Acoustics, Home Theaters, and LEED

By Bonnie Schnitta

Home theater equipment has become so affordable that the once grand home theater has evolved into media rooms throughout a home, including the family room, dining room, exercise room and master bedroom. Even the bathroom can be that pleasure room for a wonderful surround sound experience. The design process for the entertainment room is comprised of two equally important tasks: the acoustic separation or isolation and the acoustic environment of the room. Designing a great acoustic setting for the entertainment room while focusing on these two tasks provides a substantial foundation to the quality of life. Due to the impact that the acoustics of a room has on the quality of life, it in itself, has evolved into a LEED requirement. As Randy Correll of Robert AM Stern Architects once said to me, "Acoustics are an integral part of the architectural design."

Acoustic Environment

Every enclosed space exhibits reverberation, which is sound persistence due to repeated boundary reflections after the source of sound has stopped. Excessive reverberation reduces the intelligibility of speech and music in a room by causing overlapping of successive syllables or tones. A high reverberation time will elevate the sound level and produce an unpleasant noisy room. The correct acoustics of a room can elevate the joy of a person. An acoustically correct room provides other advantages such as:

- The correct reverberation time enhances the audio experience, as well as improves the ability to comprehend and retain spoken information.
- The ideal acoustic environment actually makes a person feel wonderful.
- The reduction of interfering noise eliminates annoyances that can disturb creativity, productivity, sleep, and so much more.

Reverberation in a room can be corrected by mathematically locating and applying acoustic materials such as absorbers and diffusers at various locations on or within the boundaries of the room. Traditionally, this is done with fabric-wrapped compressed fiberglass. With science as the guiding force, the high reverberation time can cleverly be solved with objects that may even seem counterintuitive, but are definitely environmentally friendly products. Examples of rooms that work:

EXAMPLE ROOM 1:

- Replace synthetic carpet with a natural acoustic carpet.
- Replace regular molding with acoustic millwork (LEED points available). Acoustic millwork includes crown molding, base board, ceiling beams, columns, etc.

EXAMPLE ROOM2:

- Put a space between each plank of wood with an absorber behind and between the spaces, as shown in Figure 1.

Figure 1. Example Room Two Installation. In this application a high tech 1/32” fiber free absorber was attached to the beams. Planks of wood were then placed on the ceiling joists with a 3/8” space between each plank. The reverberation time of the room without this treatment was such that speech from the media system would have been difficult to understand. Instead the wood spacing described reduced the reverberation time so that the audio system had pure tones and speech was audible

EXAMPLE ROOM 3:

- Replace pillows with natural acoustic pillows, or add more pillows.
- Insert an absorber behind paintings that do not have glass.

EXAMPLE ROOM 4:

- Install acoustic bookcase inserts, or soft objects on the shelves
- Insert an absorber under carpet.

EXAMPLE ROOM 5:

- Upholster a wall with Dacron underlayment or install acoustic wallpaper on a wall that was previously drywall

EXAMPLE ROOM 6 (Ben Krupinski’s Citta Nueva in East Hampton, as shown in Figure 2):

- Install acoustic wood beams
- Install acoustic panels with an NRC of .85 or greater between the beams

Figure 2. Example Room Six Installation. Acoustically correct and quiet restaurant.

The number of ways a room can be acoustically transformed is endless. Frank Greenwald, an architect in East Hampton, New York, said after experiencing the quietude that resulted from installing acoustic ceiling clouds in his office, "I am now beginning to understand the magic". This magic can be accomplished by contacting an acoustical consultant. Alternatively, if a consultation is not in the budget, an architect can contact a manufacturer of absorbers and diffusers and have them specify the quantity of products to be included in the design to achieve the required reverberation time. It is important to ask if all frequencies have been evaluated, since many materials only address high or low frequencies

Acoustic Separation or Isolation

When designing a home theater or similar active room, the acoustic isolation or separation of the room from all adjoining rooms is as important as the audio system. It would be irrational to install a high-end audio system in a room and never be able to turn the volume to the intended level because someone in an adjoining room (or equally bad, your neighbor) was bothered by the sounds from the room. It is also unpleasant to be listening to music or watching a movie and hear disruptive sounds from an adjacent room such as footfall noise or another audio system. Equally unpleasant is to have the home theater experience disturbed by noise from the heating system, plumbing pipes, or road noise.

