Market Trends Drive the Need for Effective Sound Solutions

Acoustically enhanced gypsum board and other options offer efficient ways to build better partitions

Provided by National Gypsum Company

Noise is an increasing concern in structures of all types. Skyrocketing land costs have spurred high-density multifamily housing and office construction in a growing number of markets in the United States. Nationwide, retirement-age baby boomers are diversifying from single-family homes to condominiums and townhouses. In high-rise housing, individual living units are closer together than in traditional single-family dwellings—putting tenants in position to hear sound from neighboring units. Noise is also a potential problem in single-family dwellings where home theater systems are becoming more prevalent in use and sophisticated in technology, resulting in the possibility of more noise being transmitted between spaces. Schools, hospitals, retirement homes, hotels and resorts are also seeking methods of keeping rooms quiet, and are increasingly looking for ways to control sound among areas within their facilities.

Such changing market dynamics have meant an increased need for wall partitions that can reduce the transmission of airborne sound between spaces within buildings. In addition, in many places specific levels of acoustical performance are mandated by building code.

While some acoustical solutions have existed for decades, manufacturers have also responded to the growing need for sound control with new products that achieve the same or better results with easier and more reliable installation, as well as lower material and labor costs and less floor space.

Among the challenges to architects and owners is to be aware of all the available solutions and to understand which are consistent with the goals of a particular project. This article will discuss the ways in which acoustical control can influence building design. The comparative advantages of traditional and new sound-damping solutions will be highlighted, as will best practices in increasing STC performance of wall partitions.

Markets for Increased Sound Control

Construction of apartments, townhomes and condominiums is on the rise. To illustrate this point, consider the housing situation in San Diego, California, the nation’s eighth largest city and one of the most expensive housing markets in the United States. In 2006, building permits in San Diego for multifamily housing units exceeded those for single-family residences for the first time since 1986.

Multifamily housing, with hundreds of families living in close proximity, brings on the potential for noise-related complaints. In a national survey of 1,500 adults conducted by Alan Newman Research, noisy neighbors were the single most frequently cited annoyance of those living in multifamily dwellings. More than 60 percent cited housing neighbors through the walls as the top noise complaint, with more than half identifying loud music as the chief source of that noise.
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Key Acoustical Terms and Concepts
Understanding key acoustical concepts is critical in order to gain an understanding of the way in which sound is transmitted through walls, as well as human sensitivity to changes in noise levels.

Airborne Sound: Airborne sound consists of energy generated by a source, transmitted through a medium, and detected by a receiver. All three of these conditions must be in place and airborne sound cannot exist. The level of airborne sound is determined by the frequency of vibrations. This measure of frequency is given in hertz (Hz). The unit hertz can be thought of as the number of sound waves that pass a fixed point within a given amount of time. For example, frequencies between 20 Hz and 20,000 Hz are detectable by children. As people age, their ability to hear high-frequency sounds is significantly diminished. Humans are most sensitive to sounds in the range of 100 Hz to 5,000 Hz. Speech and other traditional sounds within a building range from 125 Hz to 4,000 Hz, which is the frequency range considered when calculating STC.

Decibels: The units decibels (dB) are used in acoustics to calculate the intensity or loudness of sound and to provide a relative measurement of sound level. Higher dB levels relate to loud sounds while lower dB levels relate to quiet sounds. A change of 3 dB would be barely noticeable to most human ears, while a change of 5 dB would generally be noticeable to the average person. An increase of 10 dB would sound twice as loud, and a decrease of 10 dB would sound half as loud. It’s important to note that the decibel scale is not linear. For example, the sound of a conversation (55 dB) with that of a lawnmower (85 dB) the lawnmower is not twice as loud as the conversation, but several orders of magnitude louder—a critical factor to observe when considering construction materials to prevent external noise from being heard inside a building.

Measuring Noise Reduction
Both government and industry standards were established to achieve acceptable noise levels in residential and commercial construction. U.S. standards are based primarily on a system that measures how well walls, floors, and doors prevent noise intrusion from adjacent rooms. That system is known as Sound Transmission Class, or STC. STC is a single number rating of the effectiveness of a material or construction assembly to retard the transmission of airborne sound. It provides an indication of the volume at which transmitted sound is perceived by the listener. The higher the STC value, the more effective the assembly or material in reducing sound transmission.

For interior walls, STC values are derived by conducting a test according to a procedure outlined in ASTM E 90, “Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.” ASTM E 90 is designed to measure how well building materials or specific wall assemblies reduce the transmission of airborne sound at 16 frequencies between 125 Hz and 4,000 Hz, which is consistent with the frequency range of speech and constitutes a wide range of airborne sounds at different pitches.

