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Sound Control

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Sound Control

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Sound Control in Residential Construction

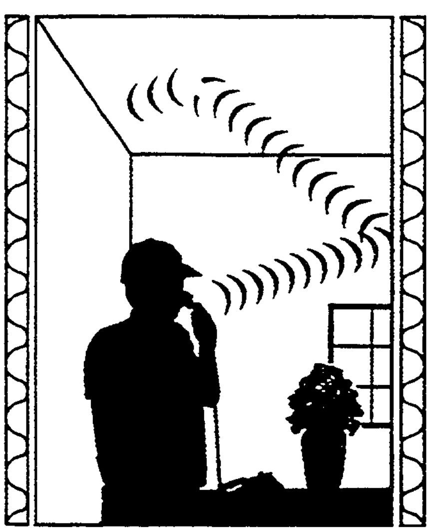
Sound Control

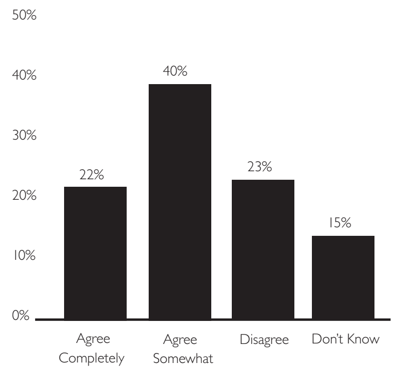
Overview

Interior sound control construction practices have been an important consideration for both multi-family and commercial construction for many years. Traditionally, interior sound control for single family construction has been limited and generally reserved for high-end homes. However, things are changing, meaning new opportunities for increased insulation sales.

The growing trade-up market, fueled primarily by baby boomers, is finding a more demanding home buyer. Customers who have previously owned homes know what they want, and don't want, in a new home. They are more interested in the detail and finishing touches that add quality, including sound control within the home. Those who are moving up from tract or production-built homes are especially aware of interior household noise.

In addition, recent lifestyle changes are moving the family and home back into the center of our lives.



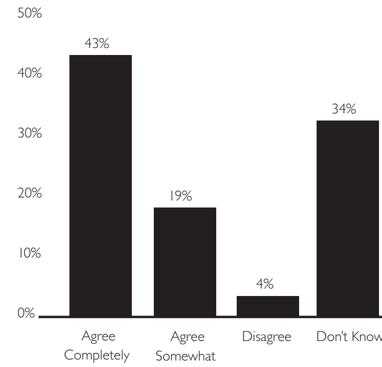


Reducing the noise level in a home is more important than it used to be.

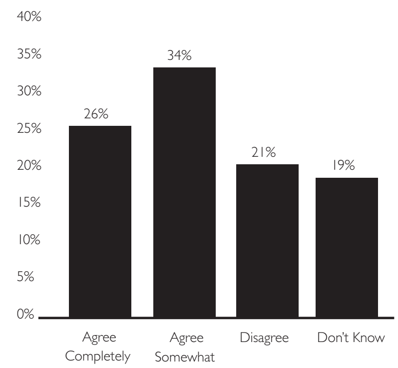
Amenities, layout and well-planned spaces that can increase the quality of family life are key. Not only is there an increased focus on comfortable family living spaces, such as kitchens and family rooms, but on private spaces as well. Home buyers are looking for secluded retreats in bedrooms and baths, where individual family members can have privacy and quiet, away from other household activity.

With quality, comfort and quiet becoming top priorities for home buyers, there is an increased interest in sound control, substantiated by a recent consumer survey. Over 60% of the homeowners surveyed felt that reducing the noise level in a home is more important than it used to be, saying they would be interested in a new home that was designed to be quieter. Further, 35% said they would pay as much as an additional $500 to reduce that noise level in a new home.

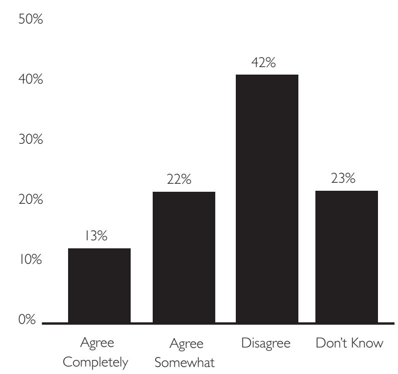
The survey also identified critical areas for sound control and privacy in a home. Respondents noted that they would be most



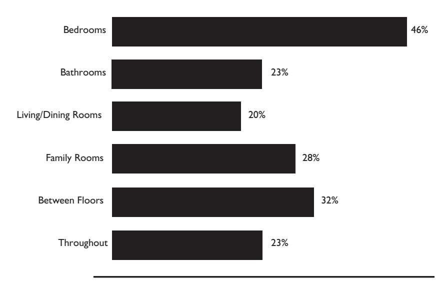
Whenever I have looked at new homes, the salesperson almost never talked about sound control features.



