Exposing acoustical myths

By Richard Schrag

Acoustical design is burdened by many time-honored misconceptions.

The Bottom Line

Acoustical principles are often misunderstood or misapplied. Much of what passes for knowledge in the field is pure voodoo, and traditional studio design is full of common practices that unintentionally limit or even reduce acoustical performance. Relying on "cookbook" acoustics can be a recipe for disaster. Successful projects avoid the fallacies and "pseudoscience," finding ways to ensure that the money and effort you spend will bring proper and predictable results. $

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.

It is 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 reveals that some acoustical "truths" are false.

Yet some of these misconceptions have managed to become such standard practice that acoustically speaking, they can be downright dangerous 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.

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Myth No. 1: Absorption improves transmission loss

Absorption means reducing the sound, right? So putting some fuzzy material on the wall will keep the neighbors happy, right? Unfortunately, no. It is true that when sound strikes a surface, some of the

Here a sound-rated door is required to maintain balance with the rest of the facility's sound-isolation performance.

energy is absorbed and some is reflected from the surface. It's also true that some materials absorb more sound than others. But in most cases, although this may do a lot for the sound *within* the room, it doesn't help much when the problem is sound transmitted *through* the walls or ceiling of the room.

It is tempting to believe that soaking up all the sound will keep it from going somewhere else. Other things held equal, increasing a room's absorption will indeed reduce sound pressure levels in the room. But the rooms we live and work in generally have moderate absorption to begin with, 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 decibels 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, such as 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 is producing and the wall's distance from it. No amount of absorption can further reduce the level.

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 effective low-frequency absorption over a wide bandwidth (e.g., a full octave or two). So the effect of absorption on sound iso-

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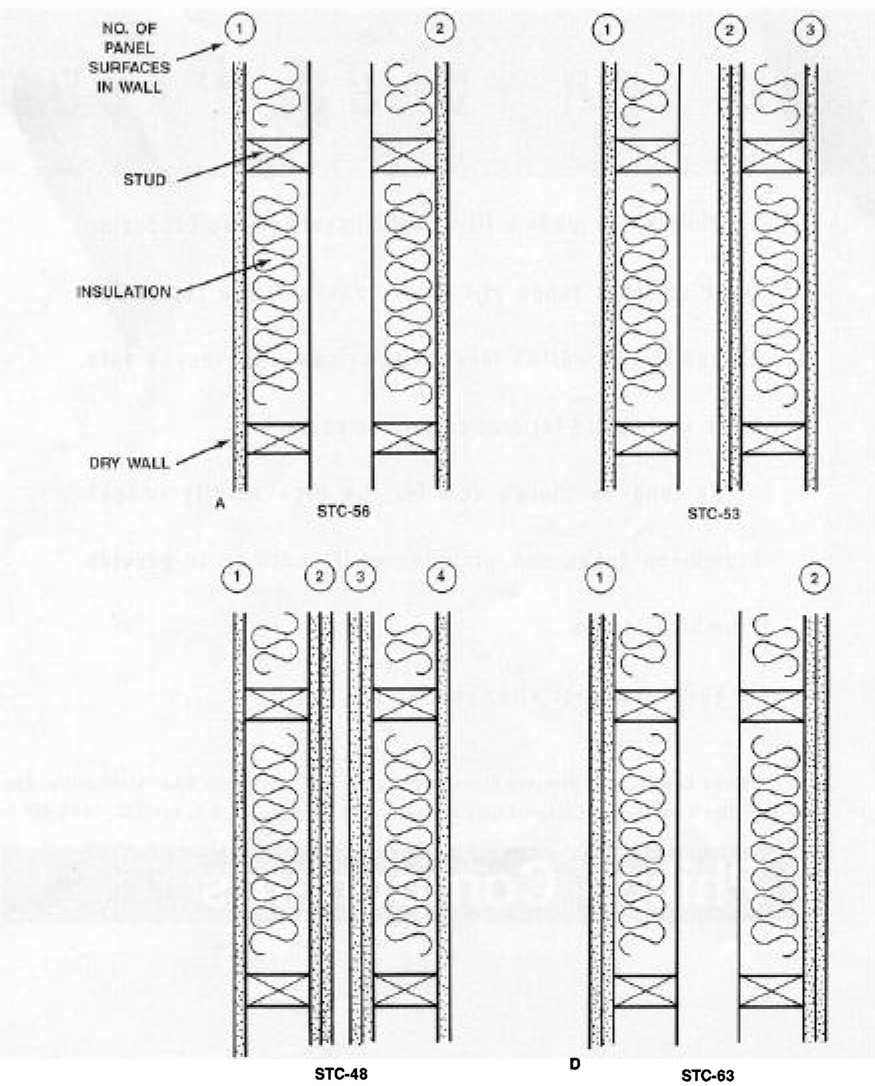

