Recording Studio Room Acoustics and Helmholtz Resonators

Trying to build an effective recording studio can be a frustrating experience because of acoustic problems. Things just don't seem to sound right. Recordings seem to sound muddy or cloudy. A primary reason for this is the tendency for rooms with small dimensions to have severe colouration in the mid bass or upper low frequency region. Coloration is a result of standing waves or resonances in a room.

Unfortunately smaller rooms have dimensions that favour standing waves or resonances that are right in the fundamental range of voice and many musical instruments where our hearing is much more sensitive and critical than at lower frequencies. Also unfortunate is the mistaken belief that the use of materials such as foam acoustical tiles and fiberglass can solve these colouration problems. The worst coloration problems are caused by frequencies around 300 Hz and below.

In smaller rooms the most noticeable build up often occurs between about 100 and 300 Hz. While foam tiles and fiberglass are excellent absorbers at higher frequencies they become increasingly less effective below about 1000 Hz. Often times trying to use foam tiles or fiberglass to cure a bad sounding room actually aggravates the problem and results in a very dead sounding room with a lose of the natural clarity and sparkle of voice and instruments. A very dead room is not a very pleasant recording or listening environment and often seems to require excessive amounts of EQ with the resulting recordings still lacking in clarity and presence.

So how to control coloration without making the room too dead? Bass traps or low frequency absorbers are commonly used in professional recording and broadcast studios and can be constructed for use in small studios. A very effective and easy to build bass trap is the slat-type Helmholtz resonator. These can be designed to absorb the offending frequencies causing colouration problems while at the same time reflecting and diffusing the higher frequencies contributing to a very natural sounding acoustical environment for recording and mixing.

A simple example of a Helmholtz resonator is blowing across a bottle to produce a tone. Changing the volume of the airspace within the bottle changes the pitch of the tone. Likewise changing the enclosed volume of the airspace inside the Helmholtz resonator bass trap changes its working frequency.

A slat-type Helmholtz absorber is simply a six sided box with openings or slots on its front side to couple the enclosed volume of the airspace in the box to the air in the room. The depth of the enclosed airspace in the box behind the slots and the width and depth of the slots control the resonant frequency of the bass trap.

Slat-type Helmholtz absorbers are very easy to design. The formula for calculating the absorber's resonant frequency is:

$$f = 2160 * sqrt (r / ((d * D) + (r + w)))$$
Where:
f = resonant frequency of the absorber in Hertz (Hz)
r = slot width in inches
w = slat width in inches
d = effective depth of slot in inches (1.2 x the actual thickness of the slat)
D = airspace depth (depth of box behind the slots) in inches

You can use a spread sheet such as Microsoft Excel to model various dimensions and tunings for slat-type Helmholtz absorbers. This can be very useful as you can easily see how changing any dimension changes the tuning of the absorber.
The formula for determining the fundamental frequency of a standing wave for a particular room dimension is:

$$fo = V / 2d$$
Where:
fo = Fundamental frequency of the standing wave
V = Velocity of sound (1130 feet per second)
d = Room dimension being considered in feet (length, width, or height)

Other standing waves occur at harmonics of the fundamental frequency - that is 2, 3, and 4 times the fundamental. Thus a room with an 8 foot ceiling has standing waves forming at 70 Hz (the fundamental frequency or first harmonic), 140 Hz (the second harmonic), 210 Hz (the third harmonic) and 280 Hz (the fourth harmonic). As mentioned earlier, rooms with smaller dimensions often have standing waves or resonance build ups that are very noticeable causing colouration at around 200 Hz or so.

For example, building a box with an airspace depth of 4 inches using wood slats 1/2 inch thick and 2-1/2 wide results in a box tuning of about 240 Hz. In practice it is not usually necessary to be extremely exact with the tuning frequency. Being in the ballpark will often work very well. In fact many slat-type bass traps are designed with slots of varying widths (perhaps plus or minus 1/16 to 1/8 inch of the design centre frequency) to cover a wider band of frequencies. Also loosely lining the inside of the box with materials such as fibreglass widens the bandwidth (lowers the Q) of the absorber.

Building and mounting multiple units perhaps with slight variations in tuning can also improve the control of colouration. Mounting multiple units throughout a room improves absorption effectiveness and promotes diffusion of higher frequencies.

Click on this link then choose Save to download a spreadsheet for Microsoft Excel that will calculate Helmholtz resonators such as discussed here.

viewed best with a computer !