

Win the Battle Before It Begins Part 2

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The conflict we're battling is noise control. When it comes to building a home theatre, noise control is a crucial factor that shouldn't be overlooked if you want to create an immersive and enjoyable movie experience. But what exactly is noise control, how much of it do you need, how do you choose a product, and will it really work? In this article, we'll answer these questions and more, helping you choose the right noise-control products for your home cinema setup. In this article, we will focus primarily on the shell of the space, leaving HVAC, plumbing, electrical, etc. for another time. Note that after we battle noise control, we battle sound quality.

Why is noise control so important? There are two main reasons:

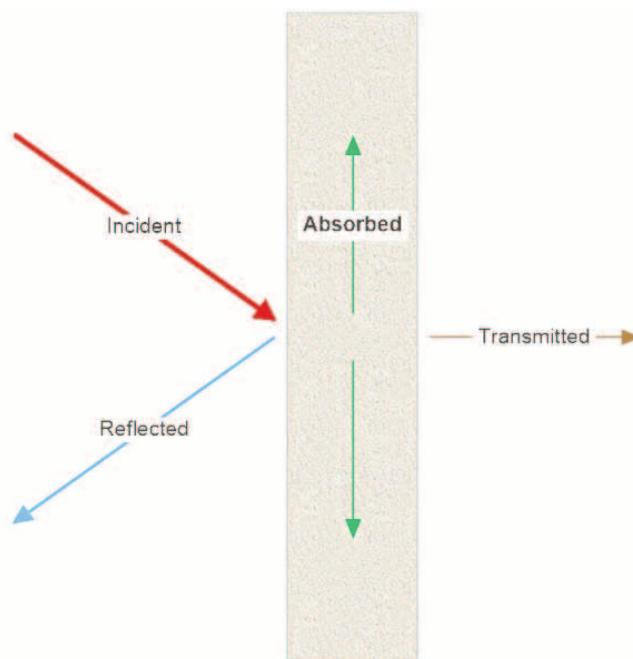
1. Improving sound quality
2. Reducing disturbance to ourselves and/or others.

By designing a home theatre that prioritizes noise control, you can create the ideal conditions for a cinematic experience that fully captures the intensions of the artists, and capabilities of your equipment. But if we fail, we risk creating a disappointing or even disastrous result. As they say, "garbage in, garbage out." Noise is distortions and/or distractions that are not part of the original audio signal.

As discerning movie-watchers, we know that the listening experience is critical to our enjoyment of the film. One of the most important reasons we approve or disapprove of any home cinema experience is the result of our own ability to listen and experience sound with a critical ear. The desire to re-create and understand this experience is probably why you're reading this article. We love it, because we know when the experience is right, likewise, we know when the experience isn't right. We quickly become a discerning audience that knows the difference between awesome and awful, and as a result, become "critical" about our expectations and how we "listen to our surroundings" during the home cinema experience. We emphasize, "listening to our surroundings," because what we hear within the shell of a home cinema is largely influenced by how the walls, floor, doors, and ceiling treat the sound energy generated within, around, and through the space. So let's begin by taking a closer look at how walls, floors, doors, windows, and ceilings influence your listening experience. There are three basic ways that the shell of the room influences sound

energy:

1. The partition will absorb sound energy.
2. The partition will transmit sound energy through it.
3. The partition will reflect sound energy back into the listening space.



Graph 1: Indicating the three ways a partition (wall, floor, ceiling, door, window) handles sound energy. Different assemblies will handle the total energy uniquely in different percentages.

How sound energy reacts with its surrounding room envelope can vary immensely, depending on how much sound energy travels via each energy path. Changing or varying the energy path for better or for worse depends on a complex array of products, their material properties, and how they are integrated together to form

an assembly.

To optimize your home cinema's sound quality, you need to choose the right noise-control products and methods, and integrate them properly.

Sound energy is a powerful force that can travel through walls, ceilings, and floors, and radiate on both sides. When designing a room, it's crucial to consider how sound travels and how different materials can affect its transmission.

