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Design, Installation And Calibration Of A High-Performing Home Cinema

Part 1

Norman Varney

In my past series of ten articles ("Ultimate Home Theatre"), I discussed the approach of good design and implementation with sciences involving acoustics, biology, and computer modeling of data collected from acoustic lab testing of construction materials and methods. I covered the perception, causes and control of noise and vibration, both airborne and structureborne. Reviewing and referring to that series would be beneficial to those of you wanting to make improvements on an existing home cinema, or getting ready for a new one. See Issue 224 February 2018 through Issue 233 November 2018 of *Widescreen Review & Custom Home Theatre Design*.

This series of articles will be based on a current home theatre project I have just started. Because I am working on it in real time, there may be a gap between articles. I will go through the entire process from learning about the project through calibrating it (voicing) onsite. This is going to be a Dolby Atmos 5.1.2 overhead system. Though simple in configuration, it will include state-of-the-art equipment, construction and acoustic treatments customized to fit the desired results. In addition, the client has decided to get into two-channel playback as well. So a high-end phono section and streaming device will be included.

The primary purpose of any home cinema is enjoyment. More specifically, when we control the environment of unwanted vibrations, we are allowed more enjoyment. Unwanted vibrations are any airborne or structureborne sound waves that are not a part of the original playback signal received from the loudspeakers. Unwanted vibrations would include room construction/furnishing resonances, room modes, reverberation, buzzes and rattles, outside noise, etc. More enjoyment is obtainable because more of the original data, and less unrelated data is received. This allows the brain to relax and focus more on the original events and work less on trying to make sense of the data by filling in what is missing, or trying to hear through noise and distractions from inside or outside the room, masking due to long reverberations, setup and/or calibration errors that cause spatial and timbre errors, etc. When things are done right, the investment potential is realized. When things are done right, escapism and envelopment are amplified. The story is told and understood with more impact and emotion. It brings more satisfaction to the experience.

Accuracy is the name of the game. We want the room to be visibly and audibly removed, leaving only the intended signals to arrive at our eyes and ears. Great effort was made to control the A/V content in production, and the same effort must be applied in playback. By removing variables and incorporating standards, we can come closer to experiencing the same sights and sounds that the artists did in the studio when creating their master for consumer release.

This is a good place to review some of the points made in the "Ultimate Home Theatre" series:

1) Every room has compromises.
2) Big sound trumps big picture.
3) Noise control must be established before good sound quality can exist.
4) Room dimensions dictate loudspeaker/listener locations, which dictates first reflection points and screen location and size, which dictates projector requirements, etc.
   a. The audio/video playback hierarchy is always:
   b. Physical set-up
   c. Calibration
   d. Acoustic treatments
   e. Equipment quality

In this series of articles, I'll apply what we've learned to a real-world home cinema. We'll talk about the A/V goals of the customer, the decisions that must be made, physical and budgetary

constraints, etc. Every room has different compromises. The acoustic designer must understand what these various compromises mean to the performance, and then be able to explain to the customer how they translate to the experience. The acoustic designer also needs to know what solutions are available to meet the goals, and offer solutions for physical, budgetary and/or cosmetic constraints that arise. This includes equipment compatibility, construction materials and methods, interior acoustic treatments, HVAC noise control, electrical, etc.—not just sightlines and SPL capabilities. My company, AV RoomService, does not specialize in interior décor or lighting but can work with such designers and make recommendations to obtain optimal audio/video performance and functionality.

Goals?

What is desirable vs. tolerable for the client? Can we achieve them with the given constraints? We should review some of the goals that were discussed in the last series of articles. Most clients will need a lot of help around this topic because: 1) The client may not have the knowledge or experience of what is possible. 2) The client probably cannot correlate acoustic jargon and specifications to performance value. It is up to the acoustic engineer to convey what a compromise or sacrifice means to the experience. Once the client understands the pros and cons, he can make an informed decision and not end up with any disappointing surprises. Often the expectations of the client are unrealistic and the laws of physics have to be gently explained. For example, clients use the term "sound proof" all the time. We never say "sound proof" in our line of work. Doing so may cause a legal battle if not nipped at the bud.

Though compromises may be driven by budget, décor or even weight constraints, the most common is space, more specifically, not having enough. Remember that for good sound quality, the speakers and the listeners should be away from the boundaries. It is common to see front loudspeakers against the front wall and the rear row seats against the rear wall. As the number of seats increase, so should the size of the room. That being said, the most frequent acoustic problem that comes into play occurs when the client fires up his cinema for the first time, after the kids are put to bed. This is when he realizes that because his A/V integrator never discussed noise control with him, he cannot use his cinema after 8:00 PM!

A few things to keep in mind here: 1) Noise control must be in place before sound quality can exist. The ambient noise floor should be low enough that it does not mask low-level information in the soundtrack. Audible clues to the story line may be missed, or the mood not felt and/or the distraction of noticing the HVAC system turn on or off, or noises from outside of the room can really ruin your "willing suspension of disbelief." Silence is often used for dramatic effect. 2) Physical set-up, equipment calibration, and acoustics are the most important issues for obtaining a great home cinema experience. State-of-the-art equipment won't matter without these things in place. 3) Décor has nothing to do with the experience after the lights are off, unless it is still visible, which is never a good thing.

