Acoustics: Win The Battle Before It Begins Part 4 - Sound Quality

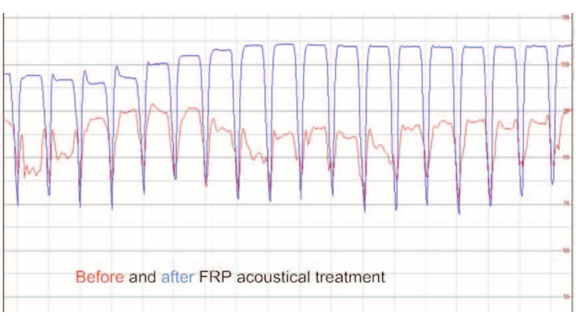
Norman Varney

In this four-part series, we have talked about what it takes to prevent problems from occurring in the first place. In our final part of the series, we will dive a bit deeper into sound quality attributes to discuss the following:

1. Good low frequency articulation
2. Linear reverberation times
3. Tonal balance
4. Soundstage imaging, width, depth, and height
5. Wide dynamic range
6. Uniformity of sound

Some of the above topics we touched upon in the last issue, but here we will discuss not only what they mean, but what it takes to control them — testing, computer modeling, and incorporating acoustical products. You will notice that many acoustic characteristics affect others.

The acoustics of the space must be established via onsite instrument testing or estimated via computer modeling software. Then computer modeling is applied to get from the existing acoustical conditions to the goal conditions using data from acoustical products that have been tested in labs following standards. Acoustics characteristics are tested for physical properties such as transmission loss, absorption, diffusion, vibration transmission, propagation, etc. With known test data of products, solutions can be applied to discover the best product types, locations, and quantities for the specific project.



Test results showing acoustic improvement of articulation.

Good low frequency articulation typically refers to room modes and frequencies around 300 Hz. and below being linear in SPL level across the frequency range, as well as fast attack and decay. The quality of the low frequency response is what most people notice first. There are five ways to control room modes passively:

1. Use construction materials and methods that allow flexure to help absorb low frequencies. Resilient construction methods not only help with noise control, but also sound quality. A room of concrete construction does not absorb low frequencies well. It reflects and contains them, allowing them to linger for a long period of time. This reduces articulation, and dynamic range, and is tonal. Computer modeling is often used to determine if the existing or predicted energies will be controlled enough to meet the goals.

2. Build a room whose dimensions distribute the modes evenly across the low frequency bandwidth. It is common for room mode energies to vary as much as 25-30 dB SPL in small room environments such as home theatres. The dimensions dictate how well or poor the room modes are distributed. When modes are too close to each other or too far apart, they will draw attention to themselves audibly. Poor dimensions regarding modes mean some frequencies will sound much louder than others and some will sound much quieter. There are some basic room mode calculators available on the Internet, but they do not account for many perceptual things that should be considered.

3. Place loudspeakers out of the way of primary and/or problematic room modes. You can control the amount of excitement of the room modes by placement of the source of energy- the loudspeakers. For example, placing a subwoofer in the lower tri-corner of the room will allow all the room modes to be excited. Though this means an efficient subwoofer, it does not mean quality sound. They need to be positioned where they will not exasperate problematic room modes, and where they will blend well with the mains to sound like one voice. Computer modeling will get you in the ballpark and onsite testing with instrumentation and trained ears will nail it. You can't completely rely on the construction being built to spec, the modeling input to be 100 percent, accounting for loudspeaker propagation, listener preferences, etc.

“Thanks for all the years”

I had a very simple idea: to create a better-sounding speaker that all music lovers could afford. It has been 51 years since I started Magnepan. In 2001, it was time to pass on the family business. My son Mark is the president now. I've retired and since been inducted into The Absolute Sound's "Hall of Fame" (and I'm still alive!!!).

So, what do I want for my golden years and how do I want to be remembered?

I like clever ideas, whether mine or someone else's. I am not a genius, but I am able to envision simple ideas that are powerful. So maybe I am clever.

