8.1 Broadband Absorption

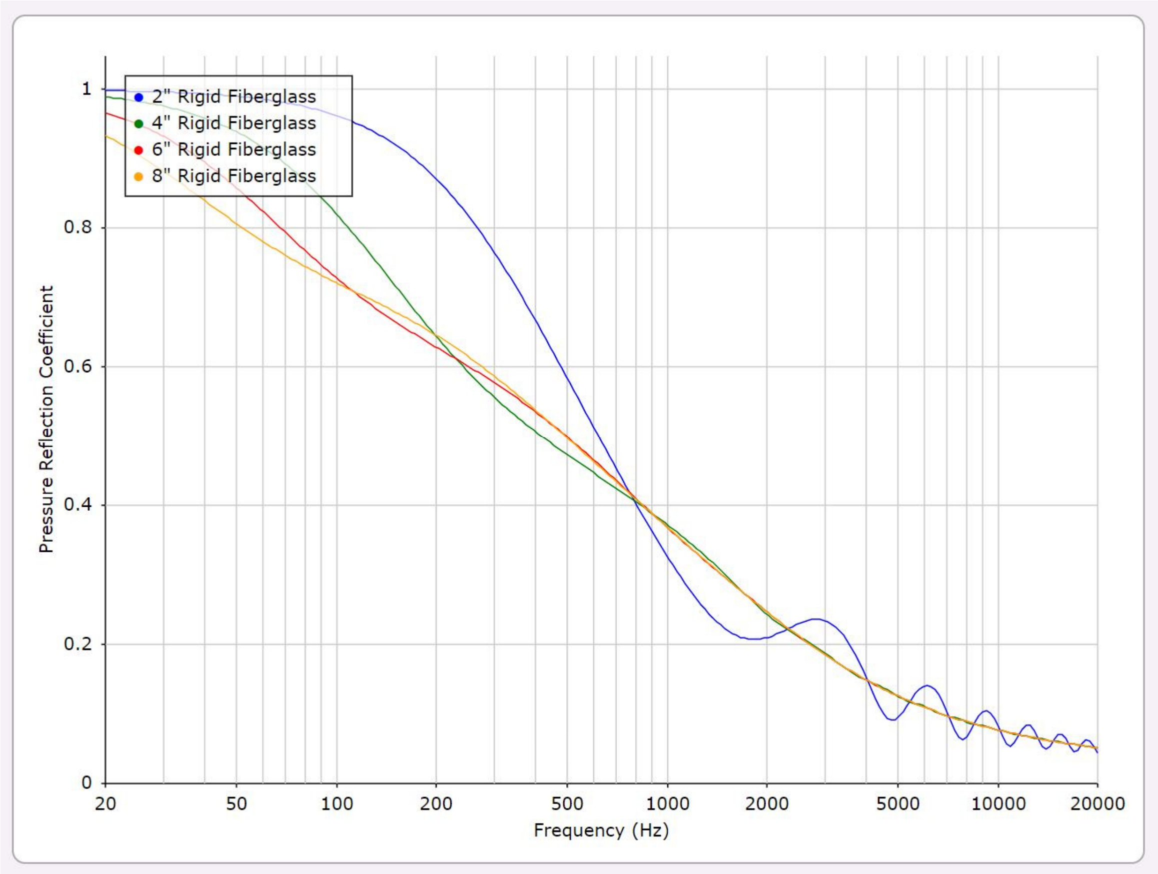
Before you begin making broadband acoustic treatment there are a few things that need to be addressed.

1. Sound pressure and sound velocity.
2. How do we transfer as much energy as possible into the porous absorption (fiber)?
3. How does impedance affect the transfer?
4. Concerning broadband porous absorption efficiency, what is the lowest effective frequency obtainable?

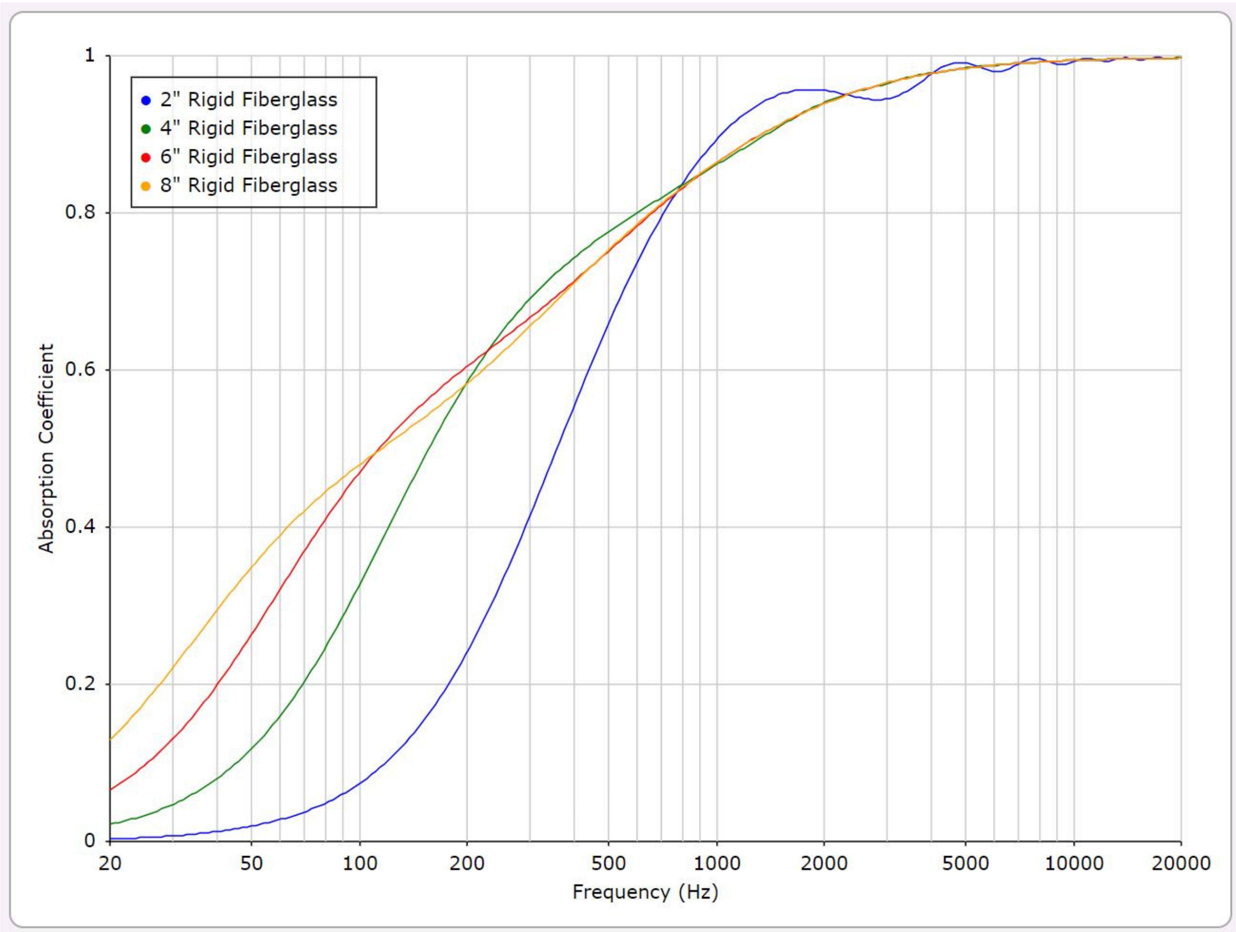
Example: Electronic circuits - If you want the most efficient energy transfer, impedances must be matched. Take an old RCA ribbon mic with a 50 ohm output impedance. The flattest frequency response results when the microphone is matched to a 50 ohm input transformant of a mic pre. The same goes for a piezoelectric contact pickup – matched to a very high impedance preamp >10 Mohms.

