Demystifying Project Studio Acoustics

Understanding More Than Meets the Ear

Room acoustics is a subject we hear about a lot these days in the project studio business. Dealers talk about it when we visit their stores, studio engineers talk about it when we visit their beautiful designer studios, writers talk about it in their monthly columns, and those brainy guys with Ph. Ds talk about it whenever we ask them what we can do to improve our systems.

So why is there all this talk about acoustics? For one thing, acoustics are audible! We've all had the experience of walking into a room that is completely devoid of furnishings and playing around with the long, reverberating echoes. Stuffing that room full of furniture and personal items kills Little Sir Echo, but there are lots of other acoustic phenomena that are totally unaffected by our knick-knacks. While these other acoustic phenomena are not as readily identifiable as a long echo, they still exist and wreak havoc on an audio system.

The plain truth is that acoustics largely determine the perceived sound quality of an audio monitoring system in a project studio – by 50% or more in most cases. On the surface, the contribution of acoustics may not be as easy to understand as the contribution of some new piece of electronic wizardry, but the fact remains that the typical audio monitoring system in a project studio can be improved more by the implementation of acoustic treatments than by the addition of any piece of electronic equipment.

Knowing that room acoustics is important wouldn't do us much good if there were nothing we could do about it. Fortunately for us, acoustic problems in studios are fixable! Purveyors of expensive electronics would have dealers, studio designers, and engineers believe otherwise, but there is no argument that can stand up against the evidence. The trick – the thing that confuses most people to the point where they cry "uncle" – is how to fix room acoustics.

Before we can learn how to fix room acoustics, we must first understand a little bit about what makes acoustics tick. Acoustics can be thought of as the interface between a speaker and a listener in the same way that an audio interconnect is the interface between two electronic components, and a speaker cable is the interface between an amplifier and a speaker. The elements of a cable interface are input/output impedance, connectors, wire, resistance, inductance, and capacitance; the elements of an acoustic interface are speakers, air, reflections, and listeners' ears. Just as we would not want a poorly-shielded cable interface made from wire with high resistance, we would not want an acoustic interface with lots of destructive reflections and strong echoes. There are many good cables on the market today that provide great interface among electronic components. The picture is not so rosy for the acoustic interface. There are relatively few products available to control the acoustic interface, and many that are available can actually be detrimental to it rather than improving it.

What, then, should we expect from an acoustic treatment product, so we will know whether or not it is actually working for the greater good of an audio system? Acoustic treatments, as we will discover in greater detail, interact with things called reflections, flutter echoes, reverberation, and standing waves, which, if untreated, reduce clarity and articulation, confuse sound localization, collapse soundstages, and shift tonal balance. Therefore, a good acoustic treatment product will enhance clarity, articulation, and localization; open soundstages; and restore an even tonal balance.

Reflections
Up to this point, we have only introduced the concept of reflections. Now, we will take a more detailed look at the nature of reflections, the ways they degrade our audio systems, and the means we have at our disposal for treating them.

Reflections occur in every room, whether it is large or small. So, unless an audio system is outdoors, its sound will be affected by reflections. In an acoustic interface, they are comparable to distortion in an electrical interface. (The video guys in the crowd will recognize reflections as the things that cause ghosting in pictures.) If an electrical signal is distorted, we cannot hear the signal in its entirety. The same is true for reflections. If an acoustic signal is riddled with reflections, we cannot hear the original, pure sound.

A reflection is a sound that has bounced off one or more surfaces in its path from a speaker to a listener. We all know that speakers, even directional ones, do not radiate sound on a laser line directly to our ears. Speakers fire sound out in an infinite number of directions. True, a little of the sound radiated by a speaker does go straight from the speaker to our ears, but a lot of it bounces off of some surface (wall, ceiling, floor, console) first. When our ears combine all this reflected sound with the small amount of sound that comes straight from a speaker, the result is severe acoustic distortion!