I am a supporter of the Minnesota Orchestra. I saw the reviews in The Absolute Sound and Stereophile of Gabriel Sakakeeny's OSIRES invention that helps small orchestras. I am able to "think outside the box" (pun intended) and so is Gabriel. But, like all audiophiles, I don't believe reviews unless I can hear the product for myself. From one inventor to another, *"Gabriel, build it so we can all hear it for ourselves."*

To help make that happen, you can be involved. **For every Magneplanar that you buy from now until the Axpona Audio Show in 2021, I will donate $35 to help Gabriel Sakakeeny demonstrate his OSIRES invention during the show.**

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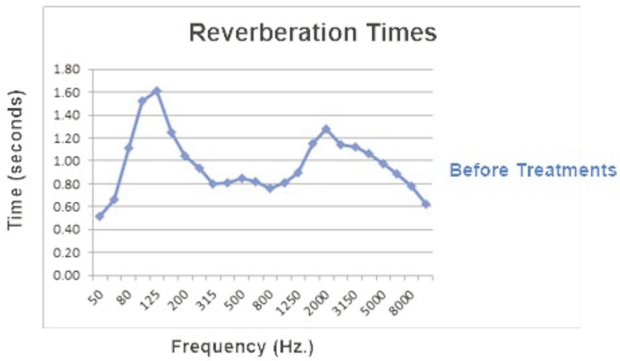
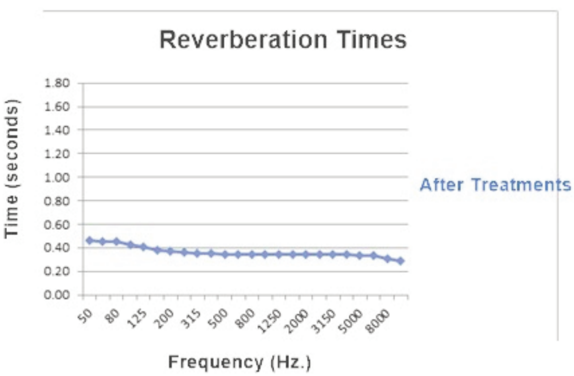
4. Place listeners out of the way of primary and/or problematic room modes. The same holds true for the listeners as the loudspeakers. Keep them away from room boundaries and problematic room modes. It will always mean compromises. At least allow there to be one seat where all the energy can be calibrated to converge in time and energy. This is where the magic is.

5. Incorporate the right acoustical treatments, at the right locations, at the right quantities. With computer modeling, we can estimate what frequencies will be an audible problem (modes that are either too close to another, or too far apart), by drawing our attention to them. When we know their frequency, we can determine where they live (their high and low pressure points) in the room, as well as their approximate energy levels. This helps us determine the best low frequency absorber type, location, and quantity to smooth out the frequency response.

Linear Reverberation Times





Test results showing linear reverberation times after acoustic treatments.

Reverberation times can cause many sound quality problems because it affects most of the sound quality attributes like resolution, dynamics, intelligibility, spatial cues, tonality, etc.

Reverberation times are estimated by computer modeling software at the design stage or tested onsite if already existing. Then further computer modeling is incorporated to take the data from the estimated or existing conditions to the target conditions. Absorption coefficients, scattering energy of diffusers, etc. from lab product tests are used. Finally, onsite tests are conducted to either confirm or to reveal what adjustments need to be made to attain the goals.

Though some absorption is typically better than none when needed, reverberation times are the easiest to mess up. Most absorption panels are only effective from 500 Hz. and up, so they do not address the lower half of the keyboard. It is extremely easy to end up with too much mid and high frequency absorption, which makes the room uncomfortable and unnatural. Common now are companies that offer free estimates based on your room dimensions. Without test data, room dimensions are meaningless. You must test or calculate the absorption coefficients of the shell's construction, the room's volume, and all the furnishings, otherwise you're blind. These companies notoriously end up selling you too much absorption for the mids and highs, and don't have products that effectively address lower frequencies. Diffusion on the other hand, once reverberation times are under control, is difficult to introduce too much of into the space.

