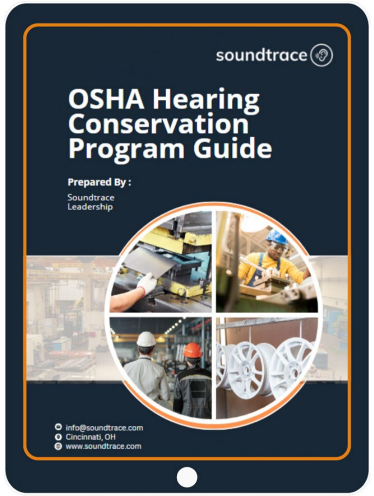
Industrial Acoustics
Why Do We Care?

Why sound is important

- Sound defines our surroundings
- Conveys the character, atmosphere, and setting of a locale
- Communication

Industrial processes are noisy!!

- 22 million workers exposed to potentially damaging noise at work*
- 1 in 8 workers experience hearing issues*
- Estimated U.S. average OHL claim costs **$49 to $67 million**/year**
- Industrial environment with TWA noise levels ≥ 85 dB requires hearing protection
  - Employees exposed to 85dBA ≥8 hours, employer HCP is required
- Property line sound levels may violate zoning



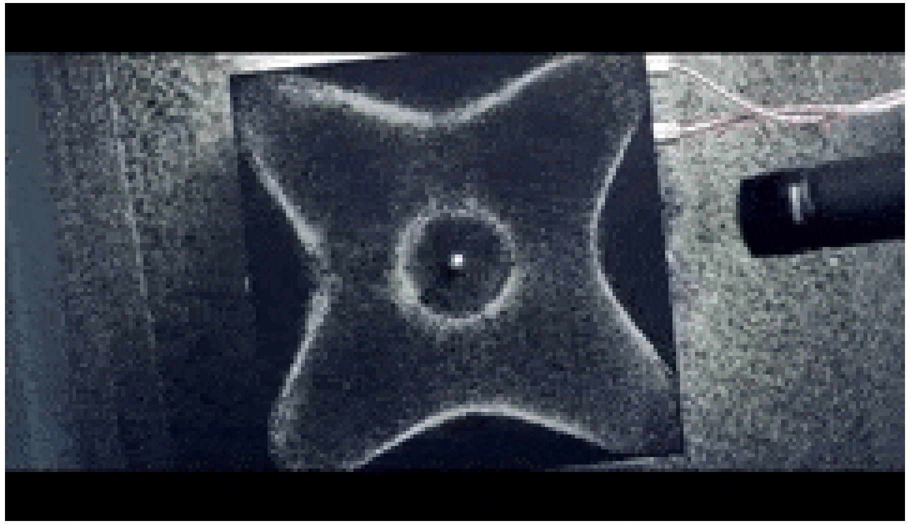
Sound control installed during construction is significantly cheaper than remediation.

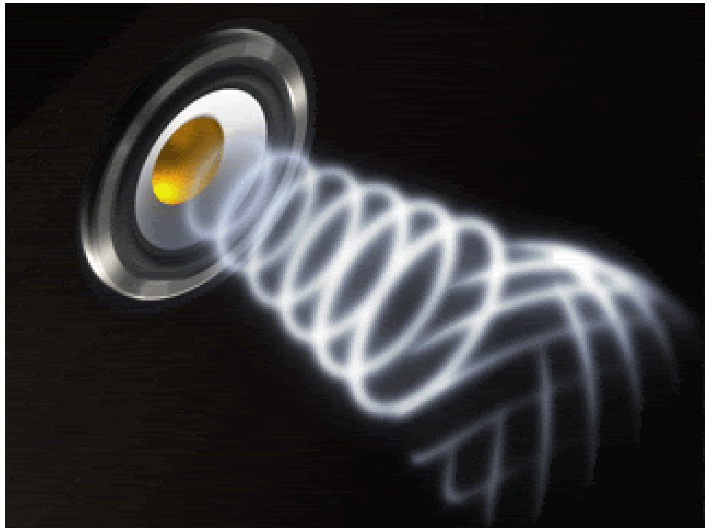
* OSHA .gov ** Semin Hear. 2023 Jun 22;44(4):412–436. doi: 10.1055/s-0043-1769587

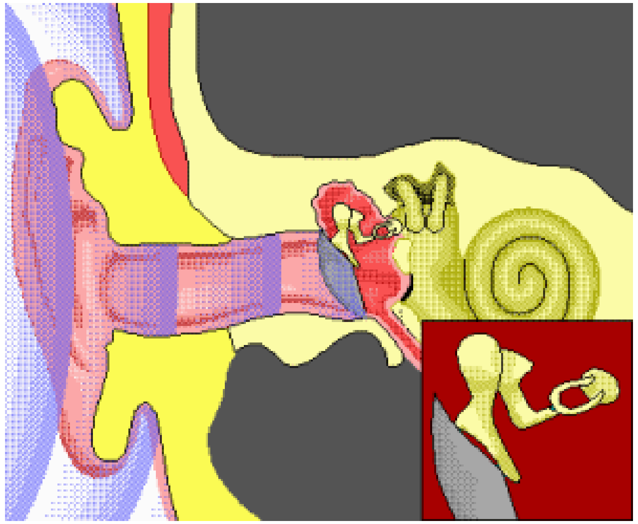
The Science of Sound

What Is Sound?

- Signal produced when a vibrating object causes air particles around it to vibrate
- Consider a speaker…
- The moving air particles bump into each other and transfer the energy as a pressure wave
- That wave travels to the receiver’s ear and is turned into an electrical signal sent to their brain





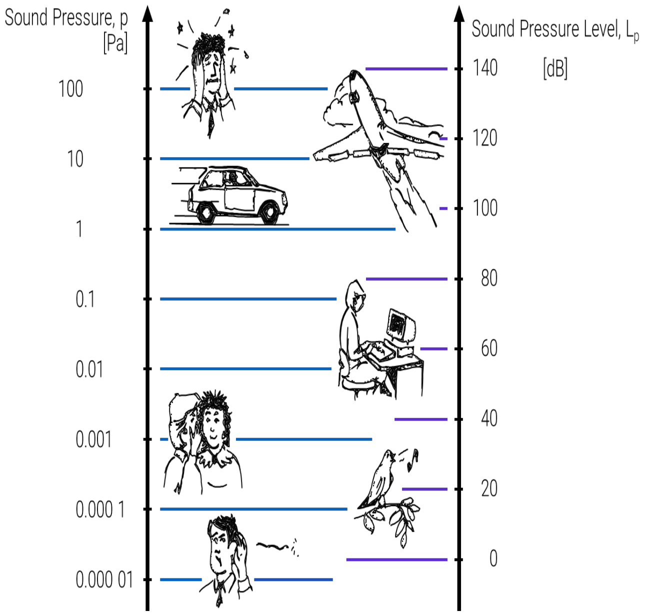


Sound Measurement – The Decibel

Our Amazing Ears

From 0 to 100 dB the difference in pressure is 100,000 times!