I would be very interested in a new home that was designed to be quieter.



I would pay as much as $500 more to reduct the noise level in a new home.



Whenever I have looked at new homes, the salesperson almost never talked about sound control features.

likely to spend extra money controlling sound in bedrooms, between floors and the family room.

Finally, the survey uncovered an opportunity to help builders promote the advantages of sound control to their prospective buyers. (Over 60% stated that the salesperson never mentioned sound control features.)

A Sound Opportunity

The focus of trade-up, family-centered home buyers on quality, comfort and quiet presents a variety of opportunities, including interior sound control. In fact, sound control offers the single largest opportunity for upgrading the levels of insulation within a home. A well-insulated interior envelope is a winning situation for everyone because it:

- Increases the quality image of your builders' homes.
- Offers new home buyers comfort and quiet.
- Improves your sales by increasing the insulation used in a home.

This section of the binder gives you the information you need to take advantage of the sound control opportunity. It includes:

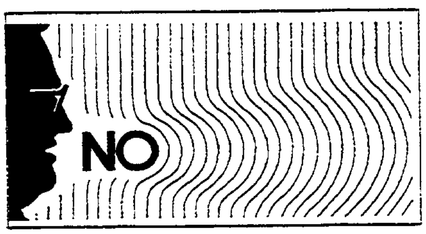
- The basics of sound control to help you understand the role of insulation in controlling household noise.
- Some construction techniques to show you various ways to provide sound control in wall and floor/ceiling assemblies.
- A review of various construction methods that allow you to offer your builders a systems approach to sound control.
- Guidelines to help you promote the advantages of interior sound control to your builders, including samples of the Owens Corning literature available to help you with your selling efforts.
- A glossary that provides definitions for some of the more common sound control terms.

Sound Control

This section addresses some of the basic technical questions concerning residential sound control.

What is sound?

Sound is defined as the pulsation of air pressure capable of being heard. Sound travels outward in all directions as sound waves at a speed of 1,130 feet per second.



What is noise?

What turns sound into noise is subjective. Noise is defined as unwanted sound. The most beautiful music, if unwanted, becomes annoying noise. There are two types of noise —airborne noise and impact noise.

Airborne noise is produced by a source which radiates sound directly into the air. Examples are people talking, a dog barking or a radio playing.

Impact noise is structure-borne sound caused by a direct mechanical impact. Examples include the noise made by a person walking, furniture being moved, or a dropped object. Another type of impact noise is caused by the vibration of mechanical equipment in contact with the structure. The impact or vibration is transmitted through the structure and radiated from surfaces as airborne sound.

Another term used in describing noise is background noise. This term is used to describe the almost constant sounds present in a room. Background noise is created by a variety of sources including street traffic, ventilating systems, appliances, etc.

However, unlike unwanted noise being transmitted into a room, background noise can be used as a noise control strategy. If the level of background noise is higher than that of the offending noise transmitted from other rooms, the background noise will mask or drown out the transmitted noise

How is sound measured?

The unit used to measure sound is a decibel (dB). The more intense the sound, the higher the dB level. The chart below lists the decibel level range of various everyday sounds.

How is sound control rated ?

A sound transmission class (STC) is a single number rating of the ability of a wall, floor or ceiling assembly to minimize sound transmission. The higher the STC rating of the assembly, the better its ability to limit sound. (See chart) An STC of 50 is generally considered to be an acceptable noise control rating. STCs above 50 are considered to provide excellent noise control.

In addition to STC ratings, floors and ceilings are also rated in terms of their Impact Insulation Class (IIC). This rates the ability of the floor/ceiling assembly to control sounds caused by impact (walking or moving furniture). As with STCs, the higher the IIC of a floor or ceiling assembly, the better its ability to control impact sound transmission. An acceptable IIC rating is typically 50 or above.