Sound vibrations in air, to be efficiently absorbed or controlled, need to be met with the same considerations.

The following charts show the modeling of several different types of absorption. Rigid Fiberglass, Lightweight Fiberglass, and composite absorbers.

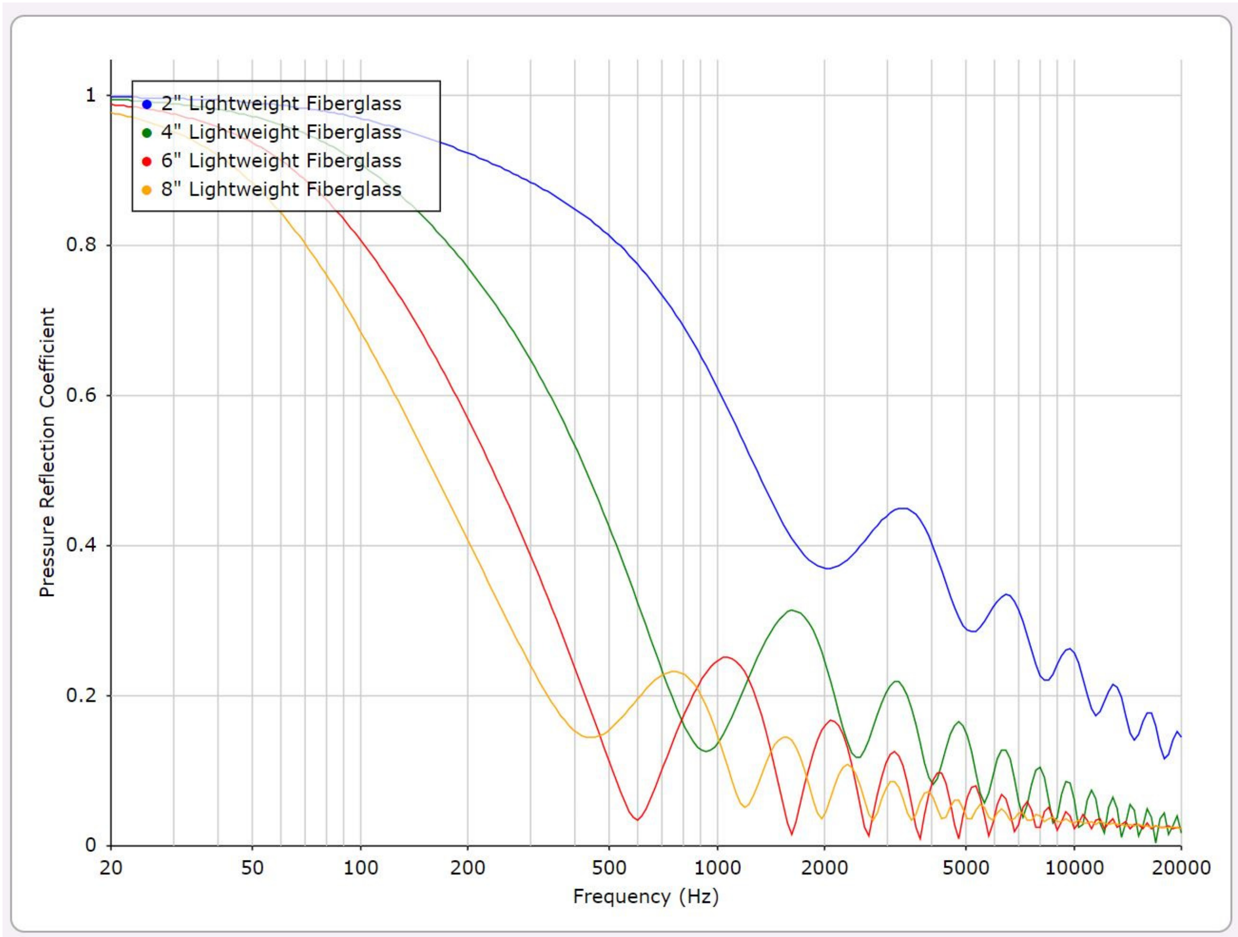


As shown above, the reflection coefficient of high-density glass/rock wool is rather high in the low frequency region. i.e.; Owens Corning 703