Pressure Ratio	– db +	Pressure Ratio	Pressure Ratio	– db +	Pressure Ratio
1.00	0.0	1.000	0.501	6	1.995
0.989	0.1	1.012	0.447	7	2.239
0.977	0.2	1.023	0.398	7	2.512
0.966	0.3	1.035	0.355	9	2.818
0.955	0.4	1.047	0.316	10	3.162
0.944	0.5	1.059	0.251	12	3.981
0.933	0.6	1.072	0.200	14	5.012
0.923	0.7	1.084	1.158	16	6.310
0.912	0.8	1.096	0.126	18	7.943
0.902	0.9	1.109	0.100	20	10.000
0.891	1.0	1.122	0.0316	30	31.62
0.841	1.5	1.189	0.0100	40	100
0.794	2.0	1.259	0.0032	50	316.2
0.708	3.0	1.413	10^{-3}	60	10^3
0.631	4.0	1.585	10^{-4}	80	10^4
0.562	5.0	1.778	10^{-5}	100	10^5

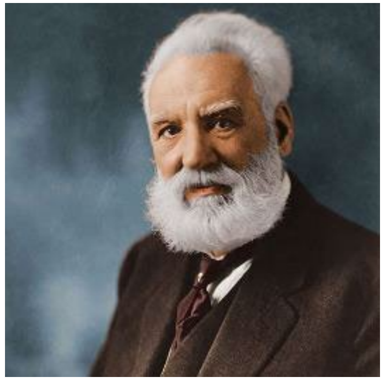


$$L_p = 20 \log\left(\frac{p}{p_0}\right) \text{ dB re 2e-05 pa}$$

(p_0 = 0.00002 pa = 2 × 10^{-05} pa)

(3 x 10^{-9} psi)

History of the Decibel



Originates from telephone circuits audio levels – Originally called the ***transmission unit*** (TU)

- One ***transmission unit*** is defined as 10 x Log (P_m/P_r).

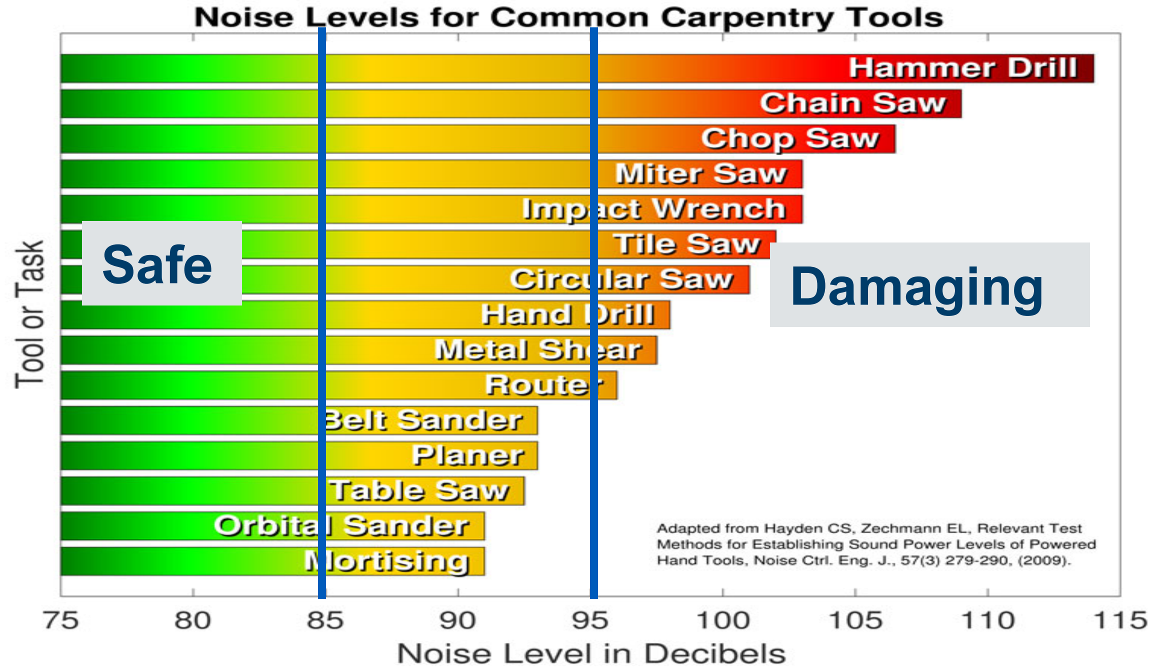
Eventually, international standards bodies adopted this ratio as a standard unit

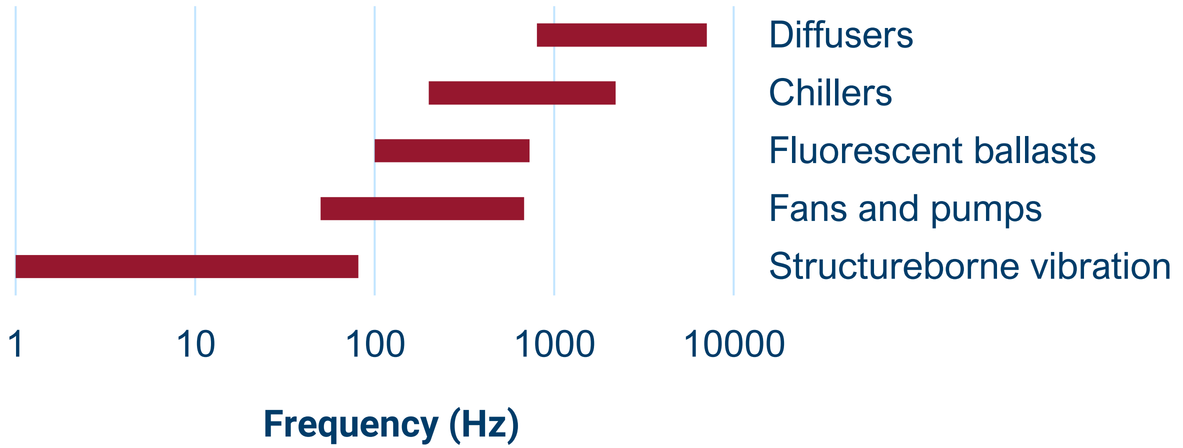
- Named the ***bel*** in honor of telephone pioneer Alexander Graham Bell.
- The ***bel*** is 10 times larger than the TU, such that 1 TU equaled 1 decibel.

Fun Fact: The bel proved inconveniently large, giving way to the decibel becoming the common unit of choice.