Absorbers
One way to minimize the detrimental effects of reflections is to absorb them using treatments that are, remarkably, called absorbers. Absorbers, such as the StudioPanel Absorber, are like acoustic vacuum cleaners that suck in sound energy and convert it into heat energy through a resistive process. Little, if any, sound is reflected off of an absorber. The effectiveness of an absorber is determined by its thickness, which, contrary to popular opinion, mainly affects the range of sound absorbed, not how much sound is absorbed! For example, a 1″ think absorber absorbs sound over a range from 1,000 Hz to 20,000 Hz, a 2″ thick absorber from 500 Hz to 20,000 Hz, and a 4″ thick absorber from 250 Hz to 20,000 Hz. Naturally, if we want to absorb as many reflections as possible, the thicker an absorber is, the better. Unfortunately, to absorb reflections over the entire range of audible sound, an absorber would have to be 64″ thick! In the world of studios, 4″ thick absorbers provide the best compromise between range of absorption and practicality.

Diffusers
Diffusion is another method for treating reflections. Diffusers, like the StudioPanel Diffuser, control reflections by breaking them up into many "little" reflections that bounce around a room randomly rather than combining with direct sound at our ears and causing acoustic distortion. Like absorbers, diffusers only perform their magic over a certain range of frequencies which is – you guessed it – determined by the depth of the diffuser (among other things).

There is a rhyme and reason to using a blend of absorption and diffusion in a project studio. A general rule of thumb is to implement a blend of 50% absorption and 50% diffusion. If too much absorption is applied, the resulting sonic character of a room is too "dry" and "dead". On the other hand, too much diffusion can spray an overabundance of little reflections around a room and confuse soundstaging.

Bazorbers
We've shown that we can't use traditional Absorbers or Diffusers to control reflections over the entire range of audible sound. Does this mean that we have no way to treat reflections that are not absorbed by the StudioPanel Absorber or diffused by the StudioPanel Diffuser? Absolutely not! We may not be able to use the same type of absorber for reflections below 250 Hz that we used for reflections above 250 Hz, but there are absorbers designed specifically for the range of sound below 250 Hz. In the past, most of these absorbers have utilized one of two different approaches: Helmholtz or diaphragmatic. The StudioPanel Bazorber is a combination of both methods, taking advantage of the best of each! It does its work from 100 Hz to 250 Hz.

StudioPanel Absorbers, Diffusers, and Bazorbers are normally placed on the walls of a room in locations where reflections occur. Diffusers are usually placed directly across a room from Absorbers to insure that no reflections or flutters echoes (which we will discuss next) that are outside the Diffuser's range of operation can develop between Diffusers. In most cases, Bazorbers are placed on the front wall of a room to reduce reflections in the upper bass. Reflections across the entire range of audible frequencies are now controlled, with the exception of very low frequencies. However, single point reflections at very low frequencies are not as problematic as another acoustic phenomenon known as standing waves. We will save the discussion of these mysterious standing waves for a later section.

Flutter Echoes
In addition to low, mid, and high frequency single point reflections, we must control pesky things called slap or flutter echoes. Flutter echoes occur when sound bounces back and forth between two large, flat, parallel surfaces. In rooms, we call these surfaces walls. Like reflections, which are close relatives, flutter echoes reduce clarity and articulation, confuse sound localization, collapse soundstages, shift tonal balance, and lead to bright sound with a characteristic "zingy" quality. Fortunately, StudioPanel Absorbers and Diffusers are very efficient over the range of sound where flutter echoes develop, so the Absorbers and Diffusers can be effectively employed to control flutters echoes.

Reflection Decay Time
Reflection decay time is another acoustic phenomenon that we must control in a project studio. After a period of time, the reflections in a room that are not absorbed combine to create an ambiguous wash of decaying sound. The time that is required for this wash of sound to decay to a certain level is called the reflection decay time of a room. Reflection decay time is very important. If the time window is too long, clarity and articulation will be reduced, sound localization will be confused, and stereo separation will suffer. Extensive research has been done to determine the proper level and time window for reflection decay time. This research shows that most people prefer a time window of about 0.2 to 0.4 seconds in a room the size of a typical project studio.

In large rooms, reflection decay time is called reverberation time, which is a statistically random soundfield with no particular time or direction component. Rooms the sizes of project studios are not big enough to exhibit true reverberation because the reflections die out before they reach fully random character.

Reflection decay time is largely determined by the percentage of surface area in a room that is covered with absorptive material. Rooms with little or no absorption will have time windows that are too long.