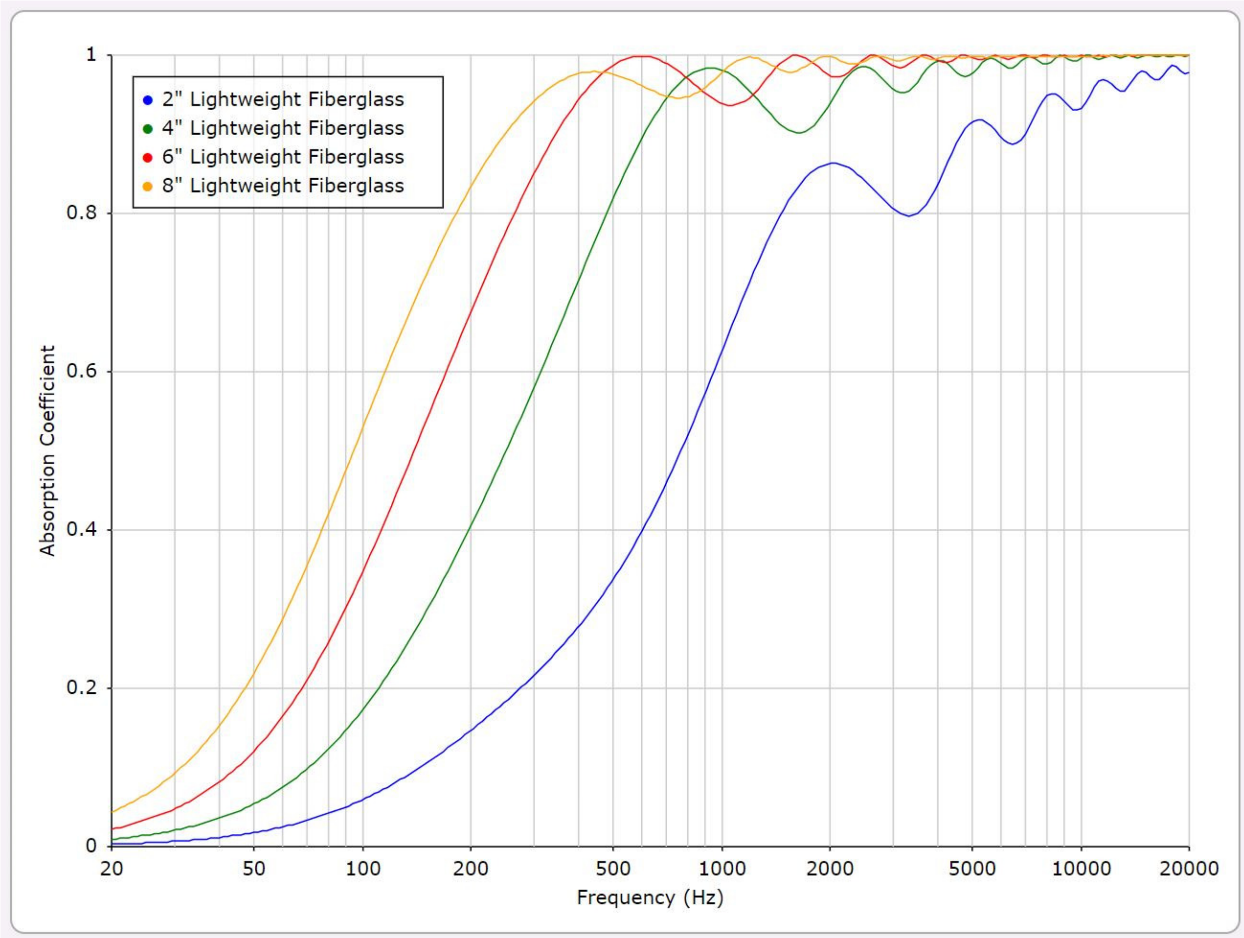


The absorption coefficient of the high density fiber is poor in the low frequency region. For conservative reasons, I never look below 0.6 (60% efficiency). 0.7 or 70% efficiency is my recommended cut-off point.

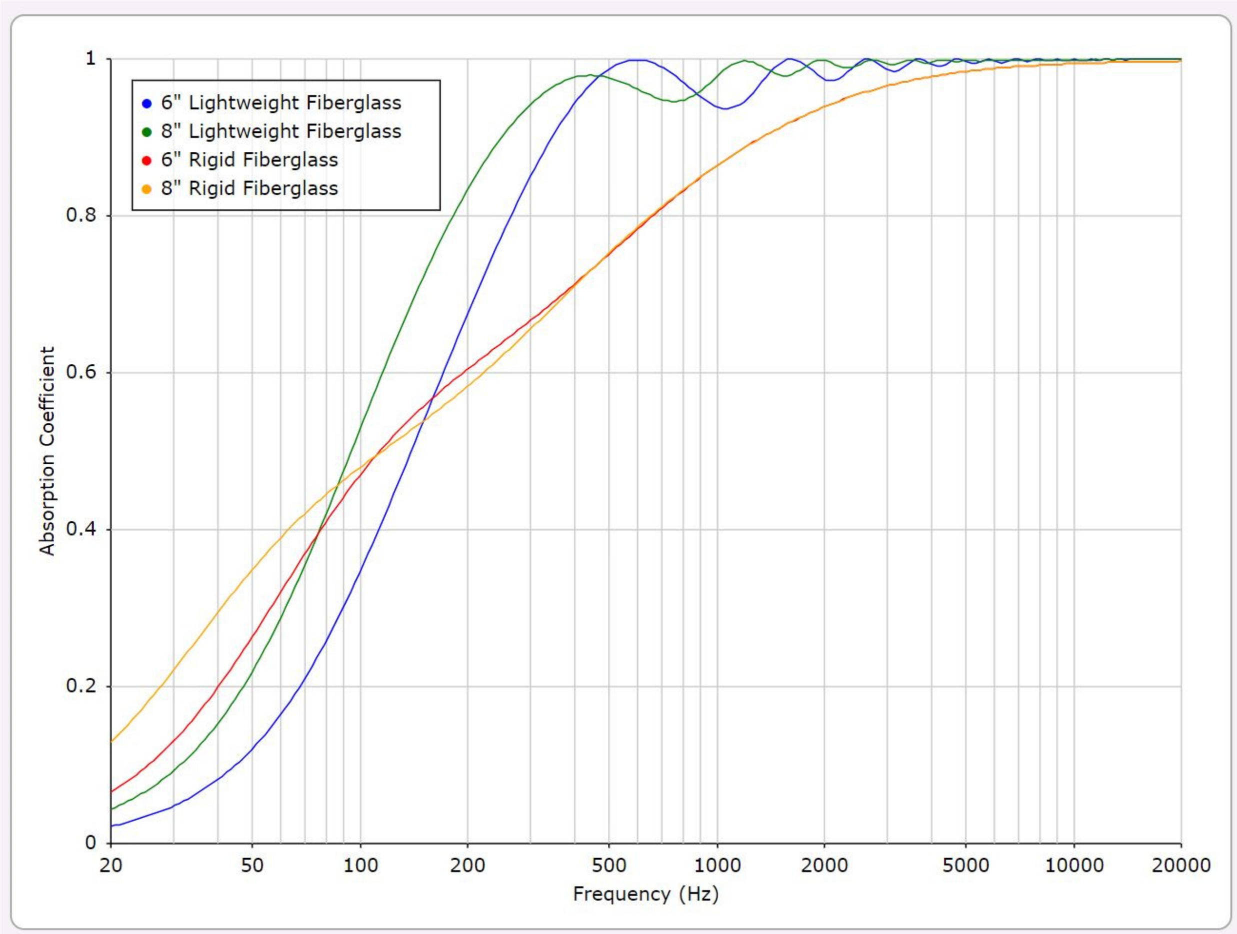
As thickness increases, low frequency absorption does not.