Sound

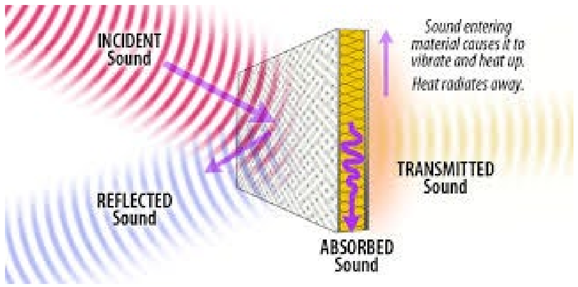
Level, Frequency, Differences



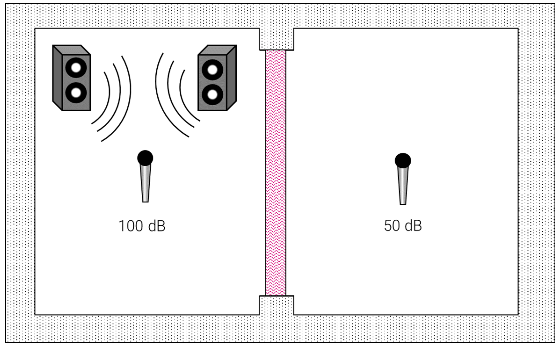


Subjective Change	Objective Change
Much louder	More than +10 dB
Twice as loud	+10 dB
Louder	+5 dB
Perceptibly louder	+3 dB
Perceptibly quieter	-3 dB
Quieter	-5 dB
Half as loud	-10 dB
Much quieter	Less than -10 dB

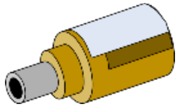
Acoustic Measurements



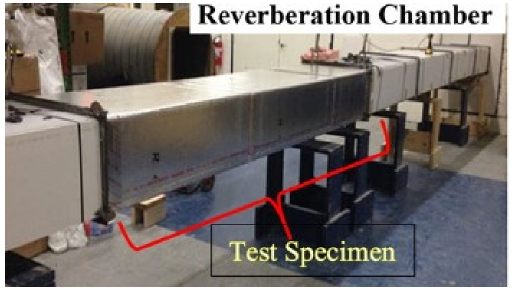
- **Sound Absorption: ASTM C423**
  Absorption is a function of the resistance (friction) in a porous material.



- **Transmission Loss: ASTM E90**
  An effective material or system that acts as a barrier that restricts the transmission of sound energy from one area to another.

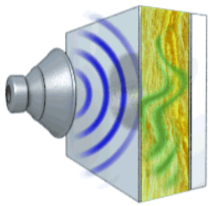


- **Insertion Loss: ASTM E1222 / ISO 15665**
  Insertion loss refers to reducing sound by adding insulation, jacketing/lagging, or both to a pipe system reducing sound radiated by the pipe.



- **Insertion Loss: ASTM E477**
  Insertion loss refers to reducing sound by adding insulation to a duct system reducing sound transmitted through the duct.

Sound Absorption

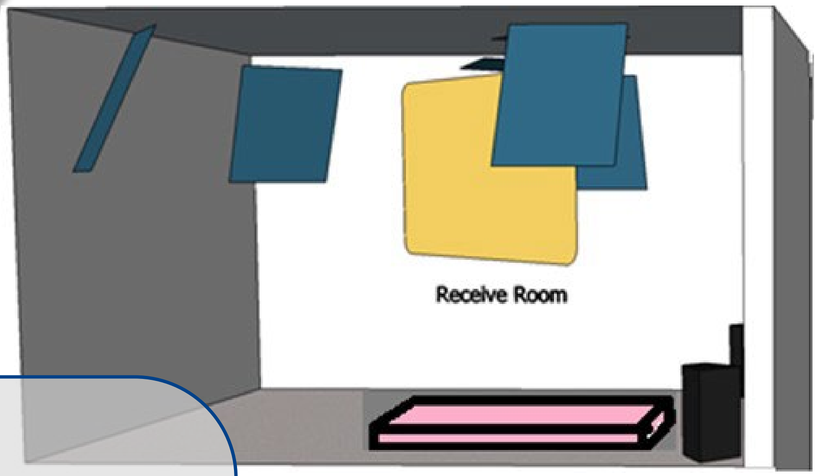


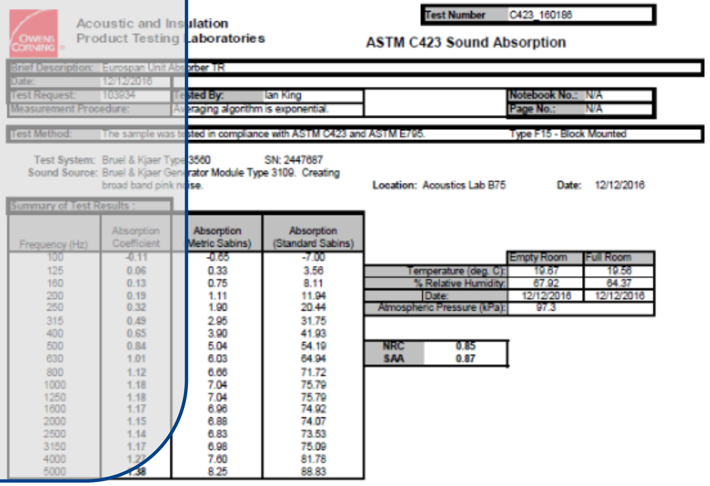
- **NRC: Noise Reduction Coefficient**
  - Single number rating
  - Average of the 250, 500, 1000 and 2000 Hz absorption coefficients
  - Represents how well a material absorbs sound
    - Typical range of (0.4 – 1.2).
  - Determined using ASTM C423/ISO 354
  - Measured in terms of sound absorption coefficient
  - Varies with frequency
  - Calculation of absorption coefficient (α)

Material/Product Rating

$$\alpha = \frac{\text{Acoustic Absorption (Sabines}[m^2])}{\text{Sample Projected Surface Area }(m^2)}$$

Absorption coefficient ≠ percentage of sound absorbed





Acoustic and Insulation Product Testing Laboratories

Test Number: C423_160186

ASTM C423 Sound Absorption

Brief Description: Eurospan Unit Absorber TR

Date: 12/12/2016

Test Request: 103934 | Tested By: Ian King | Notebook No.: N/A

Measurement Procedure: Averaging algorithm is exponential. | Page No.: N/A

Test Method: The sample was tested in compliance with ASTM C423 and ASTM E795. Type F15 - Block Mounted

Test System: Bruel & Kjaer Type 3560 SN: 2447687

Sound Source: Bruel & Kjaer Generator Module Type 3109. Creating broad band pink noise.