Different wall partitions will treat sound energy differently. The construction materials and methods will call out how the sound energy is handled. In home theatres, it is a delicate balance for noise control and sound quality. Achieving this is easier said than done. Often, the use of too much mass and too little panel absorption provides good sound transmission loss results at the expense of interior room sound quality, i.e. way too much energy is being pumped back into the room from an unoptimized partition assembly design. You can imagine that a concrete bunker will have good noise control, but poor sound quality. On the other hand, no boundaries will offer no noise control, but good sound quality. You must also consider physical size and weights, decor, costs, and local codes.

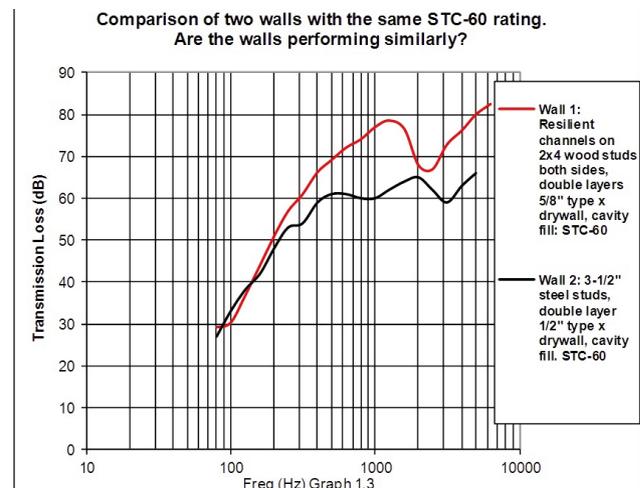
The amount of decibels transmitted from sound passing through a partition can be known by lab measurement. The higher the decibel loss, the greater the panel's ability to reduce transmitted sound energy. The term for this type of measurement is called "Sound Transmission Loss" or TL for short. Another way to put it is that transmission loss (TL) is the loss in sound power that results when sound travels through a partition. Sound transmission data is used to determine the single-number sound-performance rating for partitions called the STC (Sound Transmission Class). The higher the number, the better the partition isolates noise from one side to the other.

However, like most single-number classifications, it tells you very little of the story. While single-number STC ratings are convenient, they can be misleading as they don't give the complete picture. TL frequency curves show if specific wall, ceiling, or door assemblies have any specific frequency weaknesses not evident in a single STC rating. It's important to find the actual test TL data that reflects the advertised STC number when designing the shell of a home theatre or studio environment. Apple-to-apple comparisons in noise control assemblies can be difficult, and STC ratings often pivot around one or two key frequencies, which can be misleading. Therefore, it's crucial to look at the TL curves when selecting partitions.

However, TL has its limitations too. Most TL curves are measured at center frequencies of 1/3 octave bands, starting around 80 Hz to 100 Hz. ASTM standard E-90 states that a laboratory only needs to report data from 125 Hz through 4,000 Hz to get an STC rating, which is far from the total frequency spectrum being reproduced by a standard home theatre system. It is the low frequency (subwoofer) energy that is the most difficult to mitigate. Testing laboratories can only report low-frequency data that can accurately be reproduced in their test facility and have a high level of repeatability and confidence. That means for testing laboratories to accurately measure low-frequency waves, it's necessary for the test rooms to be very large. This is to allow the long wavelengths associated with center frequencies of 31 Hz, 50 Hz, or 63 Hz to become fully developed and diffuse within the space.

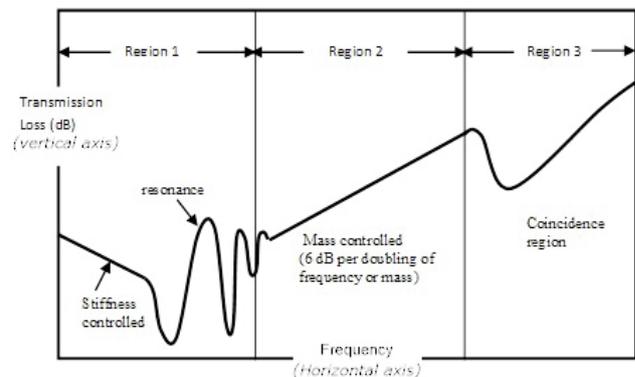
Furthermore, while home theatre designs often recommend a minimum STC rating of 60, STC ratings can also be deceiving. For instance, two different types of high-performance walls can have the same STC-60 rating, but their TL curves can differ. Wall 1 appears to perform better than Wall 2 in the mid- to high-frequencies, and their average dB difference over the TL spectrum is

approximately 8 dB. These decibel differences occur in the "speech frequency" region of human hearing, which makes up most of human speech. Thus, it's crucial to review TL curves for partition assemblies and doors to know what frequencies and at what decibel level the partition assembly will perform, as not knowing this upfront could lead to expensive disappointment later.



