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Practical Acoustic Treatment, Part 4

Tips & Techniques

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More In This Series:
Part 1 (Jul 1998)
Part 2 (Aug 1998)
Part 3 (Sep 1998)
Part 5 (Nov 1998)

PRACTICAL ACOUSTIC TREATMENT

PART 4: Continuing his quest for the perfect listening environment, PAUL WHITE looks at ways to treat a control room without having to bring in the builders. This is the fourth article in a five-part series. Read Part 1, Part 2, Part 3 and Part 5.

Over the past couple of months, I've looked at some of the techniques that can be used to vary the reverberation time of rooms at different frequencies. To apply this information in a meaningful way, it's necessary to understand what happens to sound within a control room. You also have to understand that sound absorbers are only one of a number of tools for controlling room acoustics -- in addition, you have to take into account sound scattering (or diffusion) and placement of key items within the room.

The source of all the 'wanted' sound in your control room is the loudspeaker system, so it makes sense to start by considering what happens to the sound after it leaves the speakers. At mid and high frequencies, monitor loudspeakers have a reasonably controlled directivity. As a broad generalisation this means that most of the sound emerges as a cone of energy from the front of the box. However, this cone widens as frequencies get lower, until at very low frequencies, the speaker cabinet is effectively an omnidirectional radiator with as much energy coming out of the back and sides as out of the front.

However, attempting to absorb all the sound that misses the listener and instead hits a room surface is generally impractical and undesirable. There are designs for studios that are virtually anechoic chambers, but most people find them oppressive to work in -- a completely absorbent control room renders speech very dry and quiet as there are no wall reflections to give it life. Also, because so much energy is being absorbed, you need a very powerful monitor system to get the desired sound level.

TIME FOR REFLECTION

In a normal music listening environment, sound coming from the speakers is reflected from the walls and other surfaces in ways that can be both musically constructive and destructive. So the secret of good control room design is to try to avoid the wrong type of reflections, while encouraging and controlling the right type. A well-diffused reverberation with an RT of around 0.3 seconds is generally considered to be about right for professional control rooms, though the project studio might get away with a slightly longer RT. Well-diffused, spectrally neutral reflections, arriving very shortly after the original sound, tend to fuse with it and increase its subjective level. However, these reflections should be at least 10dB lower in level than the direct sound for the best results, which usually means avoiding reflections that originate from surfaces close to the speakers themselves. It also means avoiding reflections from materials that only reflect a part of the audio spectrum. Longer delays caused by reflections in larger rooms (over 40 milliseconds) are audible as slap-back echoes and are clearly undesirable. This would correspond to a front-to-back room distance of around 20 feet (6 metres).

SPEAKERS CORNER

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It helps to understand what's going on if we split the audio spectrum into two bands. In a typical room, frequencies up to around 300Hz are mainly influenced by room modes and by the physical position of the monitors within the room. At higher frequencies, most of the problems are associated with multiple reflection paths. Looking at the loudspeaker position first, you can see from Figure 1 (on page 192) that if a speaker is positioned on a stand somewhere out in the room, sound from the back and sides of the cabinet will hit the side and rear walls of the room and then reflect back into the room. This is known as the speaker boundary effect. The best way to imagine what effect the reflected sound will have is to visualise the walls covered with mirrors. Everywhere you can see a reflection of the monitor, a phantom sound source will be created. Because controlling the right type."

the walls aren't perfectly reflective to sound, and because the sound radiating from the sides and back of the speaker is mainly at low frequencies, the phantom sources are effectively low-pass filtered so that only low frequencies come back. These low-pass filtered reflections combine with the direct, low-frequency energy from the front of the speaker as shown in Figure 2, above. Because of the distance the reflected sound has to travel, it will never be exactly in phase with the direct sound. But at very low frequencies, where the wavelengths are long, they're sufficiently in phase to cause some constructive addition.

In simple terms, this means that putting a speaker close to a solid wall will cause an increase in bass energy, as some of the low-frequency energy normally lost from the back of the cabinet is reflected back to the listener. As the frequency increases, the path length difference between the direct and reflected sound will correspond to a different number of wavelengths, so that at some frequencies the direct and reflected energy will add, while at others it will cancel. That's why the graph shown in Figure 2 shows a series of ripples in the amplitude response.

If the speaker is placed close to a corner, reflections from both the rear and side walls combine to produce a greater bass rise and more pronounced ripples in the low frequency response. If the floor reflections are also included, the bass rise can be very significant. While some users might view this as a simple way to get 'free' extra bass, the deep ripples in the low-frequency response can lead to problematic hot spots and dead spots in the bass end. The only way to avoid this is to keep monitor speakers away from corners and to try to randomise the distances between the speaker cabinet and the nearby room boundaries. That's why in small studios, it's often best to place the monitors along the longest wall and away from the corners, rather than along the shortest wall, nearer to the corners. If the speakers are placed exactly the same distance from the rear wall, the side wall and the floor, the bass boost can be up to 18dB at very low frequencies with huge ripples extending into the bottom couple of octaves of the monitor's response.

The only practical way to utilise the rear-radiated energy from the speaker cabinet without incurring phase difference problems is to actually mount the speaker monitor flush with the room boundary. That's why so many large studio monitoring systems are built into the front wall. This way, all the low-frequency energy is forced to radiate into a 180-degree space rather than being allowed to radiate into a 360-degree space. Also, because there is no distance between the monitor and the boundary, there is a near perfect doubling of low-frequency efficiency with no ripples. To obtain a flat frequency response from flushmounted speakers, the monitors themselves must be designed with a corresponding drop in low-frequency efficiency so that the net result is flat.