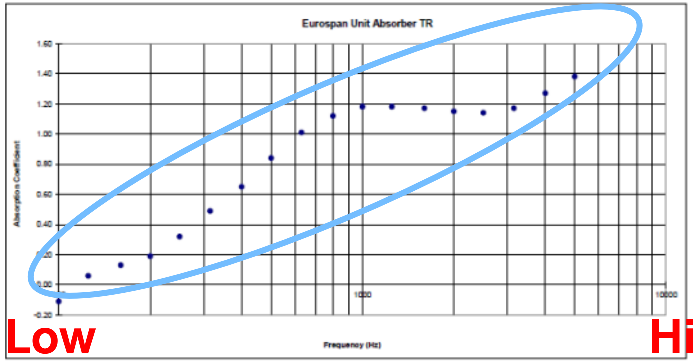
Location: Acoustics Lab B75 Date: 12/12/2016

Summary of Test Results :

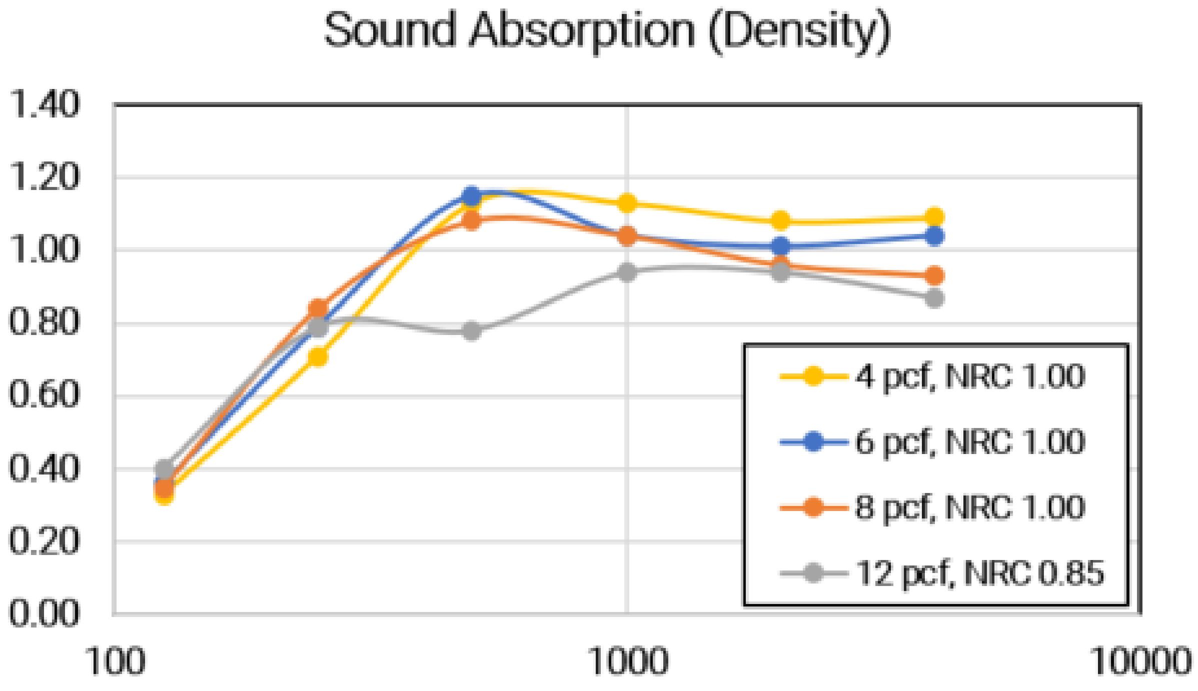
Frequency (Hz)	Absorption Coefficient	Absorption (Metric Sabins)	Absorption (Standard Sabins)
100	-0.11	-0.65	-7.00
125	0.06	0.33	3.56
160	0.13	0.75	8.11
200	0.19	1.11	11.94
250	0.32	1.90	20.44
315	0.49	2.95	31.75
400	0.65	3.90	41.93
500	0.84	5.04	54.19
630	1.01	6.03	64.94
800	1.12	6.66	71.72
1000	1.18	7.04	75.79
1250	1.18	7.04	75.79
1600	1.17	6.96	74.92
2000	1.15	6.88	74.07
2500	1.14	6.83	73.53
3150	1.17	6.98	75.09
4000	1.27	7.60	81.78
5000	1.38	8.25	88.83

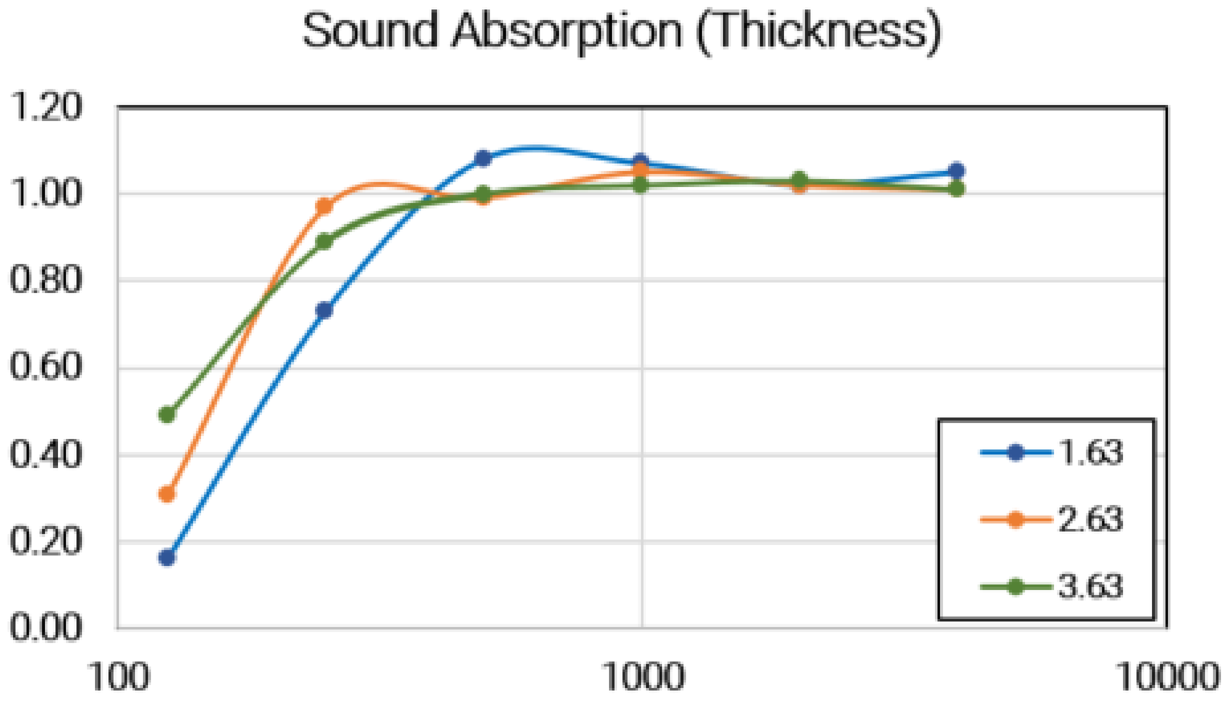
	Empty Room	Full Room
Temperature (deg. C):	19.67	19.56
% Relative Humidity:	67.92	64.37
Date:	12/12/2016	12/12/2016
Atmospheric Pressure (kPa):	97.3	

NRC	0.85
SAA	0.87



Sound Absorption (Density vs. Thickness)



