Exposing Acoustical Myths

by Richard Schrag

Acoustics can be a mysterious science sometimes. Logarithmic addition just doesn't come naturally to most of us, and the concepts of sound absorption vs. sound transmission, reflections vs. room modes, and reverberation vs. resonance aren't always intuitive.

Little wonder, then, that applied acoustics -- especially when the application is studio design -- is full of myths, fallacies, and misconceptions. Sometimes it's a misunderstanding of the principles. Sometimes it's taking a grain of truth and using it incorrectly in a different situation. Sometimes it's solving one problem but creating a bigger one in the process. Whatever the cause, a second look at traditional design concepts and construction techniques often reveals that what you thought was true about acoustics isn't always so.

Some of those misconceptions, though, have managed to become such standard practice that they give you ample opportunity to shoot yourself in the foot, acoustically, if you aren't aware of them. This article takes some prevalent acoustical myths -- each of which is encountered frequently in broadcast facility designs -- and shows that there may be a better way to get the acoustical performance you need.

Myth Number One: Absorption Improves Transmission Loss

Absorption means reducing the sound, right? So putting some fuzzy material on my wall will keep my neighbors happy, right? Unfortunately, no. It's true that when sound strikes a surface, some of the energy is absorbed, some is reflected from the surface, and some materials absorb more of the sound than others. In most cases, however, this may do a lot for the sound within the room, but doesn't help much when the problem is sound transmitted through the walls or ceiling of the room.

It's tempting to believe that soaking up all the sound will keep it from going somewhere else, and in fact increasing absorption does reduce the sound pressure levels from a given source. The rooms we live and work in generally have moderate absorption to begin with, though, so in a practical sense it is rarely possible to use "normal" finishes to make order-of-magnitude differences in the overall room absorption. As a result, it is difficult to affect steady-state sound pressure levels in the space by more than a few dB with absorption alone. That doesn't mean that you can't make a room more pleasant to work in or a better monitoring environment, only that you can't make a noisy space significantly quieter by changing the finishes. The harshness of a highly reverberant space doesn't stem from loudness as much as from factors like poor intelligibility and the direction and frequency content of the reflected sound.

Even in a completely absorptive (anechoic) environment, the sound pressure level at a wall surface still has a direct sound component, which is dependent only on the sound energy that the source can produce and the distance from it. No amount of absorption can reduce the level further.

Remember, too, that it is much more difficult to keep low frequency sound from going through a wall than high frequency sound. It is equally difficult to obtain very effective low frequency absorption over, say, a full octave or two. So the effect of absorption on sound isolation is at its least where you need it the most.

Sound absorption can be one effective component of a larger noise control solution for problems involving mechanical equipment, because the sound power of the source is fixed. When dealing with voices or reproduced sound, however, an acoustically "dead" environment sometimes encourages you to speak louder or turn up the volume to compensate. This may offset any reduction in the overall room levels, or may actually make them worse.

The transmission loss through a partition is affected by the mass of the materials used, the thickness and assembly of the barrier, and control of flanking and structureborne paths. Absorption within the rooms on either side of the partition is a relatively minor issue. For sound isolation there is no substitute for heavy, airtight construction, regardless of how you finish it.

Myth Number Two: The Three-Panel Partition

How many times have you seen magazine articles on studio design in which "high performance" partitions are detailed? Often these are touted as "triple walls" or described as a seemingly endless stack of different sheet goods with airspaces interspersed among them. ("We used wallboard plus fiberboard plus wallboard then a 1-inch gap plus wallboard plus rubber plus plywood then a 2-inch gap plus..."). By serendipity these walls may be sufficient for the needs of an individual studio, but they're not always a cost-effective use of materials or available space.

Take the example of a simple double stud partition. Starting with a single layer of gypsum board on the outside faces and cavity insulation (Figure 1a), this wall has a Sound Transmission Class (STC) rating of STC-56. If we attempt to "improve" the wall by putting two additional layers of gypsum board on the inner face of one stud (Figure 1b), the STC rating actually decreases, to STC-53. Following this "more is better" mindset, if we add two more layers of gypsum board to the inner face of the other stud (Figure 1c), the STC rating is still lower, at STC-48. (Never mind the difficulty in actually building this version.)