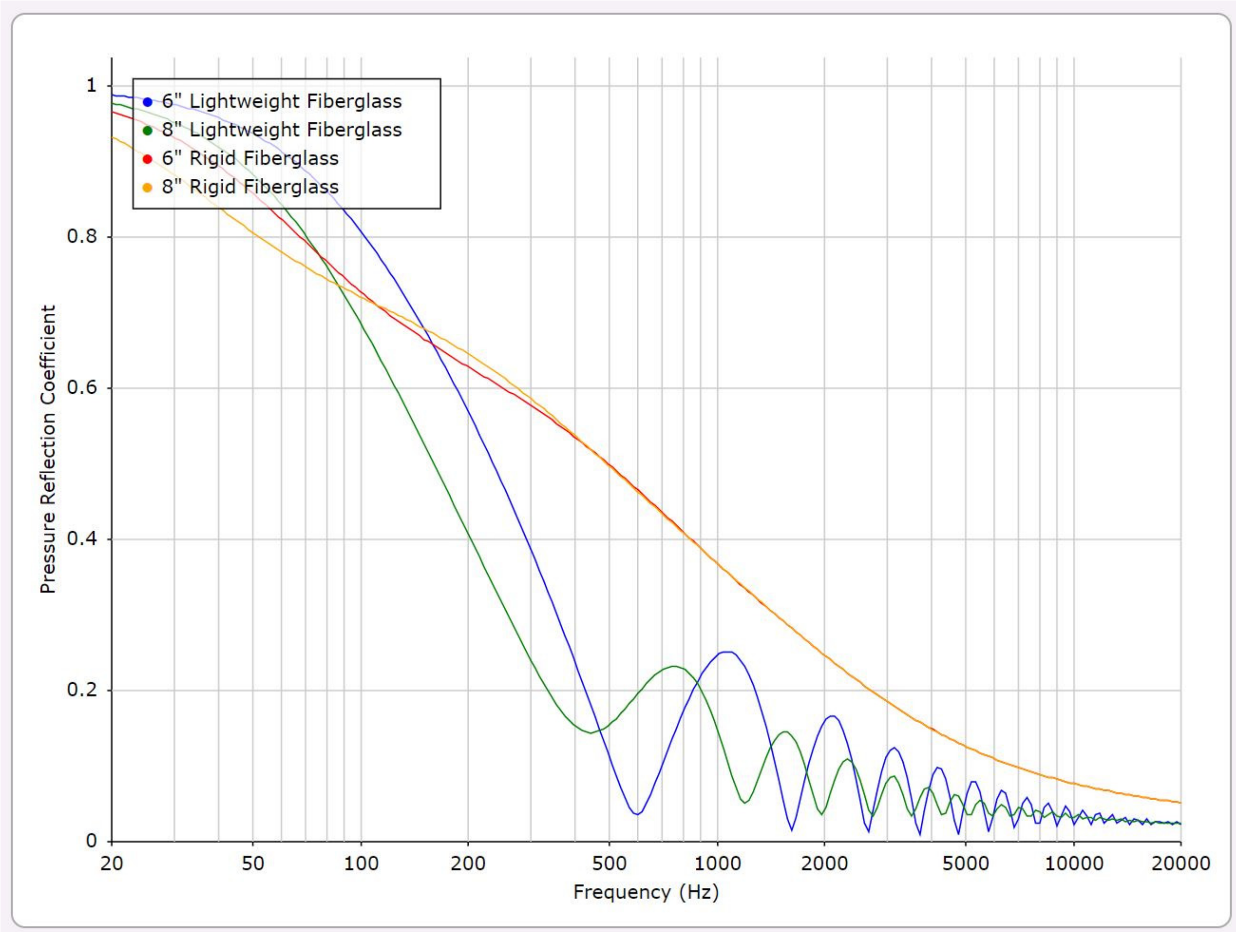
The reflection coefficient for lightweight fiber is shown above. Notice that as the thickness increases, reflections in the low frequency region decrease.



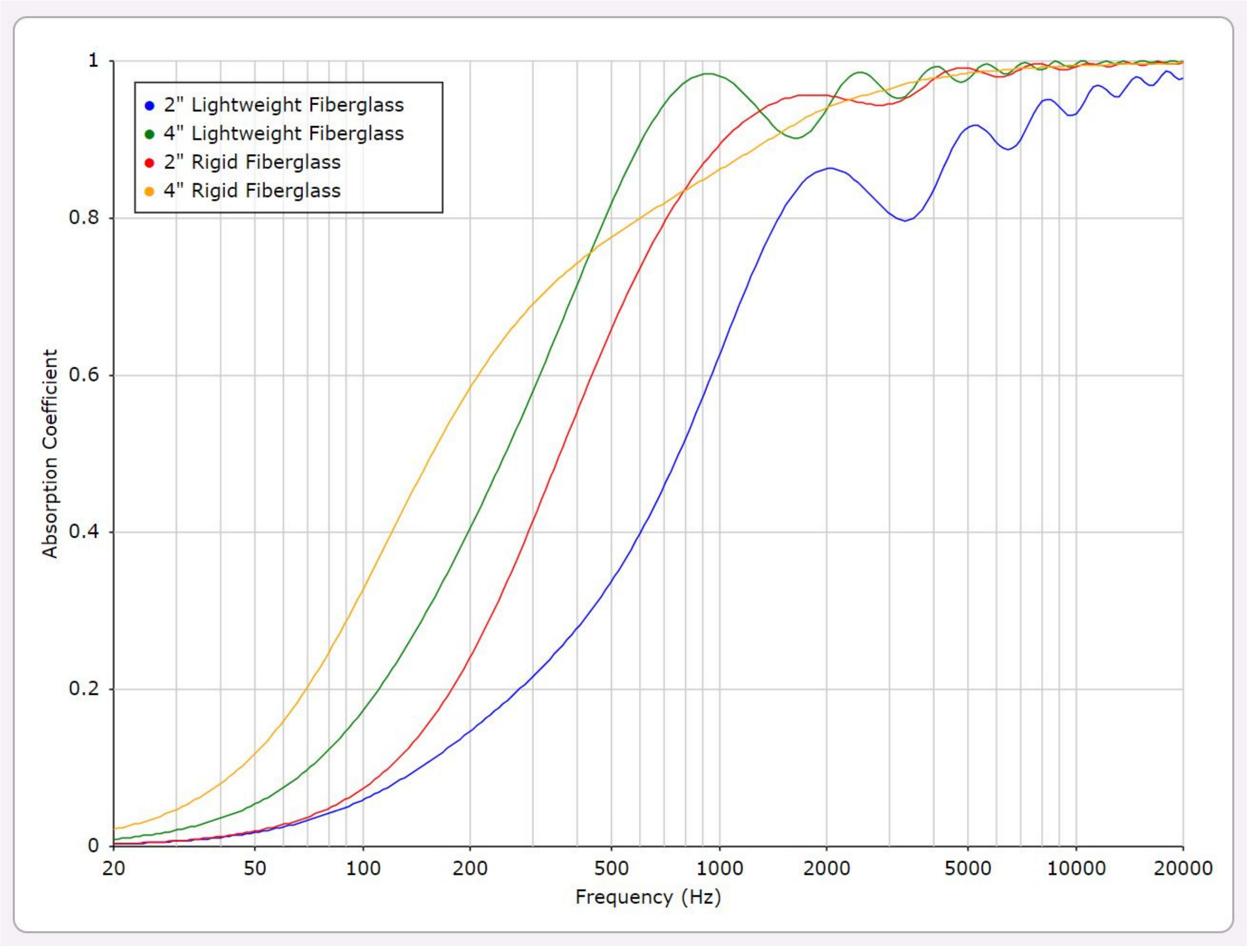
For lightweight fiberglass the absorption has a smoother, more natural roll-off. As thickness increases so does the low frequency absorption. i.e.; Owens Corning Pink (attic blanket)



