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ACOUSTOLOGY (A monthly column by our Chief Engineer, Jeff D. Szymanski)

This month: "*How Low Can You Go?*"
Bass Trap Fact and Fiction Part 1

Bass "traps" or – more technically correct – "low frequency control devices," are one of the most important considerations for small room acoustics (home studios, home theaters, recording rooms, etc.). Without good low frequency control, mixes might sound "muddy" (too much bass) or "thin" (not enough bass). Recordings could have weird resonance "bumps" or cancellation effects (sometimes described as "hollowness").

Effective low frequency control can smooth things out. After treating with effective bass traps, the bass you hear is the true bass from the recording or mix. In mixing, the guess-work is minimized and mixes translate to other systems much better. To better understand how this works – and why we all need bass traps – it is necessary to understand why low frequencies are such a challenge for small rooms.

(Uh-oh, here comes the math...)

All rooms have a certain distribution associated with low frequency standing waves, also known as "modes." Modes are the resonant frequencies of the room governed directly by the dimensions of the room. The math for figuring out the modes of a room is actually quite simple:

$$\mathbf{mode = (c/2)*[(nx/Lx)^2 + (ny/Ly)^2 + (nz/Lz)^2]^{1/2}}$$

OK. So it might not look *that* simple. But when you consider:

c = 1130 ft/sec (speed of sound in air)

nx, ny, nz = room mode numbers, n is an integer ≥ 0

Lx, Ly, Lz = room dimensions in feet

then things look a little better. Still not convinced? No problem. Simply go to www.studiotips.com. They have a download section that contains quite a few room mode calculators, including a spreadsheet put together by yours truly!

The mode numbers define whether a mode is "axial," "tangential," or "oblique." An axial mode is a standing wave between two surfaces in the room. A tangential mode is a standing wave traveling around four surfaces in the room. An oblique mode is a standing wave traveling around all six surfaces of a room. Examples:

(1,0,0) is an axial mode.

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(0,2,1) is a tangential mode.

(2,3,4) is an oblique mode.

Some illustrations of the sound pressure distribution in the room for different types of modes, i.e., the areas of high pressure and areas of low pressure, or, areas of "boom" and areas of "thin," can be found at:

http://ceae.colorado.edu/~muehleis/classes/aren4020/handouts/animations/standingwaves.html

There are also various texts, including the Master Handbook of Acoustics by F. Alton Everest that can help you understand the concept of modes more completely.

Finally, the distribution of the modes in small rooms – defined as (usually) smaller than about 25'x25'x10' or so – is going to affect the way low frequency sounds are perceived in the room. The smaller the room, the more "spread out" (i.e., worse) the distribution will be. A small cube (e.g., 8'x8'x8') is the worst case: Modes are so widely spaced that a small handful of low frequency build-ups and cancellations are detrimental to good sound production or reproduction in the room.

Having established the behavior of low frequencies, let us try and sort out truth from reality:

Fiction: **Bass traps suck out all the low-end in a small room.**

Fact: **Bass traps flatten the low frequency response in a small room.**

When you consider that the low frequencies create areas of pressure build-up and cancellation in the room, the audible result is dependent on where you are seated in the room and where the loudspeakers are placed. In a control room, you might have the listening position set up so that one series of modes cancels there and another series builds-up. There are tools you can use to figure out what the net effect will be considering the placement of you and your loudspeakers. A discussion of these tools is a bit beyond the scope of this column. Suffice to say that you may notice "less bass" or "more bass" than is really there in certain recordings or mixes.

Going back to the illustrations cited above, you might have noticed that pressure build-up is always present in the corners of a (rectangular) room. Since the areas of build-up and the areas of cancellation are "joined at the hip," treating one will treat the other. Hence, corner bass traps do not "suck out" all the low frequencies in the room. Corner bass traps absorb the energy build-up in the room, thereby minimizing the areas of build-up ***and*** cancellation. The net effect is – at a listening position – the bass you hear is the bass that your loudspeakers are producing, with fewer room artifacts. The "boom" is reduced and the "thin" is beefed up. And the better the low frequency control, the less the effect of the room will be for recording, mixing or listening to bass.

Fiction: **Corners that are not right angles (i.e., not 90°) are better for low frequency sound.**

Fact: **Low frequencies do not care what shape the room is; they will still cause problems.**

I could cite quite a few studies on this going back to about the 1940s. Most recently, Philip Newell discusses it in his books. The fact is that unless you have some really complex computer modeling software at your disposal, you are not really going to be able to tell if your angles are "good" or "bad" until you build the room. There are some "short-cuts" you can use for rectangular modeling wherein you average the dimensions. However, that is really just "throwing a dart." The best suggestion? If you choose to pursue non-rectangular room design, angle the walls with high frequency control in mind – not low frequency control. Angling minimizes high frequency effects like "flutter echoes" and "rings." This is good and a good angular wall design will certainly minimize these types of problems. However, no matter what your corners look like, you should plan on incorporating low frequency control into the room.

Fiction: **Bass traps cannot work effectively at all low frequencies.**

Fact: **Good traps will improve all aspects of the recording/mixing/critical listening process.**

As explained above, since the energy of room modes is absorbed, the low frequency sound you will actually record/mix/listen to is only being influenced by your gear – not your room. This will allow you to be much more productive and enable you to trust your mixes once they leave your room.

Next month: *The Low frequency response of loudspeakers* and *Specific low frequency devices and what they can (and cannot) do.*