Since acoustic separation typically requires the addition of acoustic materials to the walls, floor or ceiling configuration, the design for the separation should be discussed before the interior design that effects the reverberation time is discussed. The acoustic separation or isolation of the room can be divided into three categories of:

- The Sound Transmission Class (STC) of the room's perimeter,
- The Noise Criteria (NC) of the room (fan noise, HVAC noise, road noise, etc.), and
- The anomalies of the room (plumbing noise or conduits feeding other rooms, such as HVAC ducts, central vacuum lines, etc.).

Sound Transmission Class (STC) of the walls, floor and ceiling:

The STC is the rating that estimates the ability of an object or assembly to block sound. Specifically, STC is a single-number rating calculated in accordance with ASTM classification E413 by using values of sound transmission loss. This is a single-number rating for sound insulation. Generally, STC ratings can be interpreted as follows:

25 Normal speech can be understood quite clearly
30 Loud speech can be understood fairly well
35 Loud speech is audible but not intelligible

45 Loud speech is very faint
48 Some loud speech is barely audible
50 Normal speech is not audible, but amplified sound will be audible

60 Minimum requirement for amplified sound

Examples of STC ratings for different configurations:

<u>Configuration STC STC</u>

Standard 2"x4" studs with ½" sheetrock on either side – no insulation 35

Standard 2"x4" studs with 5/8" sheetrock on either side – no insulation 34

Standard 2"x4" studs with ½" sheetrock on either side – with insulation 39

Standard 2"x4" studs with 5/8" sheetrock on either side – with insulation 36

To determine what decibel (dB) reduction is sufficient, there are a couple important facts to keep in mind. First, any improvement less than 5 dB may not be audible or perceivable, so if you are going to do some work (like adding insulation) and all you are going to provide the client is an extra 4 or 5 dB, then the client may view you as wasting their money. This is especially true if the noise is still five or more decibels above background. On the other hand if you are going to bring the overall noise to 3 dB or less than background, then it is worth every penny, since the noise has not been brought to barely perceivable. It is important to remember that dB is a logarithmic measurement.

Table 1. Subjective Perception of Actual Sound Energy Change

[illegible]