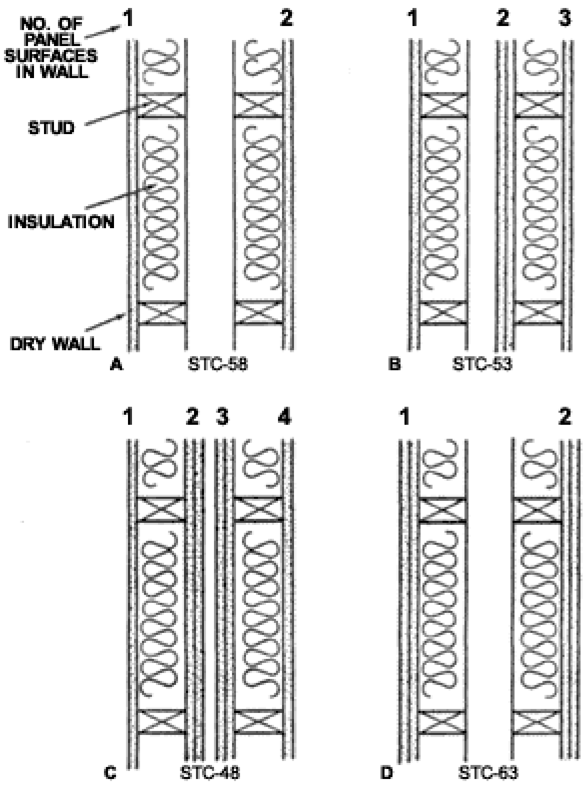

Figure 1. Plan view of a simple double stud partition (a). Adding drywall will actually lower the sound isolation if it creates a trible (b) or quadruple (c) wall. A mass-airspace-mass arrangement offers the best use of materials and space. Additional drywall at the outer faces (d) increases attenuation dramatically.

So what went wrong here? In a cavity wall, the transmission loss depends on the mass (and stiffness) of the surfaces and the thickness (and absorption) of the airspace between them. In this example, putting gypsum board on the inner faces of the studs -- creating a three-panel or four-panel wall -- divides the airspace into smaller segments, and the low-frequency sound transmission loss (which in this case dominates the STC rating) is reduced.

If we merely add one layer of gypsum board to each outer face of the original wall (Figure 1d), an STC rating of STC-63 is achieved. This uses less material and less space than the four-panel wall, but gives significantly better performance. To optimize acoustical performance, how the materials are put together is often more important than what materials are selected.

Myth Number Three: Angled Glass

In traditional studio designs, interior windows -- between a control room and a booth, for example -- very often have two panes of glass, with one or both tilted a few degrees from vertical. (Sometimes it's three panes -- see Myth Number Two.) Several reasons are given for this design technique.

One is that taking the two panes out of parallel eliminates resonances (standing waves) in the air cavity between them, which would otherwise limit the transmission loss at the resonant frequencies. In theory, this is a valid concern. In actual construction, however, there is always a practical limit on the overall thickness of the wall into which the window is built. Tilting the glass out at the top would put its center of gravity further out from the wall, and the structural support provided by the window frame and its attachment to the wall might come into question. Instead, the usual "solution" is to tilt the glass in at the bottom, so that the two panes are very close together at the bottom of the window.

The result is an average airspace between the panes which is sometimes little more than half of what it could be if both panes were vertical (Figure 2). Since sound transmission loss through the assembly is highly dependent on the width of the airspace, the acoustical benefit of angling the glass is often negated by the reduced separation between the panes. Given an overall wall thickness, sound isolation is maximized by maintaining the greatest overall airspace between the panes.

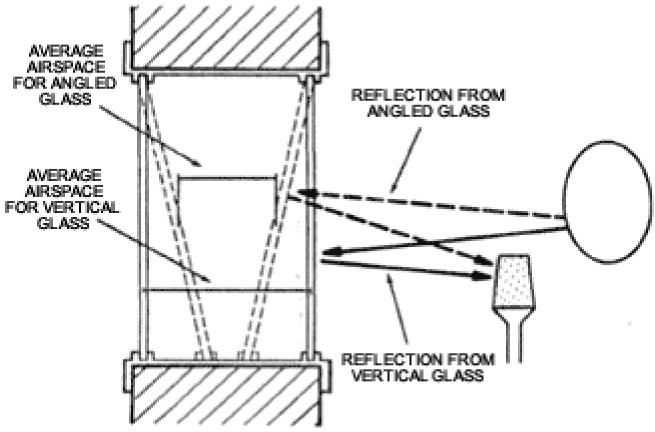

Figure 2. Angling the glass in a studio window reduces the average airspace between the two panes, thereby increasing sound transmission through it. In addition, angling panes to eliminate sound reflections is generally ineffective. Reflections are not eliminated, but simply moved.