Decibel Levels

dB Level	Loudness	Examples
100 to 120	Deafening	Thunder, boiler factory, jet
80 to 100	Very Loud	Noisy factory, cocktail party, loud stereo
60 to 80	Loud	Noisy office, average television, loud conversation
40 to 60	Moderate	Noisy home, average conversation, urban background noises
20 to 40	Faint	Quiet home, quiet conversation, kitchen noise, rural background noise
0 to 20	Very Faint	Whisper, Rustle of leaves

STC Ratings

STC	Speech Audibility	Noise Control Rating
15-25	Normal speech easily understood	Poor
25-35	Loud speech easily understood. Normal speech 50% understood	Marginal
35-45	Loud speech 50% understood. Normal speech faintly heard, but not understood	Good
45-55	Loud speech faintly heard, but not understood. Normal speech usually inaudible	Very Good
55 and up	Loud speech usually inaudible	Excellent

Based on a typical background noise level of 30 dB on the "listening" side of the assembly.

Sound Control

What is the role of insulation in sound control?

Mineral insulation, specifically fiber glass, significantly reduces sound transmission by absorbing sound. It is economical and easy to install. It also offers the primary benefit of thermal control.

Does the facing matter?

Faced and unfaced insulation are equally as effective in reducing sound transmission.

How do you control sound in a home?

There are three basic sound control strategies:

1. Block the path. This option involves blocking the path of the noise through walls, floors or ceilings by using heavier building materials (for example, adding one or two layers of gypsum to a wall construction). This can present a problem in lightweight construction because the increased weight may not be structurally practical or aesthetically pleasing and would be more expensive.

2. Break the path of the vibration. Interior and exterior walls and floors/ceilings transmit sound by vibrations from one face to another. These vibrations travel through structural elements such as studs or floor joists. Interfering with these vibrations offers a practical method of reducing sound transmission by as much as 6 to 10 dBs. This can be accomplished in two ways. First you can add resilient metal channels between the gypsum wall board and the wooden stud or a ceiling joist to break the vibration path. Or you can use staggered wood studs with ½" gypsum board and 3½" thick wood framing batt insulation.

3. Absorb the sound. This option uses mineral fiber glass insulation to fill the spaces between walls, floors and ceilings. This can further improve the performance of discontinuous construction by 5 to 12 dBs. This method also offers the benefit of thermal control.

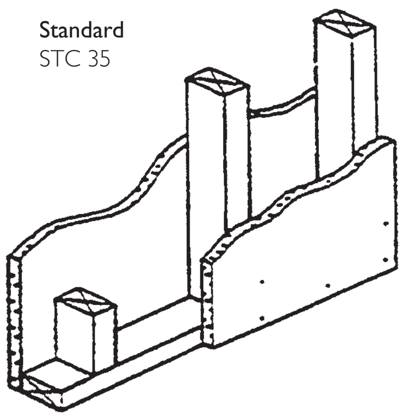
Sound Control

Wall Assemblies

Fiber glass insulation used in wood stud, staggered stud or double stud construction can diminish sound transmission levels by up to 12 dBs. Faced and unfaced fiber glass insulation provide the same acoustical performance. These illustrations depict a good-better-best approach to acoustical control in wall construction.

Standard

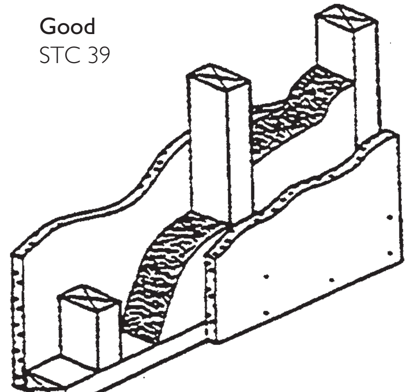
Single wood studs, 16" o.c., single layer ½" gypsum board each side, no insulation and no acoustical treatment.



Standard
STC 35

Good

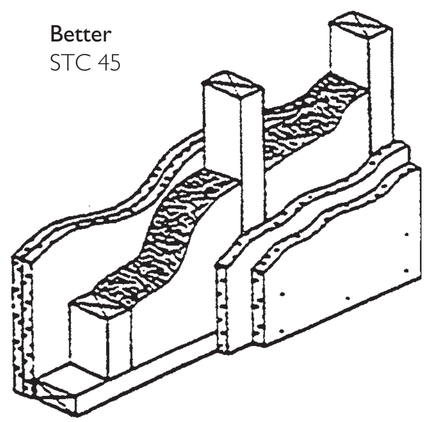
Single wood studs, 16" o.c., single layer ½" gypsum board each side, 3 ½" thick wood framing batt insulation.