0 - 3 dB Barely perceivable 50 %

4 - 5 dB Perceivable and significant 69 %

6 dB Resultant sound 1/4 higher than initial level 75 %

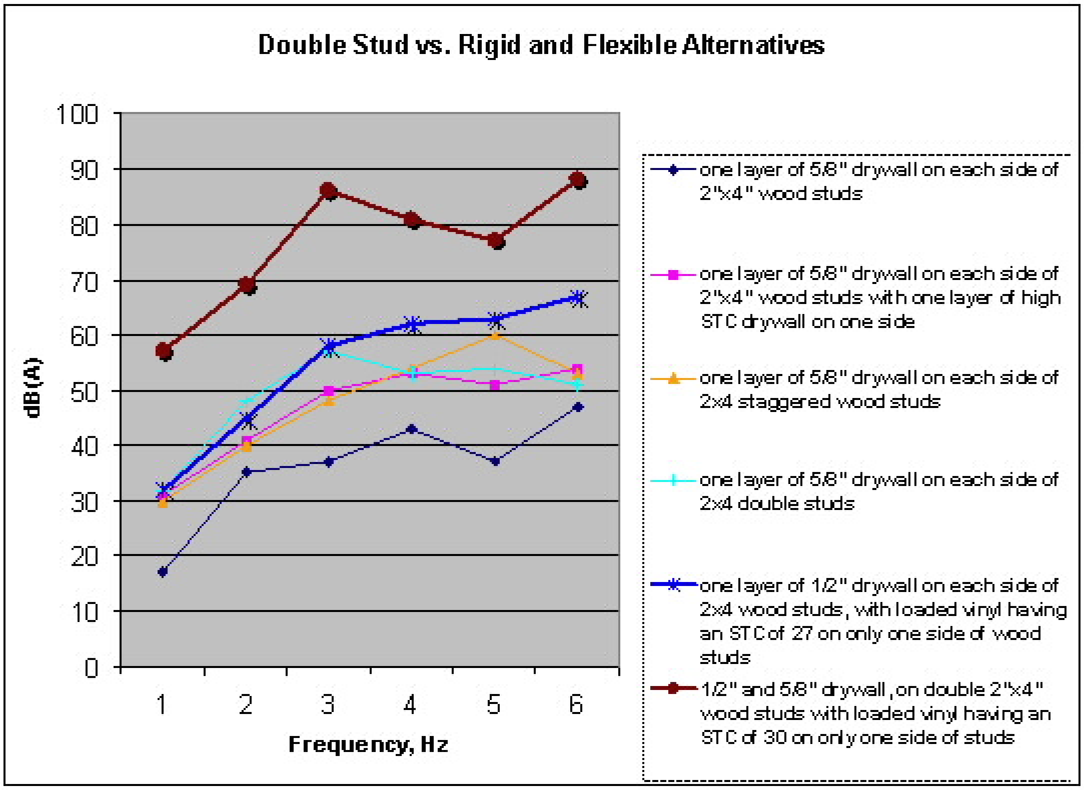
7 - 9 dB Major perceived increase 87 %

10 dB Resultant sound 1/2 higher than initial level 90 %

As children, many of us played telephone by connecting two cups with a string. When you pulled the string taunt (replicating a rigid state much like sheetrock fastened to studs) you could communicate with your friend because sound easily traveled from one location to another. On the other hand when you loosened the string between the cups you could no longer communicate because the sound did not easily travel. Just like the loose string, when a flexible material is added to the configuration, the sound has difficulty traveling.

Now let’s look at these STC values and the transmission loss for each of the configurations.

What becomes obvious is that the STC is not the ultimate guide for choosing a wall; it is actually the transmission loss it provides in the frequency of concern. Graphically it becomes more obvious:



When designing the acoustic separation of a room, it is a good idea to present your client with three configuration options: good, better, and best.

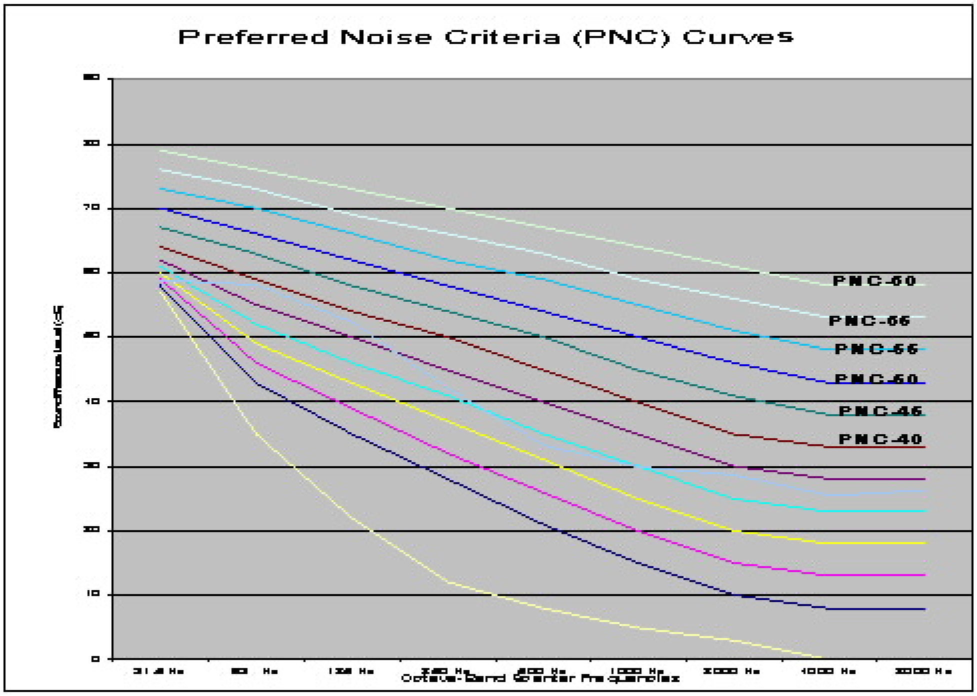
Good: A good, or basic, configuration is one that stops most speech. Reviewing the transmission loss in the speech frequencies, a great configuration at a reasonable price would be one layer of ½" drywall on each side of studs with insulation and a flexible product like a one pound loaded vinyl added to one side of the studs to add mass and decouple the wall. The entire configuration can be upgraded to LEED by replacing the drywall with sustainable wood, the fiberglass insulation with something like recycled cotton, and finally the loaded vinyl (1/8") can be replaced with a flexible product having similar density properties as the loaded vinyl, but it is ¼" thick and is made of recycled tires.