For those of us who are not intimidated by numbers and math, there are equations that predict the reflection decay time of a room. The latest and most accurate equation is known as Arau-Puchades:

$$RT = \{0.161V/[-S \ln (1-ax)]\}x/s \times \{0.161V/[-S \ln (1-ay)]\}y/s \times \{0.161V/[-S \ln (1-az)]\}z/s$$

We can use the data from this equation to prescribe the proper amount of absorption for a room…after researching absorption coefficients, calculating surface area, and simplifying complicated math problems. For those of us who are more afraid of math than we are of acoustics, StudioPanel is a true blessing. The engineers who created StudioPanel did the calculating for us, so all we have to do is pick the proper kit for our room based on square footage!

Standing Waves

We have now covered all the topics of acoustic reflections but one – perhaps the most intriguing, exciting, and complex one of all: standing waves! So what, exactly, are standing waves? We know they mess up the bass in our project studios, but what causes them and how do we get rid of them?

In order to understand what a standing wave is, we have to know something about sound waves. (Don't be alarmed, because we're not going to dive into advanced physics.) Sound waves of various pitches happen to be different lengths. Sound waves that we associate with bass are very long; sound waves that we associate with treble are really short. The rest of the sound waves we hear lie somewhere in between. Now, it happens that, when a sound wave is exactly as long as the dimension of a room, that wave will resonate in that room. A resonating wave is louder than waves that are not resonating, and also takes longer to decay. (Reference the above discussion of reflection decay time.) Such a wave is called a standing wave. In addition to the original standingwave, whose length matches that of a room dimension, other standing waves will develop when sound waves are one-half, one-and-a-half, two, two and-a-half, three, etc., times the length of a room dimension. If we consider that standing waves occur between all three pairs of wall surfaces in our project studios, we can understand why standing waves are so detrimental to sound quality!

For most project studios, the sound waves that resonate in the length, width, and height dimensions are all bass sound waves from 30 Hz to 150 Hz. The increased volume and longer decay times of the resonating bass sound waves totally destroys any chance of bass sounding clean, tight, and chestpounding like it does in large venues, commercial cinemas, and outdoor concerts. Furthermore, standing waves are not uniform across a room. Certain places in a room will experience much louder bass than others. We can only hope that our mixing position has the same level of bass as the producer's couch!

It is easy to see that we must do something to eliminate these bass standing waves. How do we go about it? Fortunately, we have a whole arsenal of ways to treat standing waves. Some ways are acoustic, some are electrical, and some are structural. For example, during the design phase of a project studio, we can adjust the dimensions of the room so that the bass sound waves that resonate are all different. (If two room dimensions are or are almost the same, the resonating bass sound waves that correspond to those dimensions will aggravate each other, creating even greater sound pressure level variations and longer decay times.) In addition, we can place loudspeakers, subwoofers, and listening positions so that their interaction with standing waves is reasonably limited. We can also use electronic equalization to reduce the volume of the resonating waves. The StudioPanel SpringTrap is another way to eliminate standing waves. Like the Bazorber, the SpringTrap is designed to absorb bass sound waves that are below the range of the StudioPanel Absorbers. However, SpringTraps operate over an even lower range of sound than Bazorbers. SpringTraps are effective from 30 Hz to 100 Hz.

Unlike Absorbers, Diffusers, and Bazorbers, SpringTraps do not need to be placed on walls at reflection points in order to function properly. Due to the nature of standing waves, SpringTraps work most effectively when they are positioned in the corners of a room, either sitting on the floor, or hanging just below the ceiling. The SpringTrap's unique shape accommodates easy and aesthetically-pleasing corner placement.

Room Acoustics Summary

Reflections, flutter echoes, reflection decay time, and standing waves are all acoustic phenomena that ruin the sound in our project studios. A blend of StudioPanel Absorbers and Diffusers can be used to control reflections, kill flutter echoes, and lower the reflection decay time so that it lies within acceptable tolerances. At and below frequencies where the Absorbers and Diffusers cease to operate, Bazorbers take over to control boundary reflections. Finally, SpringTraps can be used to eliminate bass standing waves that mess up low-end kick. Together, the whole StudioPanel package works really well, and will pay for itself after you've mixed a couple of records that sound great when they leave your studio!