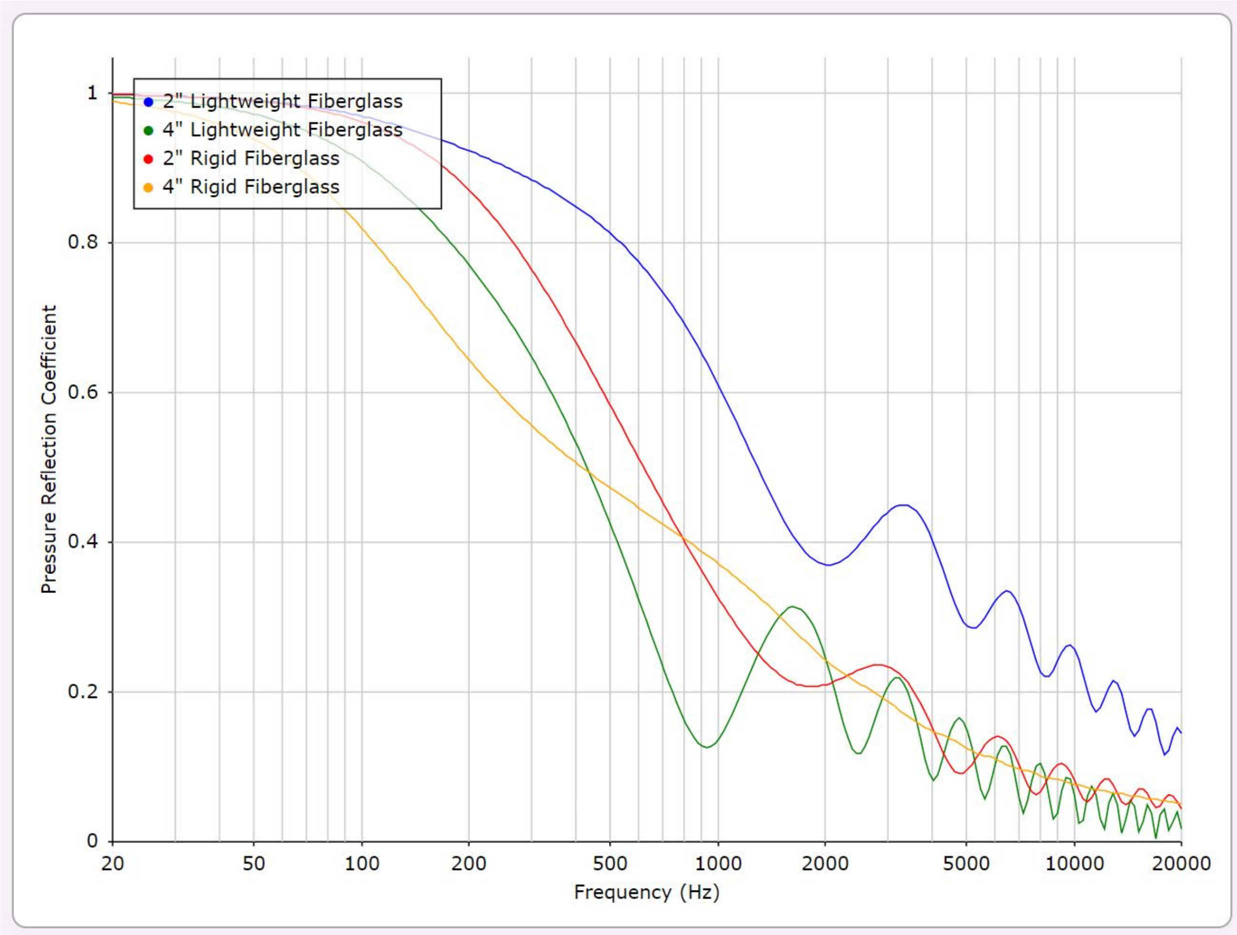
Thick Rigid Owens Corning 703 vs the Pink fluffy stuff - absorption. 70% efficiency; 8” Lightweight - 150 Hz vs 8” Rigid – 400 Hz.