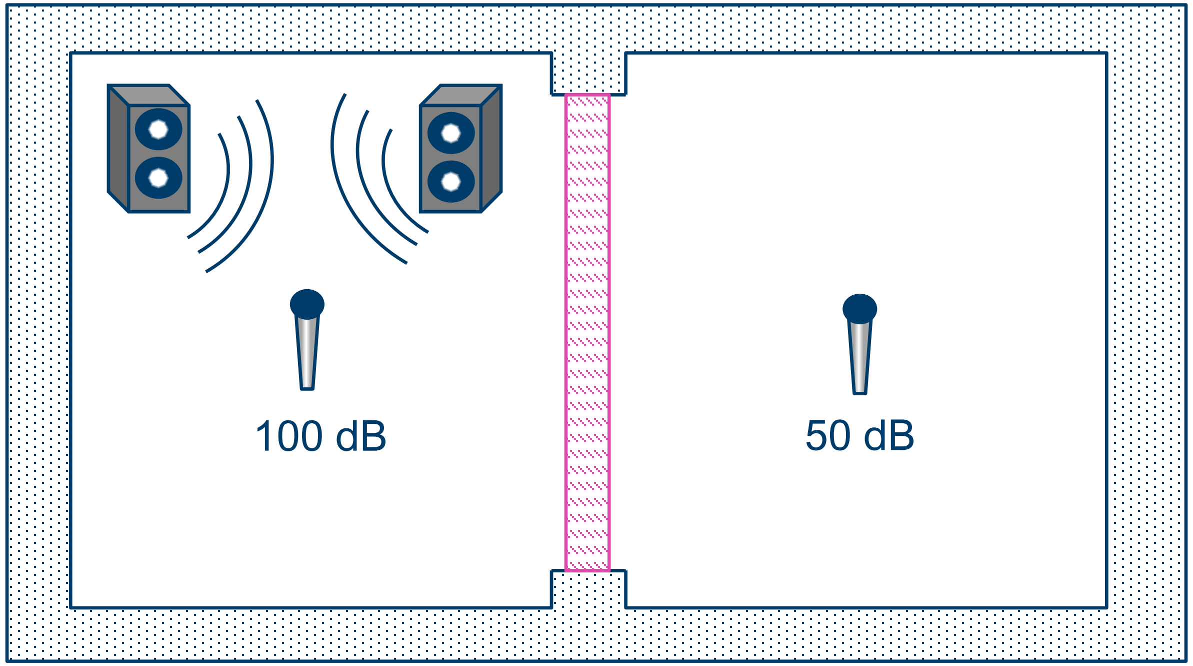


- For same thickness, increased density improves low frequency absorption.
- Higher density products can reduce absorption at higher frequencies.

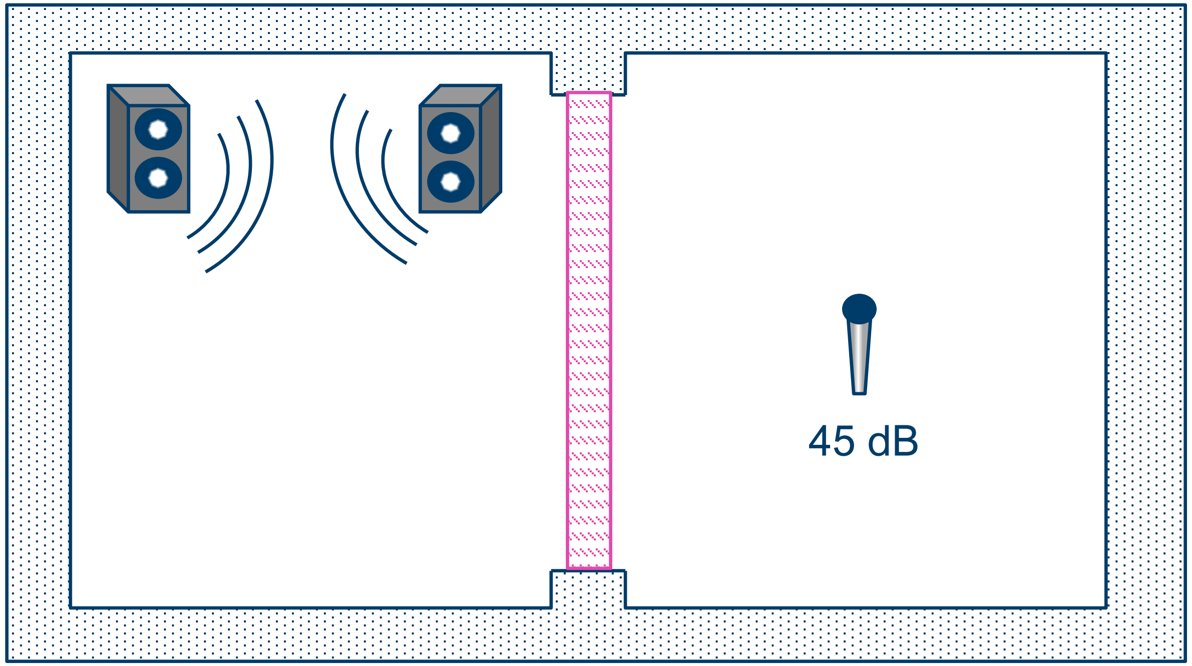
- Same density, thicker products increase low frequency absorption.
- Does not negatively affect high frequency absorption.

Thickness has a greater impact on sound absorption than density.

Sound Transmission Loss vs. Insertion Loss
Sound Transmitted through a Barrier



Source Room   Receive Room



Source Room   Receive Room

Sound Transmission Loss

The sound levels measured in both rooms simultaneously.
Sound lost to absorption in receiving room accounted for.
Result is measure of energy lost between spaces.

Sound Insertion Loss

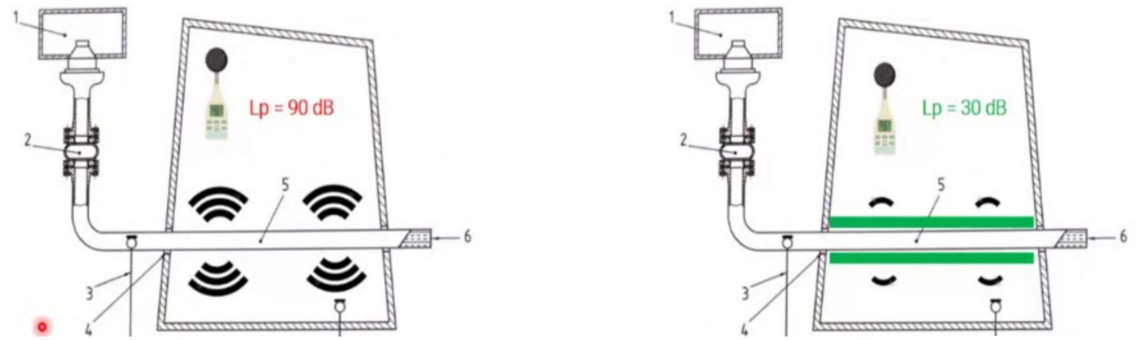
The sound levels measured in same room, before and after.
Sound lost to absorption in receiving room not determined.
Result is sound pressure level difference in receiving room due to barrier.