Good
STC 39

Better

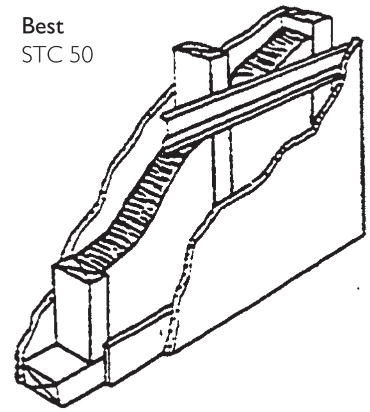
Single wood studs, 16" o.c., double layer ½" gypsum board each side, 3 ½" thick wood framing batt insulation.



Better
STC 45

Best

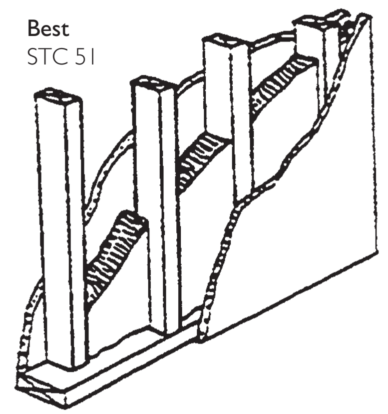
Single wood studs, resilient channel, single layer 5/8" gypsum board each side. 3 ½" thick wood framing batt insulation.



Best
STC 50

Best

Staggered wood studs, 16" o.c., single or double layer ½" gypsum board each side, 3 ½" thick wood framing batt insulation.



Best
STC 51

Sound Control

Floor/Ceiling Assemblies

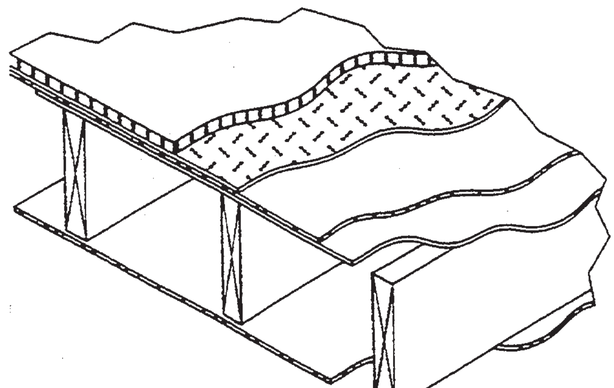
Sound between floors can be greatly reduced by adding fiber glass insulation and resilient channels to the floor/ceiling assembly. The illustrations compare standard construction for wood and concrete with examples of improved sound absorbing construction.

Standard/Wood System
Standard carpet and pad, 3/8" particle board surface, 5/8" plywood subfloor, single layer ½" gypsum ceiling.

Excellent Wood System
Standard carpet and pad, 3/8" particle board surface, 5/8" plywood subfloor, single layer ½" gypsum ceiling on resilient channel, 3½" thick wood framing batt insulation.

Excellent Concrete System for Multi-Family Applications
1½" lightweight concrete floor, 5/8" plywood subfloor, 2" x 10" joist, standard carpet and pad, ½" gypsum board, 3½" thick wood framing batt insulation.

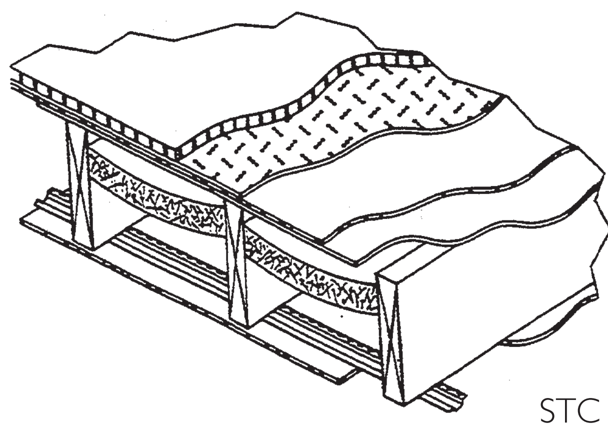
Standard Wood Construction



STC 42

STC tests performed on assembly without carpet/carpeting and pad.