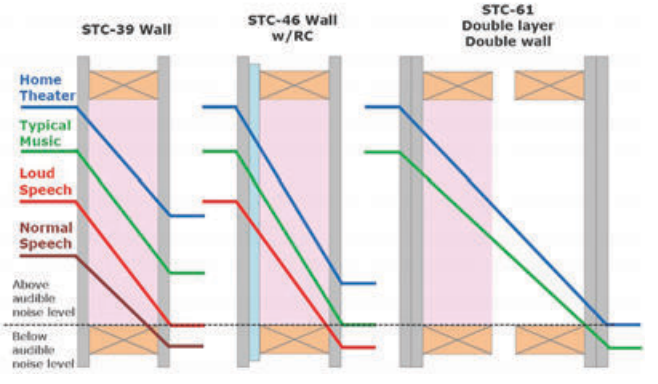
Ask Questions

When I look at accepting a project, I send out a questionnaire to learn the scope of the project. There may be one questionnaire or there may be several, depending on the project and/or my involvement. The questionnaires not only help me learn about the physical properties of the space, but help me and the client begin to ascertain what the objectives are. Usually, the customer has not given much thought as to how adjacent spaces may impact the cinema, or how loudness may affect the rest of the home, how interconnected HVAC ducts work as acoustic intercoms, or how high-backed seats destroy sound quality, etc.

Here are some examples of the design goals I typically aim for with home theatres:

Noise Floor

As mentioned above, noise control must be in place before sound quality can exist. Equipment cooling fans, HVAC, electrical transformers, plumbing and outside noise infiltration can cause loss of information in the storytelling, ruin the mood and be a distraction. I am looking for the cinema shell construction to have a Sound Transmission Classification number of STC 61 or better (higher) in order to have an ambient noise floor Sound Pressure Level (SPL) of approximately 28 dBA or better (lower). Since noise is a two-way street, this should offer the listeners in the cinema an immersive escape from the real world, while not annoying others who may be outside of the cinema sleeping or studying. If we can



accomplish this kind of sound transmission control for the shell, and can keep the HVAC, equipment, electrical and plumbing noise under control inside the room, we should be able to experience all of the dynamic range available in the soundtrack and hear all of the low-level details.

Room Dimensions

There are three important goals here: 1) The room should be big enough to accommodate the desired number of seats. This means that the loudspeakers and listeners are a good distance from the boundaries, (approximately three feet or more as dictated by the room modes, etc.), 2) Has good room mode distribution for linear bass response, and 3) Will accommodate the required shell thickness to meet the noise control goals, as well as interior acoustic treatments.

Loudspeaker/Listener Locations

Three key goals here: 1) Linear bass response. Place loudspeakers and listeners away from room mode issues as dictated by the room's dimensions. 2) Optimal soundstage. Spreading the loudspeakers too far apart or too close together in relation to the listeners will destroy spatial cues and mask audio information because a listener is too close to one loudspeaker and too far apart from others. *Note that the more channels involved, the more difficult it is for all seats to meet this requirement in small cinemas.* In addition, the primary seat should be equidistant from all of the loudspeakers and midway between side walls. 3) The tweeters from all loudspeakers must be unobstructed to all listening locations.

Screen Size and Location

Three essential goals: 1) The screen is located on the same plane as the center-channel loudspeaker. 2) The screen is sized appropriately for minimum and maximum viewing distances, as well as projector capabilities. 3) The screen is unobstructed from all seat locations. Beyond this, the screen width should physically correlate with the main front loudspeakers so that sound and picture are unified. Oftentimes, I see screens that are too big.

First Order Reflections

We want to attenuate each first reflection by 10 dB or more (depending on distance relationship between loudspeaker, reflection and listener). This can be accomplished with acoustic absorption or diffusion treatments. There is a first order reflection point for each loudspeaker on each boundary surface, so typically six areas.

Room Modes

A combination of room dimensions, construction materials and methods, along with interior acoustic treatments and loudspeaker/listener placements can tame room modes for linear bass response and articulation.

Reverberation Times

After the first reflections are controlled and low-frequency absorption is applied, we want to control the reverberation times for a linear response between 0.25 and 0.4 seconds from 125 Hz and up, with slightly longer decays below 125 Hz (depending on room size) for psychoacoustic comfort. Without control, every room introduces its own unique sound to the original signal, as well as smearing timbre and space, masking details, and limiting dynamics. There is also a Speech Transmission Index related to speech articulation and intelligibility. I would expect an "Excellent" rating for this home theatre.

I will talk about other goals throughout the project from the design stage, through construction, to voicing of the electro-acoustic system. And at the end I'll share the results of onsite measurements. WSR

Norman Varney is the owner of AV RoomService, an acoustic design company that also offers a few acoustical products. Having been in the noise control and sound quality industries for decades he has earned awards for acoustical products and room designs while working for A/V RoomService, Kinetics Noise Control, Owens Corning Science & Technology Center and MIT. Mr. Varney has presented white papers to the industry and written articles on acoustics for numerous publications over the years, as well as participated in seminars and panel discussions. He is an active member of ASTM (Committee E-33 on Building and Environmental Acoustics), Acoustic Society of America, Institute of Noise Control Engineering, AES, NAMM, CEDIA, etc.