Insertion Loss (IL) of Pipe Lagging
The Change in Noise Level Due to the Addition of Material

The insertion loss is calculated as follows: **Bare pipe SPL (dB)** – **Treated pipe SPL (dB)** = **Insertion Loss** (dB)

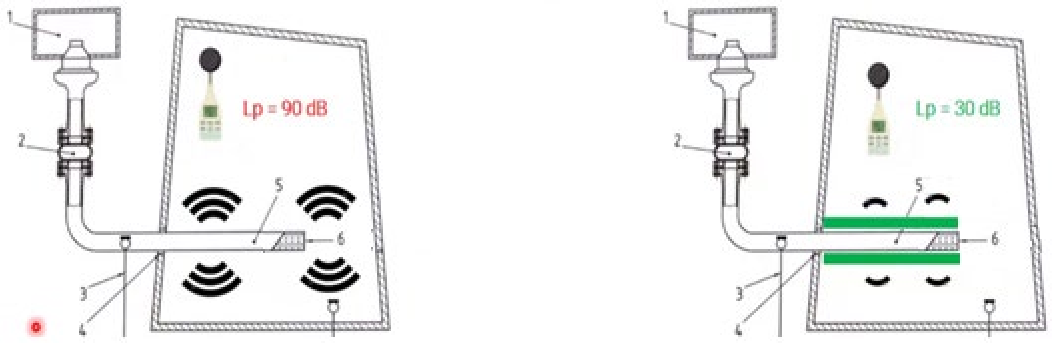
ISO 15665 STANDARD MEASUREMENT

Insertion loss – the difference (in dB) between sound power level radiated from a noise source **before** and **after** the application of acoustic insulation. Results reported in table form with a “Class” rating



ASTM E1222 STANDARD MEASUREMENT

Insertion loss – the difference (in dB) between sound power level radiated from a noise source **before** and **after** the application of acoustic insulation. Results reported in table form.



Insertion Loss
ISO 15665

ISO 15665 narrows requirements down to the following:

- Three pipe sizes
  - "1" – Diameter < 300mm (11.81")
  - "2" – 300mm (11.81") ≤ Diameter < 650mm (25.6")
  - "3" – 650mm (25.6") ≤ Diameter < 1000mm (39.4")

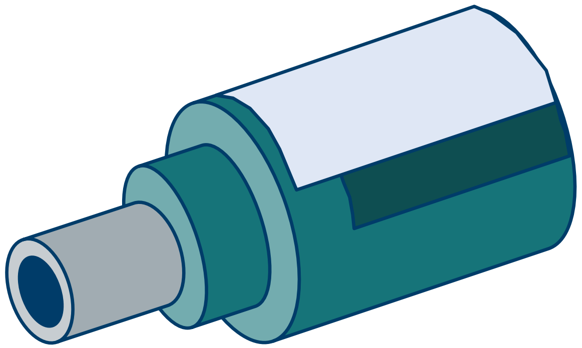
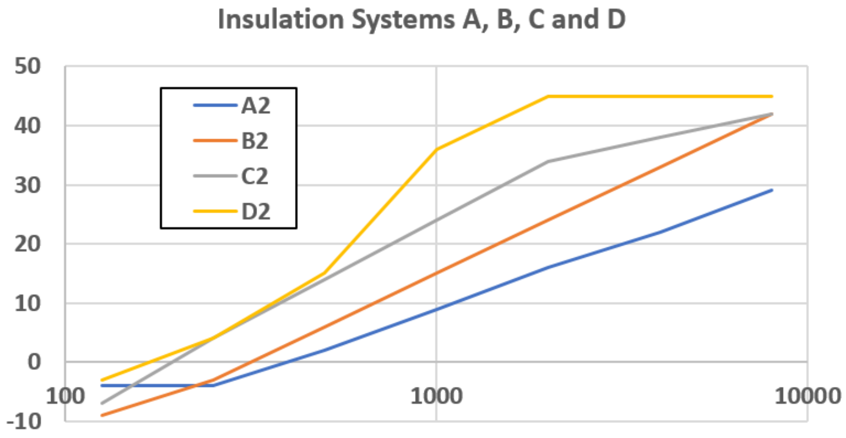


Table A.1 — Insulation constructions that can meet classes of acoustic insulation*

CLASS	DESCRIPTION	VALUE
A	Min. thickness of porous layer Max stiffness of porous layer Min. mass per unit area of metal cladding	50mm $2{,}0 \cdot 10^6$ N/m^3 4,5 kg/m^2 (e.g. 0,6mm steel plate)
B	Min. thickness of porous layer Max stiffness of porous layer Min. mass per unit area of metal cladding	100mm 10^6 N/m^3 6,0 kg/m^2 (e.g. 0,8mm steel plate)
C	Min. thickness of porous layer Max stiffness of porous layer Min. mass per unit area of metal cladding For nominal pipe diameters <300mm For nominal pipe diameters ≥ 300mm	100mm 10^6 N/m^3 7,8 kg/m^2 (e.g. 1,0mm steel plate) 10,0 kg/m^2 (e.g. 1,3mm steel plate)
D	min. thickness first porous layer min. mass per unit area of first mass layer min. thickness of second porous layer min mass per unit area of second mass layer and/or metal cladding 300 mm ≤ D < 650 mm 650 mm ≤ D < 1 000 mm max. stiffness of porous layers	50 mm 6 kg/m^2 (e.g. 0,8 mm steel plate) 50 mm 7,8 kg/m^2 (e.g. 1,0 mm steel plate) 10 kg/m^2 (e.g. 1,3 mm steel plate 10 N/m^3



Note: Class "D" was recently added to ISO 15665

* **International Standard ISO 15665 – 2023** Acoustics — Acoustic insulation for pipes, valves, and flanges