A second reason for tilting the glass is to redirect reflections of sound from the window, which due to sightlines through it is almost invariably at a height where reflections into microphones or listeners can occur. Unfortunately, the angle necessary to eliminate this problem is again usually more than the depth of the window frame can accommodate, and the detrimental reflection just occurs from a different point on the glass (Figure 2).

Actually, there are valid reasons to angle glass in double pane windows, but they have nothing to do with improving the sound transmission loss through the window. One is to alleviate flutter echo between the window and another acoustically hard surface on a parallel wall. Another is to reduce the multiple visual reflections which can occur between parallel glass surfaces. Good room geometry and finishes can fix the first problem, and good lighting can fix the second. The acoustical characteristics of the glass, the mounting details, and the interior perimeter absorption have a much greater effect on the sound isolation of the window than the angle of the glass.

Myth Number Four: Acoustically "Transparent" Materials

The sound absorbing properties of standard building materials are often given as a Noise Reduction Coefficient (NRC) rating. Unfortunately, this standard measurement takes into account only speech frequencies, and ignores the extremes of the frequency spectrum. More importantly, it measures the absorption of a material or assembly in a test chamber with random incidence of sound on a relatively small sample.

In practice, absorptive materials are often placed on walls where the sound is almost always at "grazing" incidence, or nearly parallel to the surface. When you drop a rock into the water it sinks, but when you throw it parallel to the water, it will sometimes skip along the surface. Sound behaves in much the same way: many materials which appear "transparent" based on NRC ratings or porosity are actually highly reflective to sound at grazing incidence. One example is perforated metal, which frequently is incorporated into pre-fabricated modular acoustical enclosures to provide an "absorbent" interior surface. If a modular room is shaped to provide a reflection-free zone (RFZ) for a specific listening area, or if loudspeakers are mounted near the perforated metal surfaces, sound will strike the surface at grazing incidence and the absorptive properties will be rendered much less effective than intended.

Whenever acoustical test data is used to select a material or product, make sure that not only the numbers but also the test itself are appropriate for the specific application. If the test conditions don't match the intended use, field performance may be quite different than you expect.

Myth Number Five: The Field-Fabricated Door

Doors are almost always the weak link in the sound isolation of an acoustically critical room. Anything that's operable cannot be built as solid and airtight as a fixed component, and real-life products don't seal completely or stay in perfect alignment.

To make matters worse, some manufacturers promote "acoustical doors" with ratings based on tests in which a non-operable door panel is fixed into an opening. Seeing this, many people (including some studio designers) have made valiant but futile attempts to improve a door's sound isolation performance by making the door panel better. Years ago it was not uncommon to see two solid core wood doors bolted together with a layer of "machine rubber" sandwiched between. (Hey, it may not work, but it sure is bulky and unattractive.)

What is usually overlooked, however, is that the door itself is rarely the limiting factor. The acoustical leaks are almost always worst at the seals around the perimeter of the door. Even the best field-applied door seals can quickly go out of adjustment, and won't consistently maintain optimum contact and closure between the door and its frame.

Figure 4 shows the effect of such leaks on sound transmission loss. If we consider a 3'-0" x 7'-0" door with a gap around its perimeter of only 1/64", the gap represents only 0.1% of the total area. This is enough, however, to effectively reduce an STC-36 door to an STC29 rating. More importantly, if the door is beefed up to stop an additional 10 dB of sound, the composite transmission loss increases only 1 dB. In other words, improving the door panel barely affects the overall performance, since the perimeter seals can't keep up.

Sound-rated doors -- in which the door, frame, and seals are manufactured as an integral unit -- are the only reliable means of getting acoustical performance which is significantly better than a relatively simple door panel and field-applied seals. Alternatively, using multiple doors in a vestibule arrangement or keeping the door opening separated from the noise sources will help obtain appropriate sound isolation.