My approach once I have the actual or estimated reverberation times, is to address the first order reflection points for each loudspeaker on each surface with absorption or diffusion to attenuate the hard specular reflections that interfere with tonality and spatial cues. Once this is in place, then I look at the remaining reverberation times that need to be addressed. This is done with computer modeling and then confirmed with instruments onsite.

Tonal Balance

Tonal balance covers the entire audible frequency range from 20 kHz. on down regarding room response, not the loudspeaker's near-field frequency response. There are several things that affect tonal balance in the system, which includes the room and the playback system that is exciting the room.

1. Room modes, as previously mentioned. Specifically, from about 300 Hz. and down.

2. Reverberation times, as previously mentioned.

3. Listener/Speaker locations, as previously mentioned, and including the geometric relationship between the separation of loudspeakers in relation to the listener, as well as their toe-in angle. This is dependent on the loudspeaker's sound output propagation into the room, and also personal preferences. This is where a bit of art comes into play. You can have an acoustically neutral room and still play some of the sound quality characteristics to personal taste.

4. Keep the loudspeakers the same model or at least the same brand so that they sound like the same voice. This is especially important for the front loudspeakers.

5. Be sure the subwoofers can be dialed in to mate well with the main loudspeakers. This means that the subwoofers should include a means of controlling the cross-over to the mains, gain, delay, and phase with variable knobs. Better yet, is when you can control the crossover slope between the mains and the subwoofers. Remember that subwoofers on the floor will excite the height modes, and that there is going to be a specific elevation that will alleviate the problem. Finally, one of the biggest, easiest things you can do is to physically isolate them from the structure. Mechanical isolation will quiet the room of resonances, buzzes and rattles, and quiet the rest of the house.

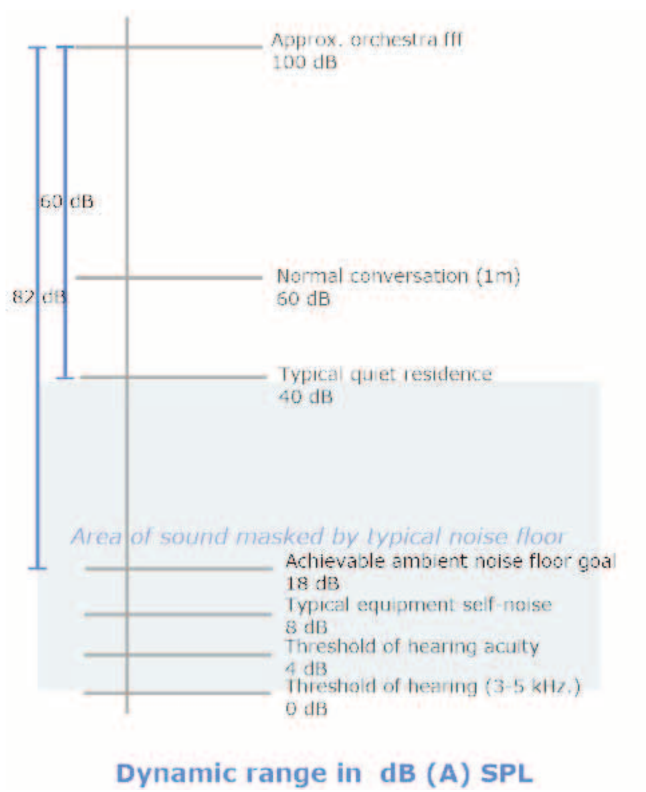
Soundstage Imaging, Width, Depth And Height

This is further refinement of the listener/loudspeaker relationship, along with personal preferences. When you have the loudspeakers and/or listeners near boundaries, or listeners too close to one loudspeaker and too far from the others, there is little hope for decent soundstage imaging. The problem increases the more channels and people you add to the space. Think about how well a single loudspeaker can cover an audience. As you add more channels, it gets more difficult for everyone to hear all the discrete channel information due to proximity.