ASTM E1222 – Pipe Insertion Loss/Pipe Lagging Systems

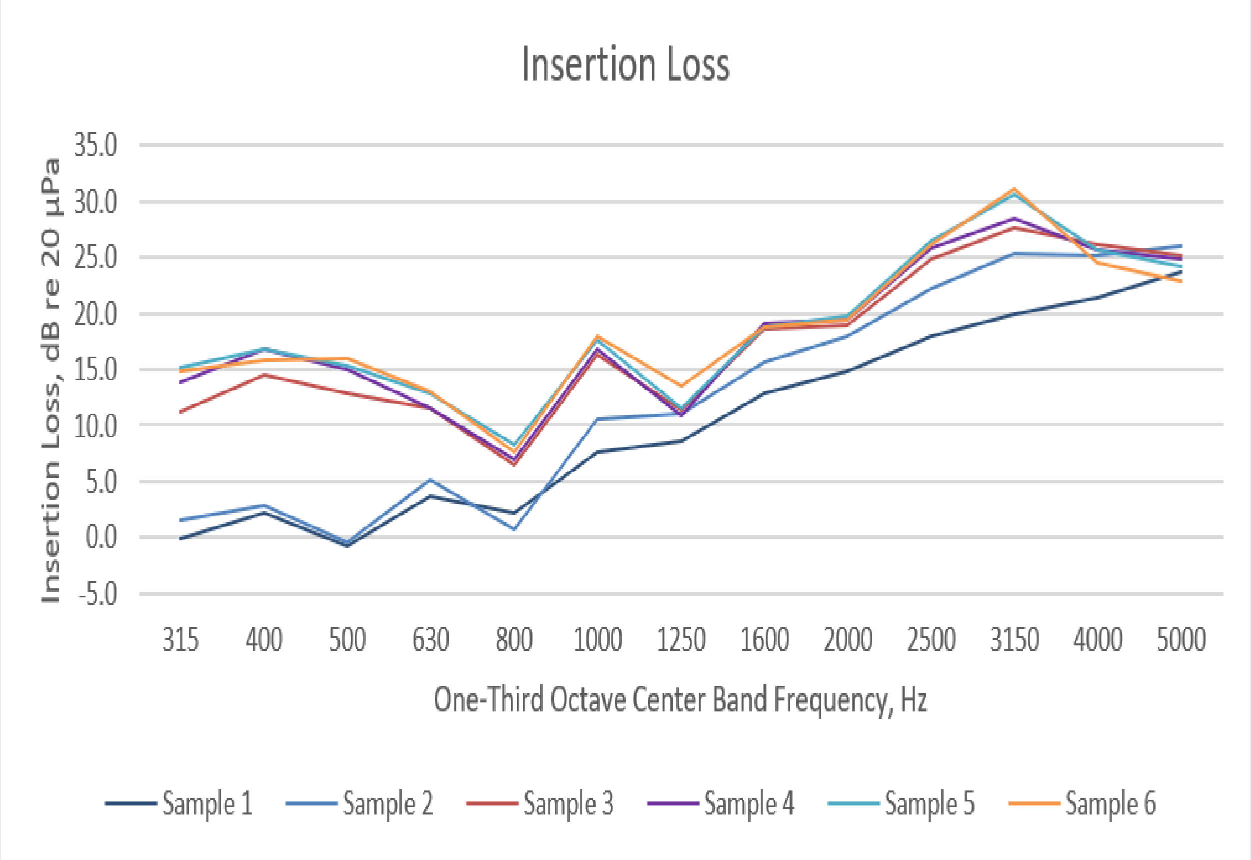


Figure 2. Insertion Loss for submitted samples. This is the value of the bare pipe measurement minus the lagged pipe measurement.

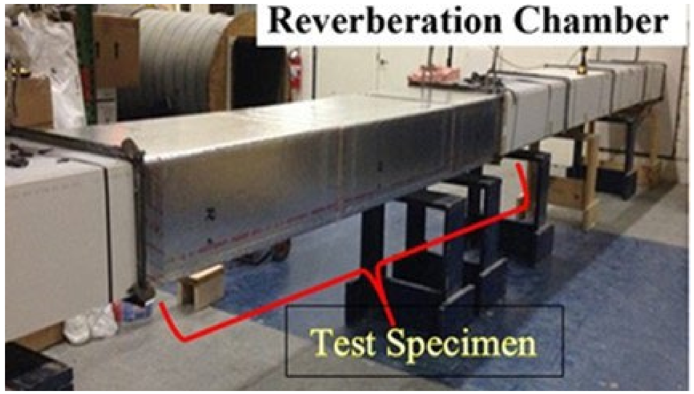
Table 1. Insertion Loss values for submitted samples.

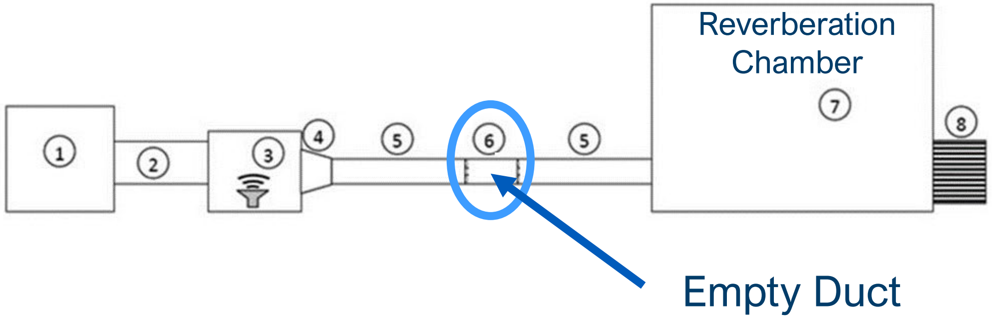
Frequency, Hz	Sample					
	1	2	3	4	5	6
315	-0.1	1.6	11.3	13.9	15.2	14.8
400	2.2	2.8	14.5	16.7	16.9	15.9
500	-0.8	-0.5	12.9	15.0	15.3	15.9
630	3.7	5.2	11.5	11.6	12.9	13.1
800	2.2	0.7	6.5	6.9	8.3	7.6
1000	7.7	10.6	16.3	16.8	17.6	18.0
1250	8.5	11.1	11.4	10.9	11.6	13.6
1600	12.8	15.7	18.6	19.1	18.8	18.8
2000	14.9	17.9	18.9	19.4	19.9	19.5
2500	18.0	22.2	24.8	25.8	26.5	26.2
3150	20.0	25.3	27.6	28.5	30.6	31.1
4000	21.3	25.2	26.1	25.7	25.7	24.6
5000	23.8	26.1	25.1	24.9	24.3	23.0