Graph 2: TL comparison of two walls with the same STC-60 rating.

It is important to understand the principles governing how partitions vibrate in order to select effective noise-control products within wall, floor, ceiling, and door (partition) assemblies. There are three basic regions of the frequency spectrum that indicate how a barrier reacts to sound energy, as shown in Graph 3.



Graph 3: Transmission Loss characteristics for homogeneous panel.

The first region is stiffness and mass resonance, which includes the low-frequency resonance region (wavy line area of Graph 3). In this region, stiffness alone forces the partition into motion, acting as a large spring. The overall stiffness of a partition influences its ability to radiate sound energy in the low-frequency range just below the low-frequency resonance region. Reducing the stiffness of a partition will improve its ability to attenuate low-frequency sound energy, but partition design is always a balancing act between the structural load requirements, physical space constraints, budgetary constraints, and desired noise-control performance.

As we move up the frequency spectrum in the low-frequency region, there are many low-frequency resonances that are driven not only by stiffness but also by the mass of the overall structure. Low-frequency resonances are not always attributed to mass

alone, but can also be influenced by wave velocity within materials, partition size and thickness, use of structural vibration connections, and cavity air space.

Overall, understanding the principles of partition vibration and resonance can help in selecting effective noise-control products within wall, floor, ceiling, and door (partition) assemblies. It is important to consider various factors such as stiffness, mass, wave velocity, partition size and thickness, and cavity air space in order to optimize partition design for desired noise-control performance while balancing other constraints.

By combining various construction elements and effective products, one can greatly reduce potential design problems or failures.

The following is a list of elements often considered to optimize partition absorption, transmission, and reflection.

1. Increase stud/joist spacing
2. Change stud/joist type (wood versus metal)
3. Increase depth of cavity
4. Fill cavity with acoustical insulation
5. Increase mass of surface boards (careful, don't go over-board!)
6. Introduce multiple layers of surface board
7. Reduce thickness of surface boards while maintaining overall thickness
8. Vary thickness of surface boards
9. Introduce resilient isolation between surface boards and studs/joists
10. Introduce damping compounds between layers of surface boards
11. Change the material and/or component properties of the surface boards
12. Introduce vibration breaks wherever possible
13. Remove or reduce hard surface-to-surface connections between floors and walls
14. Seal any and all gaps or penetrations to reduce air move-

ment through the partition

15. Introduce a noise-rated door or double-door assembly

16. Refrain from introducing regions with little air space available (i.e. center septums or resilient channels fastened over existing gypsum board. These often make things worse instead of better)

17. Decouple vibration sources (such as subwoofers and loudspeakers) from the structure with proper isolation feet.

As you might imagine, close supervision of the trades (framing, HVAC, plumbing, electrical, drywall, etc.) is critical to winning the battle. They are working tightly together as a team. Troup execution is as important as are the battle plans. In closing, this is a basic start toward understanding more about the importance and science of noise control. The article does offer design tips, but should convey the need for professional assistance due to the importance and complexity of acoustics. An experienced acoustician can anticipate, or take actual measurements, and then calculate solutions based on the job goals, and constraints.

Remember that noise control is a two-way street: sound that leaves the space can also enter it. Noise control partitions are system approaches to principals incorporating block, break, isolation and/or absorption of sound waves and vibrations. These systems must adhere to the unique governing weight, thickness, décor, budgetary and/or even "green" requirements of the project. These systems must be designed to address each unique noise-control issue. Anticipated or actual sound-energy levels, their frequency ranges, and their paths must be understood in order for noise mitigation to be designed appropriately. Means of acoustic computer modeling (if new construction) or testing and modeling (if existing) will increase the likelihood of solving problems through proper acoustic design, resulting in a higher performance cinema and a greater experience, whether you're inside it or out.

Our next battle to win before it begins- sound quality. **WSR**



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