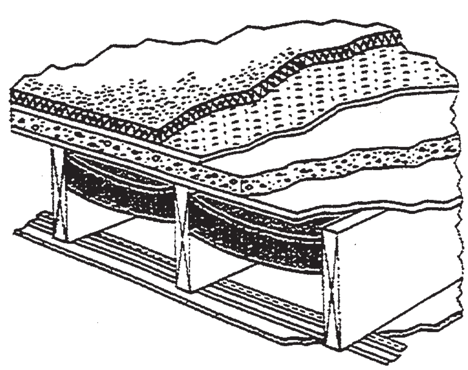
Excellent Wood Construction



STC 53

3½" thick wood framing batt insulation can be used.

Excellent Concrete Construction



STC 58

STC tests performed on assembly without carpet/carpeting and pad.

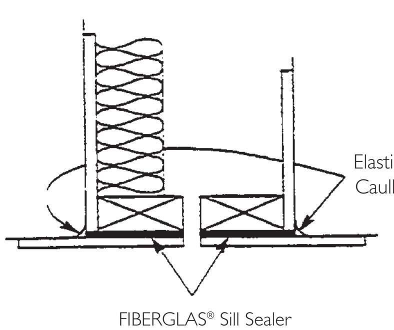
Sound Control

Attention to wall and floor/ceiling assemblies is the first step in a comprehensive noise control system. The following construction methods are recommended to help reduce sound transmission in new construction.

Walls

- Use an air seal around the perimeter of the wall for a proper acoustical seal.
- Apply a non-hardening permanent resilient caulking, such as butyl rubber-based compound, to the base of both sides of the wall.
- Install plates on sill sealers; run wall finish to floor where possible and caulk airtight on both sides.
- Install phones, doorbells, intercoms, etc. on interior walls only–never on walls separating living spaces or corridor walls.
- Install electrical distribution panels on interior walls within apartments and never on corridor or party walls.

Caulking Seal Applied to Outlet Box

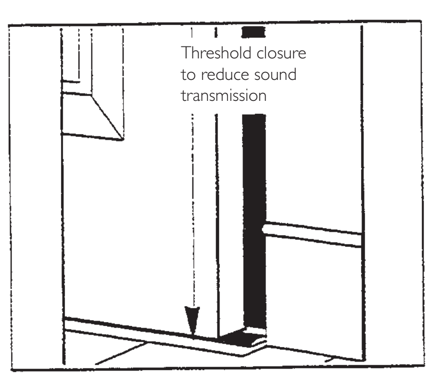


- Penetrations through common walls should be eliminated whenever possible. Surface mount medicine cabinets; or install mirrors on party walls with medicine cabinets on interior partitions.
- Book shelves, wall hangings and paintings increase sound diffusion in a room and decrease reverberation.

Doors

- Stagger doors across hallways so they do not open across from each other.
- Avoid sliding doors in areas where sound control is desired.
- Solid core doors of wood or mineral content provide better sound control than hollow core doors.
- Use a soft-type weather gasketing (acoustical gasket) on all doors where privacy is an issue. This is especially important with tile or other non-carpeted floors. These gaskets also act as weather stripping on exterior doors.

Use of Threshold Closure



- Install threshold closures at the bottom of doors to reduce sound transmission.

Windows

- Minimize the size of windows facing noisy areas.
- Separate windows to reduce crosstalk.
- Arrange casement windows so sound is not reflected into adjoining units.
- Make sure movable windows close tightly and are weather-stripped.
- Use insulating glazing or store windows to help reduce sound transmission through windows.
- Draperies can further reduce sound transmission through windows.

Wiring

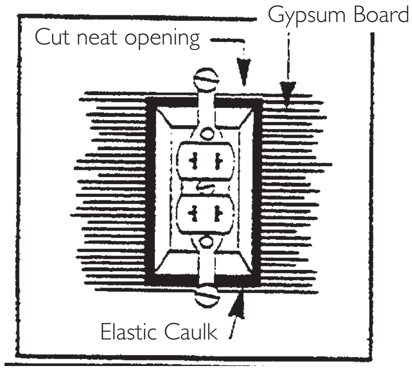
- For multi-family units, wire each apartment as a unit; avoid penetration of walls or floor between apartments.
- Caulk holes around wiring that penetrate connecting structures; use elastic, non-hardening caulk or dry packing.
- Connect vibrating equipment with flexible wiring.

Electrical Outlets

- Cut holes neatly to reduce leaks.
- Make sure outlets are airtight by using elastic, non-hardening caulk before installing the plates.