The ASTM E 90 test procedure is essentially conducted in the following way: In a controlled laboratory environment, a specialized wall partition is built between two rooms—the source room, where airborne sound is emitted, and the receiving room, where the sound is received and measured in decibels. An airborne sound source from the source to the receiving room, it naturally tends to decrease in decibels. The greater the level of decrease, the higher the STC rating.

ASTM E 413 calculates ratings for both laboratory and field measurements of sound attenuation. The test data collected would be analyzed using ASTM E 413, “Classification for Rating Sound Insulation.” The result is a single-number acoustical rating. The higher the STC rating, the greater a partition’s ability to reduce transmission of airborne sound from one side of a partition to another. Higher STC ratings will reduce typical noise from an adjoining room, including normal or loud conversation, a baby crying, dogs barking or sounds made by kitchen appliances.

Acceptable STC Ratings for Wall Partitions. In determining an acceptable STC rating, the industry generally turns to a prominent study by the National Research Council of Canada, “Deriving Acceptable Values for Party Wall Sound Insulation,” by J.S. Bradley. Looking at the attitudes of residents in 600 multifamily units with 300 party walls between them, the study found that residents with lower STC-rated walls were more likely to be awakened by noises, have trouble falling asleep due to noises, and think their neighbors were less considerate. They were also more likely to want to relocate. The study concluded that an STC rating of 50 was the greatest goal for acceptable sound insulation and that an STC rating of 60 would virtually eliminate negative effects of noises from neighboring units.

The results of the Canadian study are reflected in the federal noise-reduction standards used by the United States Department of Housing and Urban Development (HUD). HUD uses a three-tier system for rating construction quality in terms of sound attenuation. An STC-35 or above is the criterion for the highest rated Grade 1 dwelling. Ultra-high-end dwellings may incorporate wall partitions of up to STC-45. HUD’s Grade 2 building indicates an STC-50 rating. Grade 3 signifies a rating below STC-50. In the national building code, the minimum allowable rating for multifamily construction is STC-50.
Music-related sounds may require some of the highest STC ratings, which is important to note as local music is the chief noise-related complaint reported by residents of multifamily dwellings. In practical terms, an STC-50 rating will enable the resident of a multifamily dwelling to remain undisturbed by a neighbor playing a loud sound system. With an STC-60 rating, loud music will be reduced to the level of a normal conversation by the time it passes through the shared wall. It is important to note that the STC ratings relate only to airborne sound, they do not apply to “structural” sounds such as footsteps or structural vibrations from street noise or airplanes flying overhead.

Achieving Acceptable Noise Levels: Design Considerations in Acoustical Wall Partitions

There are three strategies to reduce noise in buildings: eliminating the source of the noise; using sound-absorbent rather than sound-reflective materials; installing sound barriers to prevent sound transmission into adjoining areas. Most of the solutions in current use fall into the third category. Several techniques can be used alone or in conjunction with others to achieve a higher STC rating. With the goal of decreasing the amount of sound transmission through the partition, the following five variables can have an impact on the ability of the partition to provide this desired loss.

WAYS TO AFFECT SOUND TRANSMISSION

Increasing Mass. Increasing the amount of material sound waves must penetrate to reach the adjoining room is an obvious tactic. More mass means sound waves must spend more energy to flow through the wall. Using multiple layers of gypsum board is one solution that can reduce sound transmission from room to room. Increasing mass in a cost- and space-effective way presents its own challenges, however. The sheer amount of mass needed to reduce desired levels significantly may require a wall thickness that is impractical for a building.

Eliminating Stiffness. Flexibility in the wall assembly will promote sound absorption; conversely, too much stiffness will reduce transmission loss. For that reason, replacing wood studs with metal studs, which inherently have more give to them, is a preferred practice and results in better acoustical performance. In general, less framing will achieve superior acoustical results, with 24-inch o.c. framing spacing outperforming 16-inch o.c. framing.

Increasing Damping. Damping is a technique for dissipating vibrational energy in a structure. Hence, decreasing the amount of energy allowed to pass through to the next room. Damping consists of one or a combination of materials applied to the wall interior to boost its ability to reduce mechanical energy. All materials demonstrate some damping, though many materials are actually effective radiators and transmitters of sound.

Increasing Cavity Depth. Increasing the depth of the wall cavity between wall panels is a two-pronged method that can increase the thickness of the overall partition, and thus increase the amount of sound transmission loss, particularly when the cavity is filled with acoustical insulation.