However, multi-channel is magical and adds to the emotions and suspension of disbelief. Room acoustics will have the most impact on how much the sound varies seat to seat. A controlled environment will reduce the seat-to-seat differences.

The geometry between the loudspeaker and the listeners is critical, as is the calibration of the electronics' outputs. When we have loudspeakers physically too far apart, we have a void in the middle, and the midrange sounds thin. When they are too close together, we can't have a wide or realistic soundstage that is cohesive with the picture content. Things sound like they are jumping around in space, rather than smooth and continuous. When loudspeakers are not aimed properly it affects the timbre, spatial cues, and even image size. When things are optimally set up in a good environment, sounds can seem to come from beyond the loudspeaker's locations in width, height, and depth. The soundstage will be large, solid, and the loudspeakers and room sonically disappear.

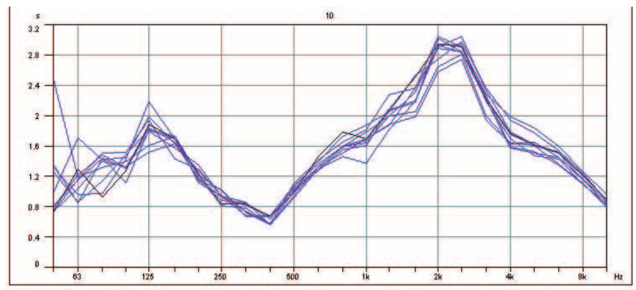
Wide Dynamic Range



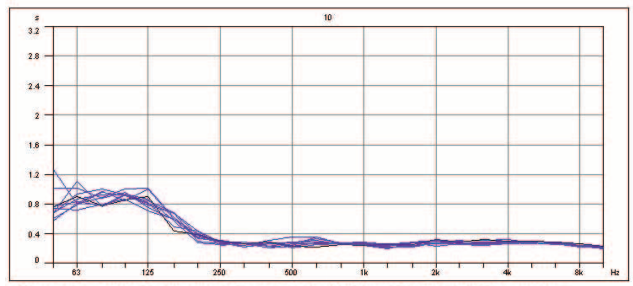
Graph indicating typical vs. desired dynamic range

When we have a low ambient noise floor, we have no noise infiltration, no distractions, and we can hear low-level details that would otherwise be masked and undetected. When we have the reverberation times under control, the same can be said. The difference between noise and reverberation is the former is the room's noise floor before signal stimulation, and the latter is the room's response after signal stimulation. Wide dynamic range is important to our emotional triggers. Limiting or squashing the available dynamic range limits our emotional connections, limits the amount of information available to us, and therefore limits our believability and enjoyment.

Uniformity Of Sound



Reverberation times (9 positions) in a typical, carpeted media room.



The same room treated with the A/V RoomService FRP system.

Test results showing uniformity of sound (from a reverberation POV) before and after acoustic treatments.

We have covered this pretty well above under the tonal balance, reverberation, and soundstage headings. Uniformity of sound does not only apply to timbre, but also spatial cues. It is controlled by the selection of the sound sources, the placement of the sound sources and the receivers (loudspeakers and listeners), their calibration, and the room's reverberation times. DSP may help to address tonal variances in the low frequencies, but at the sacrifice of homogenizing them for all, offering no optimal response for anyone. Sometimes this is what the customer wants. Like everything, understanding the pros and cons helps the decision process.

Hopefully this series will prevent a few home theatre owners the disappointment and expense of poor design, lack of acoustic modeling, and/or testing. You are now equipped with the knowledge of what to look for when selecting a design firm. Experience and knowledge are key factors, along with equipment. These are just the fundamentals. There is no such thing as one-size-fits-all when it comes to acoustics, and every room has unique constraints for which compromises must be identified and determined. As a consultant it is my job to bring up those issues and educate my customers so that they can make informed decisions. Then I know that they will be happy with the results, all while never running into any unanticipated battles. **WSR**

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