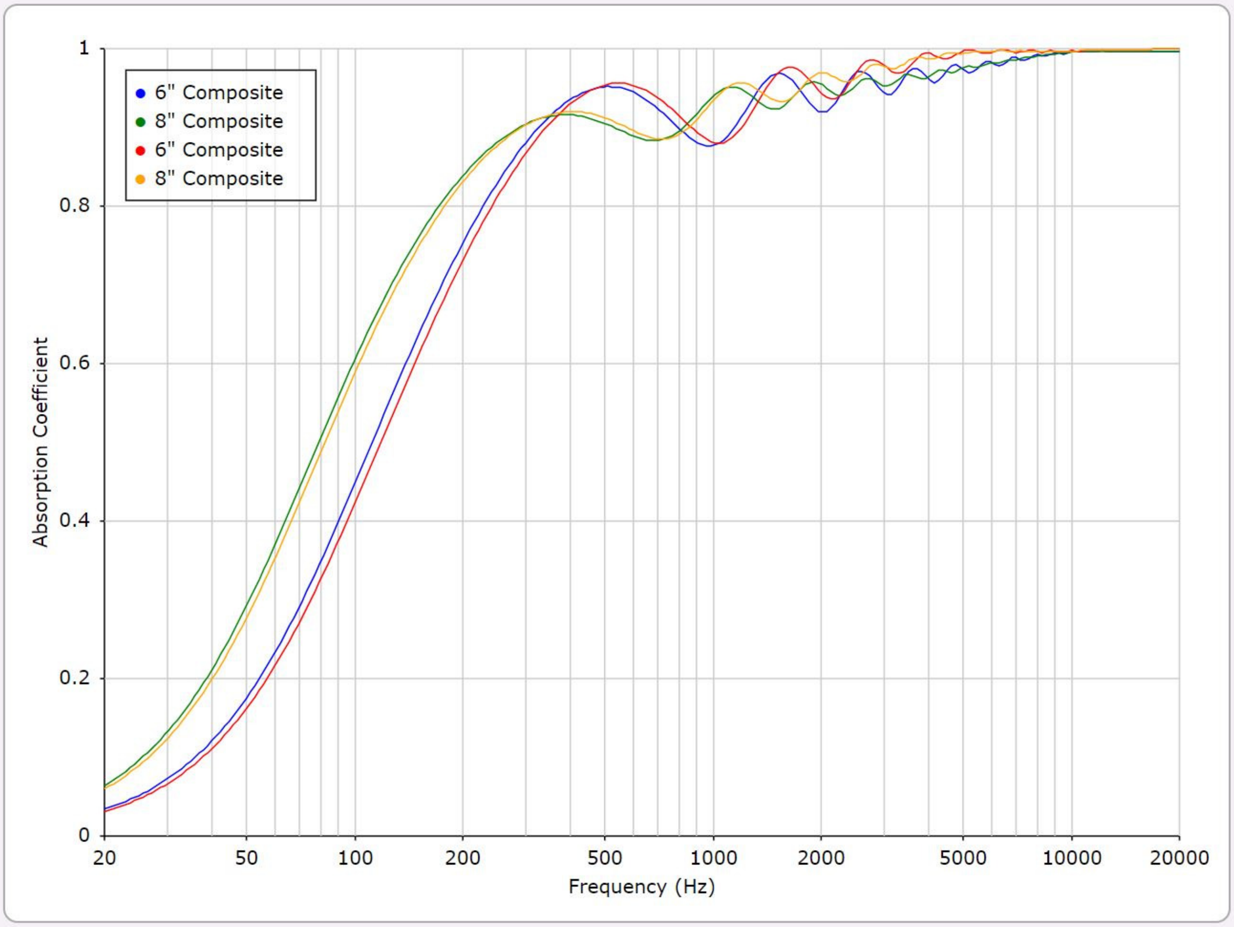
Thick Rigid Owens Corning 703 vs the Pink fluffy stuff – reflectivity.



Thin Rigid Owens Corning 703 vs the Pink fluffy stuff - absorption.



Thin Rigid Owens Corning 703 vs the Pink fluffy stuff – reflectivity.



Global Parameters

Air temperature: 20°C
Air pressure: 101325 Pa

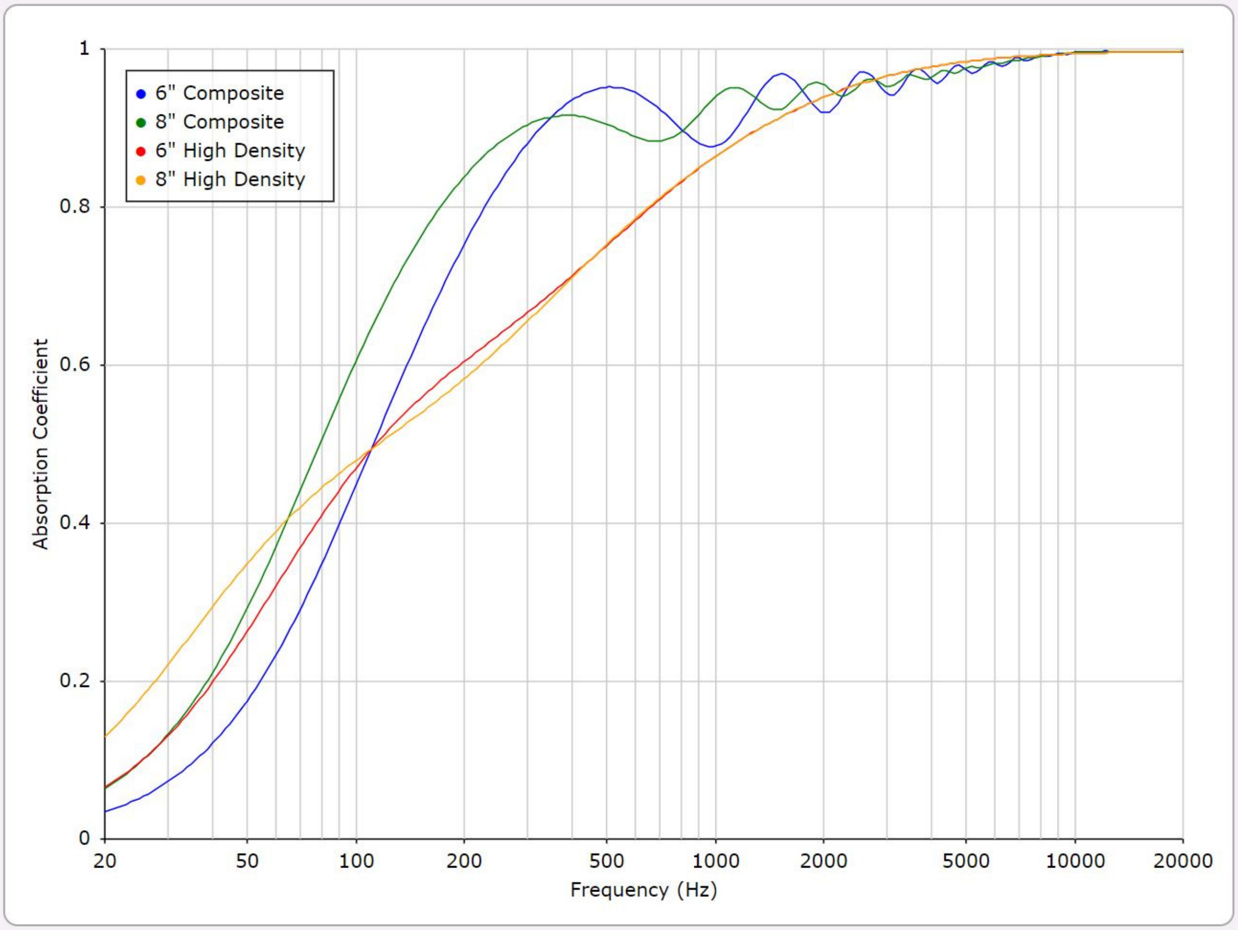
X Axis: Frequency
Range: 20Hz - 20000Hz
Scale: logarithmic
Resolution: medium