Providing Cavity Absorption. Another way to control airborne sound from room to room is through the use of materials that absorb sound by converting sound waves into heat. Adding sound-absorbing material such as fiberglass or mineral fiber-insulation to the cavity of a partition will increase the amount of sound transmission loss. The sound-absorbing material should completely fill the cavity but not be compacted or compressed in any way. Any gaps in the wall cavity should be filled.

Sound Reduction Solutions

There are a range of products that will improve the acoustical performance of a wall partition through one or a combination of strategies outlined above.

Acoustically Enhanced Gypsum Board. Mass and damping are important features in a wall’s ability to achieve a higher STC. These features are incorporated in acoustically enhanced gypsum board, a new product on the market to reduce sound transmission. This product incorporates increased mass by using gypsum board with a high-density core in an arrangement known as constrained layer damping.

While the introduction of structural damping will increase the amount of sound transmission loss, combined layer damping, in particular, is more effective. Constrained layer damping can be a three-layer “sandwich” system constructed from attaching a base layer to a damping layer and adding a third constraining layer. In acoustically enhanced gypsum board, constrained-layer damping, a new form of noise reduction, is achieved through the use of a middle layer containing viscoelastic polymer sandwiched between two pieces of enhanced high-density gypsum board. A form of plastic, the viscoelastic polymer absorbs and dissipates noise by converting the vibrational energy of sound waves into negligible heat. Acoustically enhanced gypsum board is appropriate for use as a single-layer application or as a component of multi-layered wall assemblies where sound transmission between rooms or dwelling units is a concern. The gypsum board can be mold-resistant, if need be.

A key advantage of this type of product is that the entire wallboard panel can be produced in a typical 5/8-inch gypsum board for use in the construction of high STC-rated wall assemblies. Because the solution relies on constrained-layer damping rather than structural isolation, no additional depth is required in the wall cavity, as is the case with many typical sound-reduction solutions. As a result, architects and building owners can benefit from the ability to maximize floor space in each unit.

Because acoustically enhanced gypsum board can be installed like traditional gypsum board, it is able to offer a more reliable and less complicated solution than alternative methods that require clips and channels, and where the possibility of improper installation is a key concern. Another advantage of acoustically enhanced gypsum board is that it is easily finished and can be decorated in the same manner as standard gypsum board.

Fire Resistance Ratings

While most acoustically enhanced gypsum board cannot be used as a substitute for 5/8-inch board in a fire-rated assembly, it can be used as an additional layer in all UL fire-rated assemblies without compromising the fire rating. Upgrading such an assembly with an acoustically enhanced product can increase the STC rating by as much as 10 points while maintaining its fire rating. As an option, the acoustically enhanced product may be used as an additional layer on one or both sides of fire-rated wall assemblies. When acoustically enhanced gypsum board is installed between the...
Through it cannot be used as a substitute for 5/8-inch Type X board in a fire-rated assembly, acoustically enhanced gypsum board may be used as an additional layer on one or both sides of fire-rated wall assemblies, such as the US08, UA400 and VA40 series wall and partition designs described in the Fire Resistance Directory. The profile illustrated is a 1-hour-rated fire wall with a 0.5-inch wall thickness. It is applicable as a demising wall between high-rise residential units or hotel rooms, as a corridor wall in these same applications, and as a wall in a commercial office or educational setting with a high sound-transmission class (STC). While the building code minimum in many areas is an STC of 55, most users look for an increased performance of 55 or more. The wall in the illustration with an STC of 57 provides a 0.3-foot ceiling on an already-high-STC-rated wall. Fire-rated acoustically enhanced gypsum board comes in STC ratings of 51 to 61.

Acoustically enhanced products are available in 4-foot-wide panels in lengths of 8 feet, 9 feet, 10 feet and 12 feet, and in a variety of profiles, including standard wood- and metal-frame designs and 1-hour-rated metal-stud wall designs with STCs ranging from 53 to 61. Architects should be aware that the use of acoustically enhanced products in actual installations may not produce the same results as those achieved in controlled laboratory conditions.

Resilient Furring Channels. Resilient furring channels are designed for sound control by separating the gypsum board from framing members, thereby eliminating a direct pathway for the transmission of noise and vibrations from adjoining areas. In use since the 1940s, resilient furring channels are inserted between one gypsum layer and the wall frame, and can add as many as five STC points. Acting as a shock absorber, the resilient channel softens vibrations coming from either side of the wall. Not all channels are acoustically effective resilient channels. Not channels, c-channels, and other lightweight metal furring systems may be similar in appearance, but they are too rigid to offer any acoustical benefit.