Figure 1. *Plan view of a simple double stud partition (a). Adding dry wall will actually lower its sound isolation if it creates a triple (b) or quadruple (c) wall. A mass-airspace-mass arrangement offers the best use of materials and space. Additional dry wall at the outer faces (d) increases attenuation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

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lation 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. In those cases, the sound power of the noise source is fixed. When dealing with voices or reproduced sound, however, an acoustically "dead" environment sometimes encourages you to speak louder or increase the volume to compensate. This may offset any reduction in the overall room levels, or may actually make them worse.

In the end, transmission loss through a partition is primarily affected by three things: the mass of the materials used, the thickness and assembly of the barrier, and control of flanking and structure-borne 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 No. 2: The 3-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 an attempt is made 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 two more layers of gypsum board are added 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.)

This seems grossly counterintuitive — more barriers should improve attenuation, not reduce it. Remember that in a cavity wall, transmission loss depends on the mass (and stiffness) of the surfaces *and* on the thickness (and absorption) of the airspace between them. In this example, putting gypsum board on the inner faces of the studs — creating a 3-panel or 4-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 only one layer of gypsum board was added 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 4-panel wall (Figure 1c) 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 No. 3: Angled glass

In traditional studio designs, interior windows — between a control room and a booth, for example — often have two panes of glass, with one or both tilted a few degrees from vertical. (Sometimes it's three panes — see myth No. 2.) Several reasons are given for this design technique.

Many people contend 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. Achieving the tilt by spreading the two panes of glass wider apart at their top edges would put each pane's center of gravity further out from the wall, and the structural support provided by the window frame and its attachment to the wall could be questionable. So, the usual "solution" achieves the tilt by moving the glass in at the bottom of the window, thus putting the two panes close together.

The result is an average airspace between the panes that is sometimes little more than half of what it could be if both panes were vertical. (See Figure 2.) Because 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. For a given overall wall thickness, maximizing the overall airspace between panes minimizes sound transmission through a window.

A second reason for tilting the glass is to redirect reflections of sound from the window. Because of sight line requirements, studio windows are almost always at a height where significant reflections into microphones can occur. Usually the angle necessary to eliminate this problem is more than what the window frame's depth can accommodate. The detrimental reflection just occurs from a different point on the glass, as Figure 2 also illustrates.

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 reason is to alleviate flutter echo between the window and an acoustically hard surface on a parallel wall. Another is to reduce the multiple visual reflections that can occur between parallel glass surfaces. But the optimal solutions allow the glass to be kept vertical, relying on good room geometry and finishes to fix the first problem and proper lighting to solve the second.

In any event, the acoustical characteristics of the glass itself, the mounting details, and the interior perimeter absorption (on the boundary surfaces of the space between panes) all have a much greater effect on the sound isolation of the window than the angle of the glass.