Angle of incidence: 0°
Porous model: Allard and Champoux (1992)
Helmholtz model: Ingard/Allard

Absorber Parameters

- Absorber 1 (6" Composite)
12.7mm Porous Absorbent, 24000 Pa.s/m^2
139.7mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 2 (8" Composite)
12.7mm Porous Absorbent, 24000 Pa.s/m^2
190.5mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 3 (6" Composite)
12.7mm Porous Absorbent, 3000 Pa.s/m^2
12.7mm Porous Absorbent, 24000 Pa.s/m^2
127mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 4 (8" Composite)
12.7mm Porous Absorbent, 3000 Pa.s/m^2
12.7mm Porous Absorbent, 24000 Pa.s/m^2
177.8mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing

Above is a graph of two type of composite trapping. Basically similar but the Blue and Green are missing the ½" layer of Polyester/Dacron batting (3000 Pa.s/m2).



Global Parameters

Air temperature: 20°C
Air pressure: 101325 Pa

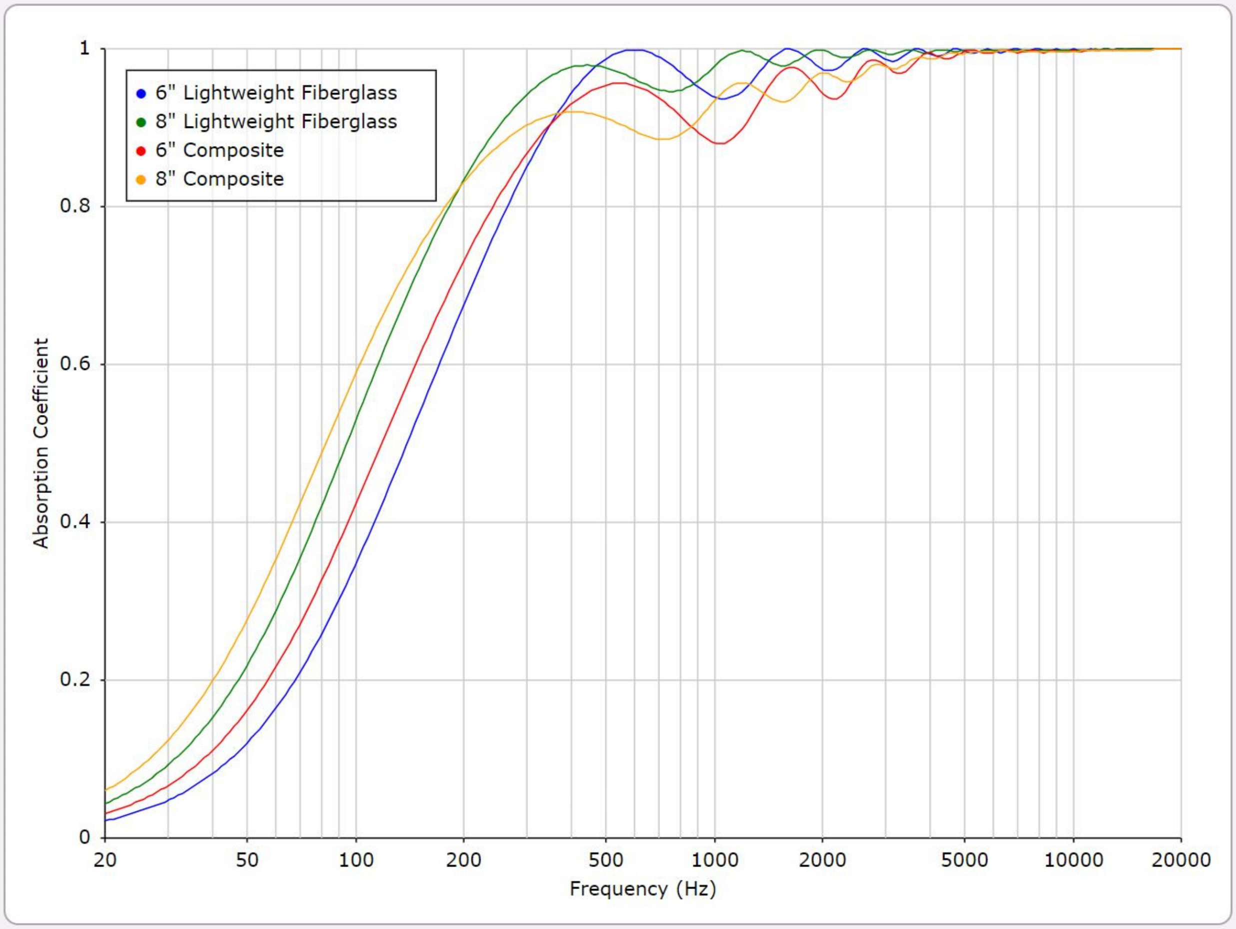
X Axis: Frequency
Range: 20Hz - 20000Hz
Scale: logarithmic
Resolution: medium

Angle of incidence: 0°
Porous model: Allard and Champoux (1992)
Helmholtz model: Ingard/Allard

Absorber Parameters

- Absorber 1 (6" Composite)
12.7mm Porous Absorbent, 24000 Pa.s/m^2
139.7mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 2 (8" Composite)
12.7mm Porous Absorbent, 24000 Pa.s/m^2
190.5mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 3 (6" High Density)
152.4mm Porous Absorbent, 24000 Pa.s/m^2
Rigid backing
- Absorber 4 (8" High Density)
203.2mm Porous Absorbent, 24000 Pa.s/m^2
Rigid backing

