Understanding the Acoustic Energy in your Room.
The reverberant field, discreet reflections, sound from the stage and standing waves.

by Barry Grzebik

What dictates the sound of your facility? Your speakers? Sometimes, yes, but more often the acoustic signature of your room is a dominating factor. A well-designed room will let the quality of your speakers, mics, and other electronics shine but in a poor room other factors are controlling the sound to the detriment of the performance ability of your equipment. Gaining control over the acoustics in your facility will usually lead to great improvements in the clarity of the spoken word, the separation of instruments and the overall experience of the listeners. Figuring out where the problems lie in your facility and knowing what to do about them is a large topic but with some fundamental information you will see how to improve you rooms acoustics.

You will need to identify as many of the different acoustical problems as you can and then attempt to solve them individually. When multiple acoustic problems exist, improving only one will make the remaining problems appear worse. This may not mean spending more money on acoustic treatments, just utilizing you dollars more wisely.

The reverberant field is the first acoustic topic we must address, as it is the most obvious characteristic of a room. The reverberant field is sound reflecting off the many surfaces in a room. It is like many echoes all layered on top of each other so no single echo is distinguishable, you only here a continuum of sound that slowly fades away. This generally takes a few seconds. Depending on the design and surface materials of your facility, the amount of reverberation will vary at different frequencies. To get a very rough idea of the reverberation time of your facility (known as RT60), stand in the room, clap your hands loudly and time how long it takes for the sound to die down to the point where you can barely hear it. A short reverberation time would be less than 1 second. If the sound go on and on, possibly for 3 or more seconds you have a very long reverberation time. Short times are not necessarily better than long. What you want is the right decay time, or amount of reverberation for what you want to do in the space. Reverberation times for common applications are listed below.

Domestic Living Room	0.5 seconds
Lecture Hall	0.7 to 1.0 seconds
Pop Music	< 1.1 seconds
Chamber Music / Opera	1.3 to 1.8 seconds
Concert Hall	1.8 to 2.2 seconds
Pipe Organ	>2.5 seconds

Shorter decay times improve speech intelligibility while longer time make choirs an orchestras sound larger and more full. Many older churches have 2 to 3 second decay times. This was appropriate for the original use of the building. Pipe organs and choirs will sound great. In these rooms, modern services focusing on the spoken word are difficult to do successfully. Also contemporary music will sound confused and blur together with this much reverberation.

To bring reverb times down you will need to put acoustic treatments on the walls and or ceiling surfaces. Things like adding carpeting, drapes and padded seats are common ways of reducing reverberation. The first problem you will encounter has to do with aesthetics. There is no getting around the fact that in most cases when adding acoustic materials to an existing facility, you will plainly see them stuck on the walls or ceiling. To help with this situation, most manufactures of sound absorbing materials make them with cloth coverings hopefully in a color that will match your aesthetic. They will also make the treatments in various thicknesses. Generally thin materials absorb high frequencies well, absorb mid frequencies marginally and have no effect on low frequencies. These thin materials will be the least costly. The problem is that you can easily end up absorbing all the high frequency reverberation in the room while barely affecting the mid and low frequencies. For good speech intelligibility and for good contemporary music performance you will need to bring the reverb down in the mid frequencies as well. Thicker treatments will do this. You will be better off purchasing less material in terms of square footage but have it be thicker, say three inches instead of one inch. With this approach you will improve more uniformly the sound quality in your room.

Where you put these treatments and how much to use depends on the architectural design of your facility. You can use too much. Without acoustical data on your sanctuary or a very specific RT60 target, use this rule of thumb. Cover between 30% to 40% of a wall surface with acoustical treatment. Center the materials on the wall. Don't put any materials lower than two feet above the floor.

The next acoustic anomaly you should look for are discrete reflections, often referred to as slap-back. A discrete reflection stands out from the general reverberation. This most commonly occurs when sound from your main speaker system hits a large surface, often an un-treated back wall and then reflects back onto stage. It is a very clean path from the speakers to the back wall then to the stage. Because of this, the sound you hear is very coherent. It sounds like the original signal just out of time. This can be very distracting to less experienced presenters and musicians. These reflections are not only a problem on stage but for audience member as well. A balcony lip can direct sound down into a main floor seating area or equally as common you will find curved walls that focus energy on to a specific area in the room.