Myth Number Six: Mostly Right is Good Enough

Failures in studio construction happen more frequently from lack of attention to detail than from an error in the overall design. One typical example is in building a drywall partition: It's carefully erected with isolated stud framing, filled with acoustical insulation, and finished with multiple layers of drywall carried from the floor slab all the way up to the metal deck above.

Later the electrician uses his claw hammer to run some conduit through the wall, and the plumber puts in a sprinkler pipe or two. You note that there are some gaps around these penetrations, and that the drywall doesn't fit into the corrugations at the deck, so you issue instructions that all gaps are to be stuffed with insulation. It seems like that would be harmless enough, but you've probably just wasted half of the effort and materials that went into the wall.

The insulation provides sound absorption, but it isn't a barrier to sound transmission through and around the wall. Even though a 3/4" gap along the top of a 15-foot length of wall represents only one square foot of opening, stuffing it with insulation instead of sealing the gap can limit the wall's overall performance by more than 10 dB. Figure 5 shows two field tests of a drywall partition. The only difference between them is the manner in which the head of the wall was sealed to the deck above -- initially the gap had been stuffed with insulation, but later a barrier designed to conform to the gap was installed and sealed airtight into place. This single modification improved the sound isolation from STC-31 to STC-44.

What's important in facility design and construction is balance. There's no point in putting a great door in an inferior wall, or vice versa. And the best, most expensive partition is only as good as its leakiest electrical box. As the sound isolation requirements of a room increase, the effect of an acoustical weak link becomes more and more devastating. Each of the components must meet the required performance, or they will fail collectively.

Myth Number Seven: You Can't Hear Heat

From the standpoint of audio fidelity, it is desirable to minimize the length of the cables which connect a loudspeaker to its amplifier. What better place, then, for the amplifier but directly beneath the speaker? Unfortunately, if you fall into this trap, saving a few feet of speaker wire may cost you dearly in acoustical problems.

Temperature gradients and air movement between a speaker and listener can drastically affect the sound field. In particular, they are likely to cause perceived shifts in the acoustical stereo image, much like heat rising from hot pavement can distort an optical image. Putting amplifiers directly beneath the monitor speakers allows them to vent heat directly in front of the speakers, and the thermal turbulence creates audible distortion. Similarly, the heat generated by some mixing consoles (coupled with poor ventilation design) ironically renders them unsuitable for use where accurate monitoring is required.

This same phenomena is often observed where air diffusers for the heating, ventilating, and air conditioning (HVAC) systems have been located incorrectly in a room. Figure 6 shows the amplitude difference in a time delay spectrometry (TDS) measurement caused solely by cycling the air conditioning systems in a room where the supply diffusers dumped air directly between the speaker and the listener.

In any critical monitoring environment, even seemingly "non-acoustical" heat sources and air flow must be carefully controlled to maintain a sonically neutral sound field.

Myth Number Eight: Reverberation Time in the Control Room

Articles which discuss the acoustical design of a facility often refer to measurements of "reverberation times" in small spaces such as broadcast control rooms. Some designers have even gone so far as to specify optimum T60 values in the range of 0.5 s or less for small rooms.

The definition of reverberation time involves the statistical decay of sound in the reverberant field of an enclosed space. In a small room, particularly one with the type of absorptive finishes generally found in control rooms, there is no location in the room which can be said to be in the reverberant field, nor do the reflections of sound within the space develop any statistical decay. Certainly the amplitude and time arrival patterns of these reflections are of paramount importance in defining the acoustical environment, but reverberation time is not an appropriate metric to use in quantifying that information.

Many times even the measurements cited for reverberation times in small rooms are questionable. Much of the test equipment used to analyze decay characteristics over full-octave or third-octave bands has a filter slope near the values of the "T60's" themselves. The measurements may have nothing to do with the room; they may be measuring the capabilities of the test gear.

Beware the Acoustical Myth

There are plenty of fallacies and misconceptions in acoustics that could be related here, but you get the idea. Individually, the examples in this article may help you avoid specific pitfalls in studio design and construction. Collectively, they serve to illustrate the dangers in believing what you read in a magazine or see at a world-famous studio. The "it's always done this way" approach may not be based on sound acoustical principles, let alone being the best means to achieve results.

Anytime an acoustical myth can be identified and replaced with a little common sense or objective proof, acoustics as a science becomes a little less mysterious, and we'll all have one less acoustical "truth" that only appears to be true.