Here the Blue and Green are composites without Polyester vs Rigid



Global Parameters

Air temperature: 20°C
Air pressure: 101325 Pa

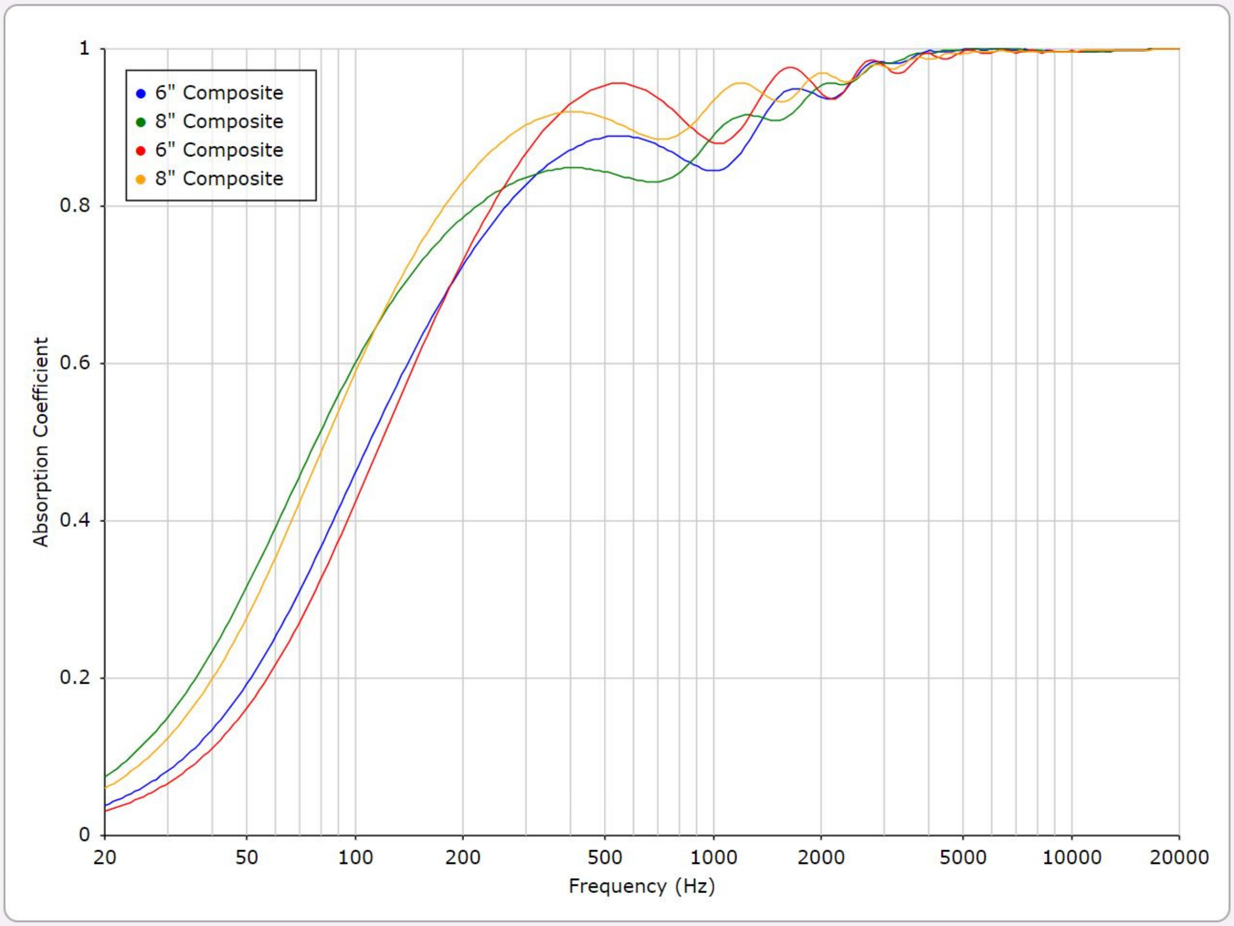
X Axis: Frequency
Range: 20Hz - 20000Hz
Scale: logarithmic
Resolution: medium

Angle of incidence: 0°
Porous model: Allard and Champoux (1992)
Helmholtz model: Ingard/Allard

Absorber Parameters

- Absorber 1 (6" Lightweight Fiberglass)
152.4mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 2 (8" Lightweight Fiberglass)
203.2mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 3 (6" Composite)
12.7mm Porous Absorbent, 3000 Pa.s/m^2
12.7mm Porous Absorbent, 24000 Pa.s/m^2
127mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 4 (8" Composite)
12.7mm Porous Absorbent, 3000 Pa.s/m^2
12.7mm Porous Absorbent, 24000 Pa.s/m^2
177.8mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing

Above, the Blue and Green are Lightweight Fiberglass only vs Composites with Polyester/Dacron as first layer. You can see how that the Composite beats Lightweight Fiberglass.



Global Parameters

Air temperature: 20°C
Air pressure: 101325 Pa

X Axis: Frequency
Range: 20Hz - 20000Hz
Scale: logarithmic
Resolution: medium

Angle of incidence: 0°
Porous model: Allard and Champoux (1992)
Helmholtz model: Ingard/Allard

Absorber Parameters

- Absorber 1 (6" Composite)
12.7mm Porous Absorbent, 3000 Pa.s/m^2
25.4mm Porous Absorbent, 24000 Pa.s/m^2
114.3mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 2 (8" Composite)
12.7mm Porous Absorbent, 3000 Pa.s/m^2
25.4mm Porous Absorbent, 24000 Pa.s/m^2
165.1mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 3 (6" Composite)
12.7mm Porous Absorbent, 3000 Pa.s/m^2
12.7mm Porous Absorbent, 24000 Pa.s/m^2
127mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing
- Absorber 4 (8" Composite)
12.7mm Porous Absorbent, 3000 Pa.s/m^2
12.7mm Porous Absorbent, 24000 Pa.s/m^2
177.8mm Porous Absorbent, 5000 Pa.s/m^2
Rigid backing

Above are similar models of Composite using 1” of Rigid vs ½” of Rigid.

Note that reflectivity is increased when the thickness of the Rigid is increased.

Conclusion:

Composite absorber construction is superior to mono-structure absorbers. It is the complex interaction of density vs the absorber position relative to a boundary. Also note that these structures will perform very differently when placed in the open or middle of the room. These models were done assuming attachment or position next too a room boundary.

Lightweight (10 – 15kg/m3) fiber out-performs rigid (40 – 60kg/m3) fiber past 4” thick.

70% efficiency =
2” Rigid performs to 550 Hz
4” Rigid performs to 300 Hz
6” Rigid performs to 350 Hz
8” Rigid performs to 350 Hz

2” Lightweight performs to 1.2 kHz
4” Lightweight performs to 400 Hz
6” Lightweight performs to 220 Hz
8” Lightweight performs to 150 Hz

6” Composite performs to 180 Hz
8” Composite performs to 125 Hz

For very deep trapping (to 40 Hz) we use a combination of wave guides, air, and composite trapping.

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