Resilient furring channels suffer a long history of high failure rates partly because of their potential for faulty installation. It is important to install them correctly as improper installation can null any acoustical benefit. Resilient channels have a wide flange and a narrow flange, with a slotted element in between. On walls, channels should be installed perpendicular to the framing with the narrow flange along the bottom. A common mistake is to install the furring channel upside down, which severely reduces and can even negate its soundproofing effect.

When installing gypsum board the screws should be connected to the channels between the studs or joists. Screwing the board to the wall behind them will “short circuit” the resilient channels because such an unfilled connection defeats their acoustical benefit. Using screws of incorrect lengths will cause the screws to penetrate into the stud framing, to similarly negative effect. Walls should have a slight line to them when resilient channels have been properly installed. If it is not possible to flex the wall, the channels may have been shorted out by screws fastened into the framing.

Even if the system is installed properly, the solution can very likely be inadvertently compromised by the building occupants. Even inserting a nail into the wall in order to hang a picture, bookshelf or even from can “short circuit” the acoustical solution if the nail causes the gypsum board to come in contact with a stud.

Staggered or Double-Stud Walls. A double-stud wall is literally two separate rows of studs, top and bottom plates installed and separated from each other. Staggered or double-stud walls will also structurally decouple, or mechanically separate, the two sides of a wall to make it harder for sounds to pass through. Staggered walls are constructed by using a common plate wider than the two rows of offset studs. Studs are set in a stagger pattern, with each side of the wall attached to a different set of studs. With no common framing of the walls, sound is not directly transmitted from one wall to another. The drawback of staggered or double-stud walls is that this construction tends to increase labor and material costs. Furthermore, the depth of the required partition takes up valuable floor space.

Sound isolation clips. Based on the premise that only isolation can effectively reduce low-frequency noise, sound isolation clips are used together with furring channels to facilitate the gypsum board to the wall assembly while simultaneously eliminating the hard connection of the wall substrate to actual structural members. In this way, the wall design provides acoustical decoupling. Clips attach easily to wood, steel, or concrete and can add up to 2X STC points to most walls. Here again, relatively higher labor and material costs for wall construction are a disadvantage. In addition, the large number of parts and pieces required for a sound isolation clip system make for a complicated installation with significant potential for error.
LEARNING OBJECTIVES

After reading this article, you should be able to:

- Discuss trends driving the need for wall partitions that can reduce sound transmission
- Explain key acoustical terms and concepts
- Specify the appropriate sound control system for your projects

Questions

1. Which of the following is NOT a possible source of airborne noise?
   - A. Airplanes
   - B. Neighbor's conversations
   - C. Passing trucks
   - D. Boat music

2. The level of airborne sound is measured by decibels.
   - A. True
   - B. False

3. Which of the following is a non-structural solution for sound isolation?
   - A. STC 55
   - B. STC 60
   - C. R-30
   - D. R-25

4. Which technique is used to reduce sound transmission through a wall?
   - A. Increasing the wall cavity
   - B. Increasing window glass
   - C. Using wood studs
   - D. Using stone blocks

5. One new product in the field of sound isolation is:
   - A. Resilient channel systems
   - B. Acoustically enhanced gypsum board
   - C. Sound clips
   - D. Sound fiber sound board

6. Resilient channel systems achieve sound control by:
   - A. Separating the gypsum wallboard from the framing members
   - B. Adding mass
   - C. Increasing structural damping
   - D. Adding absorptive materials

7. A drawback of sound isolation clips is:
   - A. Adding too much mass
   - B. The increased number of gaps, complicated installation
   - C. Poor performance
   - D. That too much floor space is required

8. Sound-reducing wall partitions often do not live up to their STC ratings because:
   - A. Poor design
   - B. Inferior materials
   - C. Faulty installation
   - D. Unrealistic goals

9. Installation of acoustically enhanced gypsum board is:
   - A. Very difficult
   - B. Best over an insulating blanket over the framing members
   - C. Challenging because it can lead to 'flanking paths'
   - D. Similar to the installation of standard gypsum board

10. In laboratory testing, 'flanking paths' that ease sound transmission are attenuated.
     - A. True
     - B. False

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Material resources used: Article: This article adds a resource in sound transmission and safety.