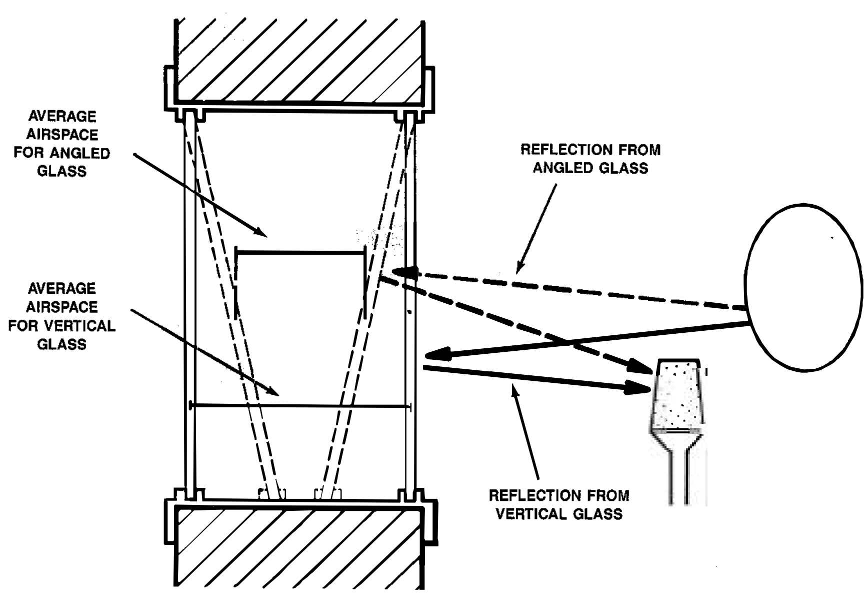

Figure 2. *Angling the glass in a studio window reduces the average airspace between the two panes, thereby increasing sound transmission through it. In addition, angling panes to eliminate sound reflections is generally ineffective. Reflections are not eliminated but simply moved.*

Myth No. 4: 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 audio spectrum. More important, 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 that 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 prefabricated 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.

Myth No. 5: The field-fabricated door

Doors are almost always the weak link in the sound isolation of an acoustically critical room. Moving parts cannot be built as solidly and airtight as fixed components, 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 common to see two solid core wood doors bolted together with a layer of "machine rubber" sandwiched in between. Hey, it may not work, but it sure is bulky and unattractive.

What is usually overlooked, however, is that the door panel itself is rarely the limiting factor. The acoustical leaks are almost always worse at the seals around the perimeter of the door. Even the best field-applied door seal can quickly go out of adjustment and lose optimum contact and closure between the door and its frame.

If we consider a 3′ × 7′ door with a gap around its perimeter of only 1/64 inches, the gap represents only 0.1% of the total door area. This is enough, however, to effectively reduce an STC-36 door to an STC-29 rating. More important, if the door panel is beefed up to stop an additional 10dB of sound, the composite transmission loss increases only 1dB. In other words, improving the door panel barely affects the overall performance, because the perimeter seals aren't improving in a proportional manner.

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 that 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 No. 6: 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 dry wall partition.

Assume that such a partition is carefully erected with isolated stud framing, filled with acoustical insulation, and finished with multiple layers of dry wall carried from the floor slab all the way up to the metal deck above. Later the electrician uses a 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 dry wall doesn't fit into the corrugations at the deck, so you issue instructions that all gaps are to be stuffed with insulation. That seems 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-inch 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 10dB. Actual field tests of a dry wall partition of these dimensions confirm this. 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 is important in facility design and construction is *balance*. There is no point in putting a great door into 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 No. 7: Reverberation time in the control room

Articles that discuss the acoustical design of a facility often refer to measurements of "reverberation times" (T_{60}) in small spaces, such as broadcast control rooms. Some designers have even gone so far as to specify optimum T_{60} values in the range of 0.5 seconds 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 that is 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-of-arrival patterns of these reflections are of paramount importance in defining the acoustical environment. However, reverberation time is not an appropriate metric to use in quantifying that information.

Often, 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 "T_{60s}" themselves. The measurements may have nothing to do with the room; they may be measuring the capabilities of the test gear.

Myth No. 8: You can't hear heat

From the standpoint of audio fidelity, it is desirable to minimize the length of the cables that 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 attendant acoustical problems.

Temperature gradients and air movement between a speaker and listener can drastically affect the sound field, much like heat rising from hot pavement can distort an optical image. This is most commonly noticed at windy outdoor concerts, where the frequency response of a distant PA speaker stack seems to be changing. The cause of this is not the wind "blowing the sound around" and changing its direction by pulling it along with the moving air, as is commonly thought. It is the result of the sound waves passing through air temperature gradients introduced by the moving air currents. The frequency-dependent refraction (bending) of some sound waves and not others results in the changing frequency response. The actual propagation direction of the sound remains relatively unaffected.

In the control room, this same phenomenon can cause perceptible effects, most frequently noticed in shifting of the acoustical stereo 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. 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.

Beware the acoustical myth

Many more fallacies and misconceptions in acoustics than what we have related here exist, 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 everything 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 be the best means to achieve desired results.

Any time an acoustical myth can be identified and replaced with a little common sense or objective proof, acoustics as a science becomes less mysterious, and one less acoustical "truth" will be preached as gospel. ■