

## Perforated Liner Tuned Sound Absorbers

Efficiencies of typical sound absorbing materials varies at different frequencies. For example one inch of glass fiber is quite effective absorbing sound at high frequencies (above 2,000 Hz) but very inefficient absorbing low frequency sound. The use of thick layers of such materials e.g., six inches of glass fiber, is very common in low-frequency sound absorption applications. The issue is that the absorbing material takes up a large amount of space.

In many noise control applications, the noise occurs only in a narrow range of frequencies or even a single frequency. Noise generated by industrial machines/equipment mostly fall in this category. For such situations, it is possible to design a sound absorption system that is "tuned" to those targeted frequencies. By employing such a system, one can avoid the overuse of sound absorbing material and reduce the space needed to accommodate them. One of the most commonly used tuned absorber is Helmholtz resonator (HR).

Effective absorption of the sound requires the use of many small HRs spread over a large area rather than one large HR placed at one location. To avoid making and installing many individual enclosures, one can use a distributed Helmholtz resonator by enclosing a layer of air between a solid backing (which could be the walls themselves) and a perforated sheet/board (with the right number and size of holes) and an adjacent layer of sound absorbing material; see Figure 1. The offending narrow frequency sound generated by a machine can be absorbed effectively by covering the interior surfaces of the machine enclosure with panels fabricated in this fashion.

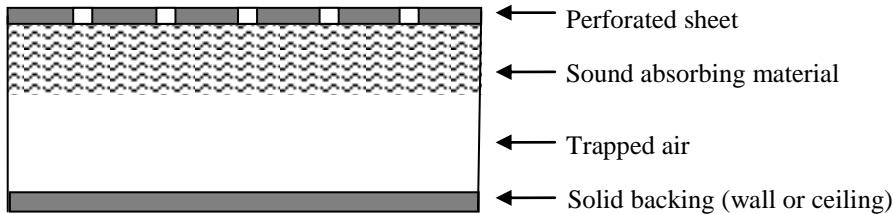


Figure 1 Make up of perforated acoustic liner

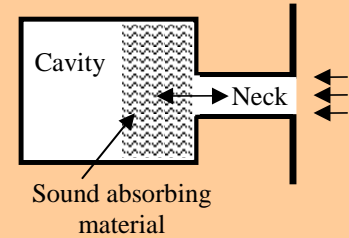
To demonstrate the absorption effectiveness of perforated tuned absorber, an enclosure with outside dimensions of 19x19x25.5 inches and wall thickness of 3/4 inch is lined with perforated acoustic liners tuned to around 430 Hz. A loudspeaker, mimicking the noise source, is located inside the box. A microphone located outside the box at 25 inch distance is used for measurements. In all the tests, the loudspeaker is driven by a random noise and the pressure of sound emitted from the box was measured by the microphone. The frequency response functions mapping the voltage driving the speaker in the box to the scaled pressure measured outside the box are evaluated for all tests.

Frequency response functions of Figure 2 depict the results of the tests for the box a) untreated, (black/dotted line), b) treated with 2 inches of glass fiber sound absorbing material (blue/dashed line), and c) treated with perforated absorber panels tuned to around 430 Hz (red/solid line).

Comparing black/dotted line with blue/dashed line traces in Figure 2 clearly indicates that the addition of 2 inches of plain sound absorbing material (glass fiber) does not dissipate low frequency sound, appreciably. Extending the comparison stated above to the red/solid line trace in Figure 2, shows the effectiveness of the perforated acoustic liner in terms of dissipation of acoustic energy in the narrow frequency range centered at the tuned frequency of 430 Hz.

High absorption efficiency of perforated acoustic liners at the vicinity of their tuned frequency make them highly attractive in acoustic treatment of machinery enclosures, fan generated noise, lining mufflers, and aerospace applications.

**Helmholtz resonator (HR)** is comprised of a cavity (acting as a spring) and a neck through which the air (acting as mass) travels back and forth between the cavity and the external medium; see the figure. Frequently a layer of sound absorbing material is also added in the cavity, next to the neck.



The cavity and neck combination, resemble a spring mass combination, and as such have a *resonant frequency* determined by the mass of the air in the neck and the springiness of the trapped air in the cavity; the whistle caused by blowing in a bottle is a tone at this frequency. At resonant and neighboring frequencies, the air moves vigorously in and out of the cavity, through the sound absorbing material causing the acoustic energy of the air to be converted into heat (dissipated).

Tuning the resonant frequency of a Helmholtz resonator to an offending narrow frequency noise, dissipates the energy of that noise.

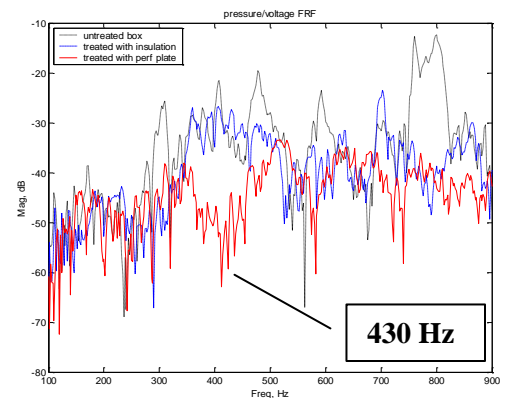


Figure 2 Frequency response functions indicating absorptions with different acoustic treatments