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Subject: Midhorns and boundary loading

Posted by [Wayne Parham](#) on Tue, 18 Aug 2009 15:08:25 GMT

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outdoors. When used indoors, you can usually use a smaller horn.

I've found that horns designed for use below 300Hz are able to get boundary loading in small rooms, even if not directly placed in a boundary. The simple fact of using them indoors provides something similar to boundary loading. I think it is partly due to the fact that the room influences directivity by being a constrained space, and perhaps also partly because of room modes. In a sense, that's saying the same thing, they're flip sides of the same coin.

I've found that boundary loading in small rooms is different than what a simple model can describe. Again, the reason is probably the combined condition of room modes and the fact that all the boundaries are affecting the horn, not just the closest ones. This is in effect saying the same thing, but to visualize the situation, I think it helps to picture what's happening.

The reason boundary loading works is really one of directivity, it's due to the fact that the room boundaries act as extensions of the horn. If in an infinitely large trihedral corner, then the radiation pattern could never exceed 90° so it is in effect a very large conical horn, with the loudspeaker sitting in its throat. A horn in the loudspeaker acts as part of the throat, setting the radiation angle at high and maybe mid frequencies and the walls of the room setting the angle at low frequencies. The same thing happens in quarter-space or half-space, but just with a larger radiating angle.

When you put a speaker in a room of finite size, the adjacent and opposing boundaries have an effect on the radiation pattern too. The larger the room, the lower in frequency there is an effect and if large enough, it's out of the audio passband, in effect, the same thing as outdoors. But that takes a really large room to act the same as freespace. The smaller the room gets, the more effect adjacent and opposing boundaries have on the radiation pattern, the energy distribution in the room.

The frequency that marks the upper end of the range where the room boundaries have this kind of influence is called the Schroeder frequency. Above that point, the walls still reflect sound but the standing wave modes formed by these reflections are grouped so tightly together you can't tell them apart. Above the Schroeder frequency, the acoustic field is said to be reverberant and below it, it's modal. The only real difference is the distance (in frequency) between modes, whether you can clearly define them or not, or if instead they blend into a continuum.

When a speaker is placed in a room, the walls contain most of the acoustic energy in the room. Some goes through the walls or out passages and some is absorbed but most stays in the room. This is, in effect, modifying the directivity of the loudspeaker, in fact, by quite a large amount. It is no longer radiating omnidirectionally or whatever pattern it would do outdoors. The shape and size of the sound field is controlled largely by the room boundaries, which hold it in. So a horn placed in a room is radiating into an environment that is (much) smaller than free-space or even half-space, and at frequencies below 300Hz, this translates into what works like boundary loading,

even if the horn is not sitting in a corner or against a wall.

Pattern flip is an issue that happens at low frequency, below the point where the horn gains directivity control. At low frequencies, the mouth exit works like a diffraction slot. At higher frequencies, the wall angle sets the pattern. So if you make an asymmetrical horn, you may want to consider mouth dimensions to see if it is large enough to set the pattern in the desired passband.

There are competing priorities with regard to vertical spacing and mouth side. A taller horn will control the vertical pattern lower in frequency, but it will also cause the vertical nulls to come closer together. You'll want to make sure that the forward lobe is positioned where you want it to be and that the nulls do not fall where listeners might be. The position of the forward lobe, the upper and lower nulls and the secondary lobes are all set by the size, shape and position of the horns/drivers and by the crossover frequency and phase.