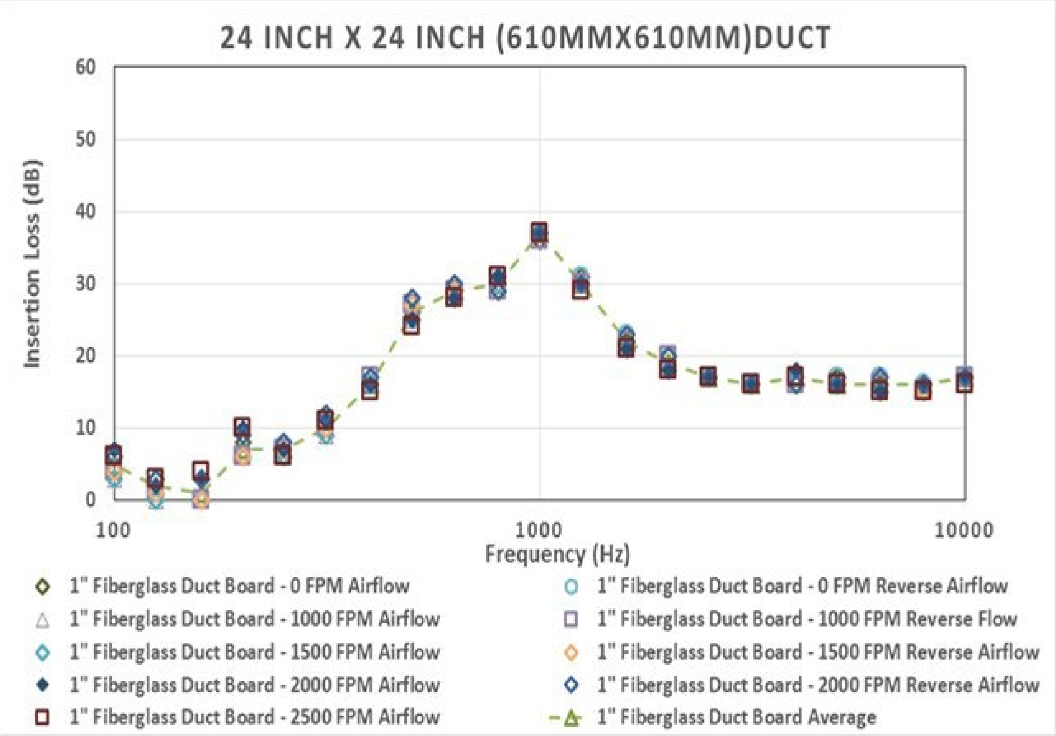
Insertion Loss Testing

ASTM E477

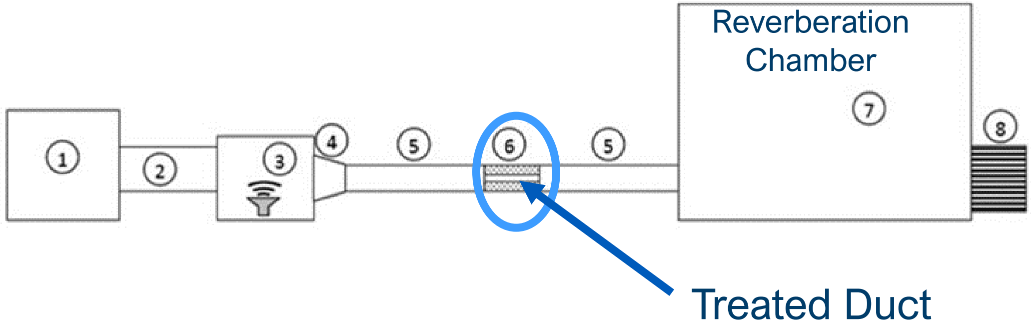
- Test used in the ventilation systems of buildings
- Tests performance of the system in well-defined and controlled conditions
- Procedures to measure:
- Measure Sound in Reverberation Chamber with Empty Duct







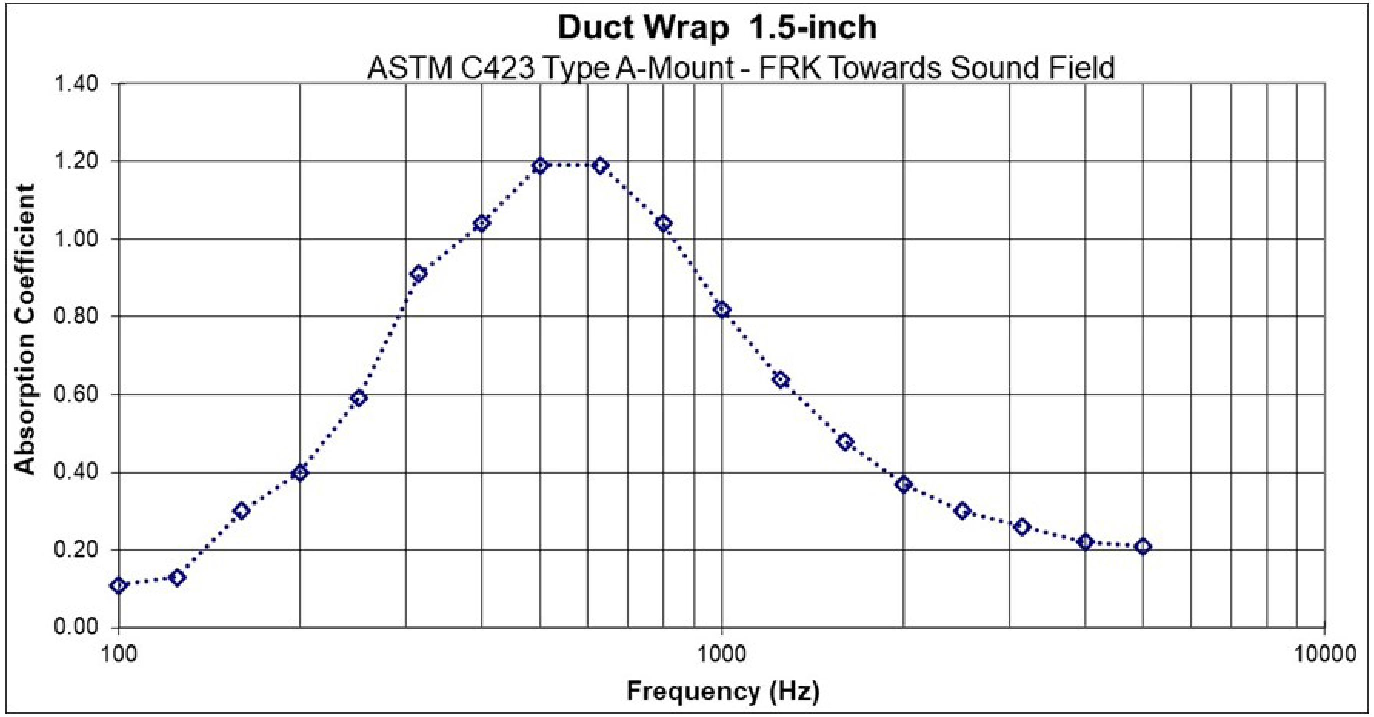
- Measure Sound in Reverberation Chamber with Treated Duct



Duct Wrap

- **ASTM C423**
  - Measured in terms of sound absorption coefficient (⍺)
  - **NRC**: Noise Reduction Coefficient

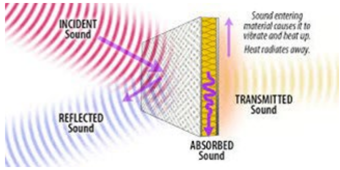
Provides a measure of the sound absorbed in a space where applied

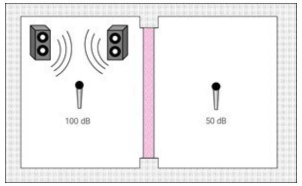


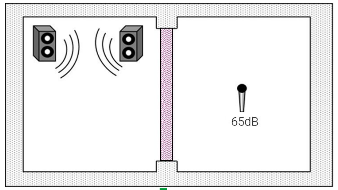
WRAPPING UP
REVIEW

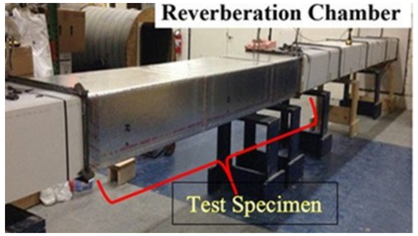
Review

- **Sound Is a Critical Part of Our Lives**
  - It is created via vibration and transmitted as a pressure wave through the air
  - Measured in Decibels
- **Measures of Sound Performance**
  - Absorption
  - Transmission Loss
  - Insertion Loss
- **Two Types of Pipe Insertion Loss Measurements**
  - ASTM E1222
  - ISO 15665
- **Duct Insertion Loss Measurement**
  - ASTM E477
- **Duct Wrap**
  - ASTM C423









Closing

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THANK YOU FOR YOUR SUPPORT IN JOINING IN!

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