To eliminate or reduce these discrete reflections you have three options to choose from. You can absorb the energy by treating the offending surface so less is reflected back, or you can use diffusion so when the energy strikes the surface it is returned to the room as may smaller reflections going out in many random directions. This effectively turns the reflection into energy that will become part of your overall reverberant field. Lastly, you can re-aim the reflection by altering the reflecting surface or the location of the sound source.

If you have speakers on tri-pod stands pointing straight out into the room, you can see that the reflection from the back wall will come directly back at you. If you suspend the speakers and then aim them down slightly you may be able to alter the angles enough so the reflection from the back wall goes directly down into the audience at the back of the sanctuary where it will not be very noticeable. If you cannot change the angle enough, the reflection may move only from the stage to the front row. Even this small change may be beneficial if the reflection is causing problems for someone on stage. If your speakers are already flown, raise or lower them.

If you look closely next time you are in a well-designed theater you may notice that some of the surfaces that would be inclined to cause discrete reflections have been designed with complex surfaces. Often you will see a series of half circles or triangle patterns that break up the reflection. Usually for aesthetics these are made of wood and finished like fine furniture but in reality, they can be any solid material in any color to match your decor.

Sound from stage can add a surprising amount of acoustic energy to the room. The acoustic energy from instruments and performers is not normally the source of problems. It is generally the monitor system. Stand in a performance theater during a sound check when the monitor system is on but the main system is off. You may find that it is nearly as loud as when you have the main system on. Listen to it the other way around. Turn on the complete system then with the band still playing mute the monitor system. If everything sounds clearer, tighter, and more distinguishable, you monitors are polluting the room. This mainly happens when the sound from the floor monitors bounces off the back stage wall and eventually makes it way into the room.

Short of changing to a full in-ear monitor system, you should put absorption on the back stage walls. You can also work to bring the monitor levels down. Even a few dB can make a difference. One common method is to bring the musicians closer together. If they hear each other better simply because they are closer to one another they will need less in the monitors. If you have drapery on portions of the walls, arrange the musicians and their monitors so the sound goes into the drapes, not the hard solid walls.

Standing waves. Often in larger environments it is difficult to correct these after a facility has been built but you should still be able to identify them. They are related to the major dimensions of your room and can be predicted with very simple calculations. To understand standing waves, you have to understand wavelength and what a complete cycle of a sine wave is. A 50Hz sine wave has a wavelength of about 20 feet. If you have a room dimension of 20 feet, you will have a 50Hz standing wave. You also will have standing waves, or resonances at related frequencies like 100 and 150Hz. You will have a whole set of resonant frequencies for the height, width and depth of you facility. The worst case, as you have undoubtedly heard of over the years, is a square room. This is because all the resonances for the length and width are exactly the same to they add together making for very strong resonant problems.

This problem is time based. Certain frequencies will seem to hang in the room longer than others. The most common way to combat this is through equalization. If you find a frequency or two that resonate badly, then with an equalizer, reduce the amount of energy at these frequencies coming out of your sound system. These frequencies will now appear to resonate less. Actually they are resonating exactly the same amount, but as a percentage of the total sound, they are now less, so the effect of the resonance is masked by the remaining sound. Although you have not fixed the problem, you will generally notice that the low end will sound much tighter and is less prone to feedback.

You can go looking for standing waves by feeding the output of a sine-wave-generator into your sound system. At a moderate level, clearly heard, but not shaking the building, slowly sweep the frequency up and down between 20Hz and 100Hz. Listen for frequencies that stand out in terms of level and decay time. You will hear at certain frequencies something different. The sound will appear bigger and as you sweep by, it will stay in the air longer. These are the frequencies to cut on your equalizer.

After looking at your facility from the standpoint of general reverberation, discrete reflections, sound from the stage, and standing waves you should be able to make some informed decisions on how to improve the sound in your facility without purchasing a new sound system. Whether you have an old tired sound system or brand new system, these room related problems will often be the same. Start by acoustically, cleaning up your room, them move on to new equipment.

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