By contrast, speakers made for standmounting are designed on the assumption that the boundary will be some distance away, which is why many manufacturers include advice on the positioning of their monitors relative to walls. It's also for this reason that some active monitors include bass-end tailoring controls to help compensate for the effects of positioning.

Because a standmounted speaker invariably produces some peaks and dips in the low-frequency response curve, it can be helpful to use a studio design software program such as *AcousticX* (see last month's instalment of this series for more on this) to determine the optimum speaker placement within the room. This particular PC program also shows the size and position of the optimum listening area.

GEOMETRY

Positioning speakers optimally with respect to the room boundaries will minimise low frequency response anomalies, but it is also necessary to minimise the level of any early reflections due to the sound from the front of the speaker striking a nearby surface and reflecting back to the listener. In a professional studio with flushmounted monitors, this is often done by combining areas of absorption with wall and ceiling geometries carefully planned so that any reflections that can't be avoided are deflected away from the listening position. This is rarely practical in the project studio, especially where standmounted monitors are in use, but it is possible to position areas of relatively simple mid/high-frequency absorber on the walls and ceiling to intercept the strongest reflections. Figure 3, on page 194, shows areas of foam acoustic tile on the side walls and ceiling that do this job very simply and cheaply.

If you're not sure exactly where to place these, get a friend to hold a mirror against the studio wall. When you can see the reflection of the monitor in the mirror from your normal listening position, you have the location of the centre of your acoustic tile. An area of one square metre of tile per side wall is generally quite adequate, but use the thickest type you can get, as it will be effective to a lower frequency than the thinner type. Something around 100mm thick is ideal. Do the same for the ceiling.

LIVE AND LET DIE

This approach to minimising strong early reflections is part of the so-called live-end/dead-end control room design philosophy which, despite a few changes, still prevails in modern control room design. The speakers are located at the dead end of the room (inasmuch as the front of the room is designed to produce minimal early reflections), and the rear of the room is designed to scatter reflected energy back into the room in a way that's as random and well-diffused as possible. What you don't want to end up with

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is a solid, flat, back wall that reflects the sound of the monitors back at you as a coherent echo. Design strategies include angled sections of the rear wall, semi-cylindrical constructions and purpose-made diffusers.

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This live-end/dead-end approach has to be modified further for small studios, because in rooms where there isn't a lot of front-to-back distance, it isn't generally possible to break up the rear wall reflections sufficiently. Because of the small distances involved, the reflections may be stronger than desirable. In such cases, it is common to employ a mixture of heavy trapping and diffusion on the rear wall. For example, a barrier-mat covered Rockwool trap around 200mm deep may be constructed with a further layer of 50mm acoustic foam on the front surface to prevent high-frequency energy reflecting from the barrier mat. This form of trap construction is shown in Figure 4, on page 196.

To introduce some scattering, randomly spaced wooden slats could be fitted over part of the surface of the trap, though a more pragmatic solution for the private studio might be to use the rear walls to accommodate shelving for tapes, computer disks, manuals and so on. Shelves full of assorted objects provide excellent sound scattering, and if you have a soft sofa for your clients, place this along the rear wall where it will do the job of some of the trapping.

When it comes to positioning other trapping that may be required, the main thing to bear in mind is to keep the room as acoustically symmetrical as possible. Bass traps tend to be fitted into corners as this is where the main room modes are anchored. In a simple setup, two rear corner traps may be all that's needed with the area in between them taken up by scattering surfaces such as shelving. If larger monitors are being used and the boundary reflections are causing problems, it may also be desirable to fit bass traps in the front corners or directly behind the monitors. However, in a typical project studio using suitably chosen nearfield monitors, it's often possible to get away with little or no bass trapping other than that provided by the furnishings.

SOUND SCATTERING

Sound scattering, sometimes called diffusion, is the mechanism of breaking up reflected sound so that the energy is returned to the room evenly dispersed rather than as a solid, coherent echo. A properly designed diffuser will spread the reflected energy out over a full 180 degrees, though the effectiveness falls off at lower frequencies. As mentioned elsewhere in this piece, when you get down to around 300Hz, the room modes take over as the principle factors in room behaviour.

One way to create diffusion is to provide an uneven surface -- although to have any effect at mid-range frequencies, the random humps and bumps in the surface need to be in the order of 150 to 200mm deep. Partially filled bookshelves are ideal for this purpose, but commercial diffuser panels are available comprising wooden cavities of different depths where the depth and spacing of the cavities is determined by a mathematical formula based on something called quadratic residue (don't ask!). Several tests have been carried out that indicate the design of these diffusers is not as critical as might be indicated by the complex mathematics, and randomly chosen sizes seem to work perfectly adequately.

Figure 5, above, shows a simple DIY diffuser that can be made from MDF or wood. The way these diffusers work is that the reflections coming back from the differently spaced depressions return to the room shifted in phase with respect to each other. This results in new wavefronts that propagate in different directions, rather like bending light through a prism. By contrast, a flat surface reflects a |phase-coherent wave that follows the 'angle of incidence equals angle of reflection' law. Properly diffused sound can help reinforce the sound from the monitors without compromising the overall monitoring accuracy or adversely affecting the stereo imaging.

Next month, I'll be providing a little more pragmatic guidance on creating a good listening space.

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