Better: If the client wants something that additionally addresses a great deal of the low or base frequencies, then the client should increase the STC of the wall. A great configuration would be to use a flexible but very dense material like the loaded vinyl with 5/8" drywall and ½" drywall on each side of a double stud configuration with dense insulation in between. If the client has room in their budget, then a product like ½" acoustic drywall should be used in place of the regular drywall. Converting this into a LEED wall would require a similar upgrade, as mentioned above for the "Good" configuration. That is, the drywall can be replaced with sustainable wood, the loaded vinyl would be replaced with recycled tires compressed for a high STC and the insulation would be replaced with recycled cotton, or equivalent.

Best: Finally if the client insists that they want to hear absolutely nothing, then an acoustical consultant should be contacted to review the design and determine if such a request is even possible.

Noise Criteria:

Noise Criteria (NC) is a way of determining if the background noise is acceptable for viewing pleasure. A home theater, like a bedroom, should have a NC no greater than 35, although a 30 is preferred.



Examples of noises that need to be addressed in order for this criterion to be met include:

- **Projector fan noise:** While quiet fans are the easiest solution, active noise cancellation is another alternative.

- **Mechanical Room Noise:** Typically if the wall is decoupled from the studs with a non-rigid material, such as a loaded vinyl, and the studs have insulation, then mechanical noise is minimized, if not eliminated. If this is still a problem, then an absorber on the inside wall of the mechanical room will solve the problem.

- **Footfall:** Locate a LEED product with some bounce, such as cork, under the finish floor.

- **Plumbing Noise:** Use cast iron for waste pipes. All PVC and copper pipes should be wrapped with an acoustic pipe lagging. Insulation alone will not solve the plumbing noise problem

- **Noise from a conduit, such as HVAC, dumb waiter, or central vacuum:** Wrap the exterior of the conduit with acoustic pipe and duct lagging. Line the inside of the duct with a non fiber absorber.

- **Recessed Lighting:** Recessed lights in a ceiling create a hole in the acoustic configuration of the ceiling, thus allowing noises to easily travel from one floor to another. The solution is to use an insulated recessed light or an acoustic high hat muffler above each recessed light. This should always be done in rooms below acoustically critical rooms, such as recessed lights in a kitchen below a bedroom.

- **In-Wall and In-Ceiling Speakers:** Any speaker located in a wall or ceiling must have an acoustic enclosure. The enclosure should be manufactured with a material that not only prohibits the sound from emanating through the house, or apartment, but also does not distort the acoustic wave of the speaker.

- **Caulking:** Caulking (of edges, junctures and cracks) is essential for acoustically enclosing a room. Any penetration of the wall configuration (such as protruding pipes) creates acoustic leakage points.

- **Door:** All doors to acoustically critical rooms (such as bedrooms and bathrooms) should be solid. They should also have mortised acoustic door sweeps and perimeter seals. These are especially recommended for doors to bedrooms next to public areas, such as the master bedroom door.

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