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National Gypsum

National Gypsum is a fully integrated manufacturer of building products worldwide. Primary emphasis is on Gold Bond gypsum board, Performance drywall finishing and Petroleum coated board products, in addition to an UF family of abrasive, impact, mold and moisture resistant products and newly introduced SoundBreak, an acoustically enhanced gypsum board.
SPECIFIC APPLICATIONS

Acoustically enhanced wall solutions can be used anywhere that sound transmission between spaces is a concern. Typical applications include:

- Residential Buildings
- Area separation walls within multifamily dwellings
- Walls separating bathrooms from other rooms
- Home theaters
- Commercial and Institutional Buildings
- Board and conference rooms
- Walls separating mechanical rooms from occupied spaces
- Interior walls of luxury hotels
- Interior walls of examination rooms
- Walls separating classrooms from other areas

Wood Fiber Sound Board. This semi-rigid building material composed of wood fibers and binders, compressed under heat and pressure into large panels of various sizes, presents another solution for reducing sound transmission. Sound board can be used in a damper layer between studs and gypsum board to improve STC ratings. The extra labor and material cost combined with a relatively minor performance improvements are the main disadvantages of wood-fiber sound boards as an effective sound solution.

Installation Concerns

To realize the full potential of any sound-reduction product, correct installation is critical. In many cases, what tests well in the laboratory may not perform up to its advertised STC rating in real-life situations. One reason for this is the complicated installation required in some sound-control solutions discussed above.

To recap, resilient channel systems are particularly prone to installation mistakes; any “hard” connections between gypsum board and studs will reduce the assembly’s flexibility and thus virtually eliminate the promised benefit of sound transmission loss. Other existing solutions rely on adding multiple layers of gypsum board to increase mass. All of these solutions involve added material and labor costs and result in deeper wall cavities, which consumes valuable floor space. A typical wall assembly using resilient channels can be up to 1 1/2 inches thick. A double-stud assembly can be even thicker—up to 5 inches or deeper in some cases.

When specifying an acoustically enhanced gypsum board, the issues for the architect include criteria for sound control on one hand, and fire ratings within the prescribed budget on the other. Yet another critical point is whether the wall assembly is contractor-friendly—so that actual installation performance meets the designer’s expectations for sound control.

Acoustically enhanced gypsum board is installed like regular gypsum board as described in the Gypsum Association publication GA 716-1994. With this relatively easy installation process, acoustically enhanced products are not prone to “short-circuit” events as they are not dependent on maintaining separation between the gypsum board and the framing studs.

Cutting acoustically enhanced gypsum board requires scoring deeply from both sides of the board before snapping, or the use of a hand or power saw. Installation recommendations are relatively straightforward and involve staggering board joints from one side of the wall to the other; limiting wall penetrations to one stud per cavity; and using ASTM-approved acoustical sealants, caulk, and putty pads. Installing acoustically enhanced gypsum board over an insulating blanket, applied continuously across the face of the framing members, is not recommended. Blankets should be removed and flanges attached to the sides of the studs or joints. When storing acoustically enhanced gypsum board off the ground—and ideally under cover—sufficient rows must be used to ensure support for the entire length of the gypsum board to prevent sagging.

Flanking Sound. Unfortunately, wall assemblies are often specified to meet the minimum building code criteria for STC ratings, but the details are ignored—a scenario that can have adverse impact on overall sound isolation. That oversight can be exacerbated by the fact that new building inspection departments often lack the expertise to conduct compliance testing with sound-isolation measures. A key consideration here is specifying and designing the full path to prevent “flanking” sound-transmission pathways. Flanking pathways are construction conditions that let noise sneak around the main wall or floor.

Sound will find its way through any weaknesses in the building’s design. These areas are known as flanking paths, and are labors of nature. To laboratory testing, flanking paths are eliminated and only the direct path is measured. In the real world, the transmission loss values of a structure can be lower due to sound passing through void walls, doorways, floor boards, and cable glands in the structural system. Doors and windows, for example, are often acoustically weak and can significantly reduce the acoustic insulation of a facade or wall. Often the transmission along these flanking paths seriously reduces the sound isolation between units. Proper use of acoustical sealant or caulk can reduce its effect. Lack of caulking, blocking, or other measures that will prevent flanking sound transmission can reduce the overall STC significantly. For best results, all perimeter gaps and non-performing gypsum board edges should be completely sealed with acoustical sealant or caulk. An unsealed 1/4-inch gap around the perimeter of a 100-square-foot wall partition with an STC in the 50s will result in a loss of over 10 STC points. This kind of design and installation prevention can potentially save a project from a post-construction lawsuit.

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