The Paradise Effect

The benefits noise cancellation and how to achieve it

by Bonnie Schnitta, Ph.D.

When I started my career in acoustics over twenty years ago, one area I worked extensively in was adaptive filters. Specifically I worked on adaptive autoregressive moving average scenarios. The adaptive autoregressive model is the core to active noise cancellation. Over the years, my clients continued to express discontent with the noisy projector, HVAC noise, noise from the refrigerator, and the like. I soon realized that in order to continue to provide them with new and innovative ways to achieve what I like to call, "the paradise effect"

Noise cancellation, or active noise control, involves recording the single cycle of a sound wave and transposing a wave with the same amplitude but opposite polarity, the anti-phase. The two waves will have the same frequency but opposite phases. As the waves interfere with one another they create a new wave and cancel out, much like a standing wave. Noise cancellation allows for any sound with a continuous wave, like that of a fan, to be blocked selectively by programming the recording device to the specific frequency of disturbance.

By utilizing active noise cancellation (NC) technology, you can easily address the disturbing noises of projector fans, HVAC units and the like, to ensure that the recommended NC level for a room is achieved.

The Paradise Effect

What does it take to have a perfect acoustic room? What is the paradise effect? What are the criteria for the perfect acoustic room? The design process for achieving perfect acoustics in any room includes three equally important tasks:

- Acoustic Environment: Having a perfect reverberation, or delay time.
- Acoustic Separation or Isolation: Keeping the sounds generated in the room from leaving the room and disturbing other people.
- Meeting a certain Noise Criteria: Minimizing the disturbance of unwanted sounds, like HVAC or fan noise, from disturbing the experience.

Designing a great acoustic setting for the entertainment room while focusing on these three tasks, provides a substantial foundation for the quality of the design of the room and thus of one's life. As Randy Correll of Robert AM Stern Architects once said to me, "you have taught me that 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. The acoustic waves can do many things after bouncing off the walls that can make the room sound awful. Excessive reverberation causes overlapping syllables and tones, which in turn reduce the intelligibility of speech and music in a room. Additionally, a high reverberation time will elevate the sound level and produce an unpleasant noisy room. If the acoustic waves strike another wave in opposite phase when bouncing off the wall, you get what is called a standing wave. A standing wave is nature's version of noise cancellation.

Mathematically locating and applying acoustic materials, such as absorbers, reflectors and diffusers, at various locations on or within the boundaries of the room, can correct reverberation in a room. Typically many home theater designers solve the problem of excessive reverberation with fabric-wrapped compressed fiberglass or diffusers. It is important to remember that there are so many other wonderful ways to achieve an acoustically correct environment.

Once, my company was designing a home theater and a family room. The home theater was truly grand, but the directive on the family room was to keep the design very simple. The family room was identical in shape to the study that was near it. The only construction difference between the two rooms was that the family room had our NoiseOut2 on the studs under the drywall. What was so amazing was that the study was painfully reverberant and the family room, with the NoiseOut 2 under the drywall, "felt" wonderful even before any acoustic treatment was incorporated into the room design. Later, by doing nothing more than placing a carpet on the floor and adding canvas art work with our Paradise Foam tucked behind, the room became acoustically perfect.

With science as the guiding force, the unwanted echo or "too dead" acoustics can cleverly be solved with objects that may even seem counter intuitive, but are definitely environmentally friendly products.

Acoustic Separation or Insulation

The acoustic isolation or separation of the home theater from all adjoining rooms is almost 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 was bothered by the sounds from the room. Equally unappealing is to have the home theater experience disturbed by noise from the heating system, plumbing pipes, or fan 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 prior to planning the interior design, as this will effect the reverberation time of the room. The acoustic separation or isolation of the room can be divided into three categories:

- Sound Transmission Class (STC) of the room perimeters.
- The anomalies of the room (plumbing noise, conduits feeding other rooms, such as HVAC ducts, Central Vacuum lines, Recessed Light Fixtures, etc).
- The NC Criteria of the room (fan noise, HVAC noise, road noise etc).

The 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

Just like loose string between two cans, when a flexible material is added to the configuration, the sound has difficulty traveling. Since acoustic separation or isolation can be of small or significant expense, when designing the acoustic separation of a room it is a good idea to decide which of three configuration options—good, better, or best—fits with the goals and budget.

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 drywall on each side of studs with insulation and a flexible product like a loaded vinyl added to one side of the studs to add mass and decouple the wall. For example, we use a product that is better than the standard one-pound loaded vinyl, since a higher transmission loss in the lower frequency is critical in a successful design.

BETTER: If the client wants something that additionally addresses a great deal of the low or bass frequencies, then the client should increase the STC of the wall. If the client has room in their budget, and space in the layout, then a product like acoustic drywall should be used in place of the regular drywall, such as decoupler clips, or a staggered stud configuration.

BEST: If the goal is to hear "absolutely nothing," then an acoustical consultant should be contacted to review the design and determine if such a request is even possible.

Holes in the Wall

What is critical in achieving the desired STC is to make certain that there are no holes in the room's structure. A hole of only one-inch square in a wall can result in more than a 10dB efficacy reduction. Caulking edges, junctures and cracks is essential for acoustically enclosing a room. Any penetration in the wall configuration is the acoustic demise to the wall. Examples of holes that are often overlooked in the design are:

Plumbing Noise

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

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.

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 to another room, but also does not distort the acoustic wave of the speaker.

Noise from a conduit, such as HVAC

In order to prevent noise from entering HVAC ducts or similar conduits, and traveling to other rooms, wrap the exterior of the conduit with acoustic pipe and duct lagging.

Noise Criteria

Noise criteria determines if the background noise is acceptable for the use of the room. A home theater, for example, should have a noise criteria no greater than 35, although a 30 is preferred.

Some typical items that cause the noise criteria of the room to exceed recommended levels are projector fans, cooling fans and HVAC Units. While quiet fans are the easiest solution to fan noise, there remains a structure-borne component is not addressed. Active noise cancellation is an exciting alternative for addressing the continuous wave disturbances of fan and HVAC noise. •

Bonnie Schnitta is a scholar in the field of acoustics and the founder of SoundSense, LLC, an acoustical engineering and consulting company.