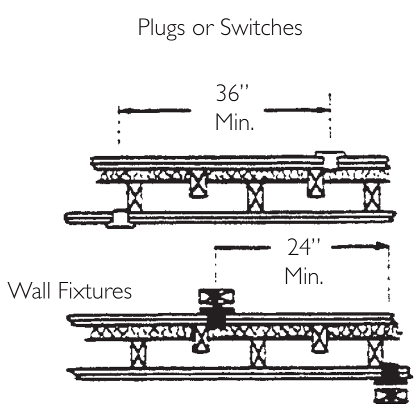
Sound Control

Caulking Seal Applied to Outlet Box



- Don't install electrical outlets back to back.
- Place wall fixtures a minimum of 24" apart, light switches a minimum of 36" apart.
- Install electrical panels, telephones, intercoms, door-bells or chimes only on non-critical interior walls between rooms.

Minimum Spacing For Plugs or Switches



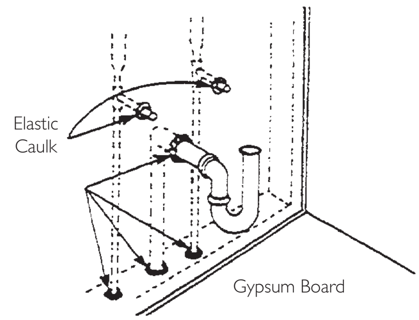
Floors/Ceilings

- Seal all cracks in the subfloor with airtight caulk; or install underlayment over entire surface.
- Install thick carpeting and padding to reduce impact sound.
- Openings for plumbing, gas and electrical lines should be properly sealed with caulk.
- Surface mount any ceiling fixtures to resiliently-mounted gypsum ceilings.
- Make sure openings around boxes are sealed tight.
- Avoid or limit use of recessed or "hi-hat" type fixtures. Use IC rated hi-hats.

Plumbing

- Design pipe to run with swing arms so expansion and contraction can occur without binding, thus eliminating noise.
- Isolate piping from structures with resilient pads and sleeves, then seal for airtightness.
- Surround all plumbing in interior or walls with insulation.
- Develop a well-planned layout with minimal pipe runs to reduce the noise of flowing water.
- In two-story homes, insulate pipes all the way down to the main floor to help eliminate noise.

Piping Isolated from Structures



- Avoid running pipes through studs to minimize stud vibration.
- Use oversized pipes and reduced pressures to slow the speed of flowing water and reduce noise.
- Provide air chambers to eliminate water hammer due to abrupt stopping of water flow.
- Use quiet-action water closets that are isolated from the structure on a floating floor.
- Caulk all openings made in walls, floors and framing for supply and drain lines.

Appliances and Air Conditioners

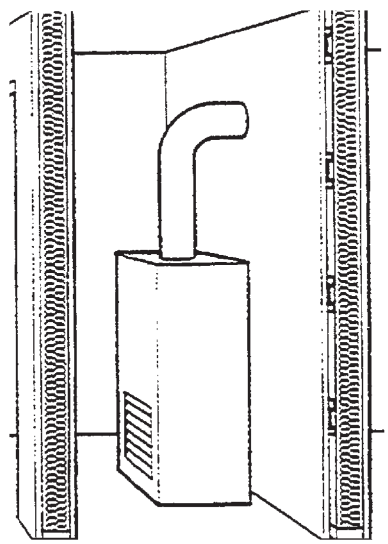
- Select quiet, high-quality appliances.
- Use adequately sized water piping and valves to minimize whistling.
- Select air conditioners with balanced fans and quiet motors.
- Select quiet external ballasts on fluorescent fixtures.

Sound Control

Equipment Noise

- Whenever possible, isolate furnaces, air conditioners and other HVAC units to keep them far from areas where quiet is important, such as bedrooms or studies.
- To quiet fan noise and the sound of air rushing through ducts, use properly sized fiber glass ducts, or fiber glass duct liner (such as Owens Corning's duct board and Aeroflex® duct liner).
- Place return air vents in strategic locations, away from primary living space.
- Inquire about equipment noise levels before buying, and insist on quiet units.
- Isolate equipment in rooms (normally in the garage or basement) with a door to the outside, or use a solid-core door with a gasket when access is from the building interior.
- Mount equipment so as to keep vibrations from entering surrounding structures.
- In multi-family units, construct partitions with an STC rating of 50 or better to separate living units from equipment rooms.

Isolated Equipment



Sound Control

This glossary provides definitions for some of the more common sound control terms and abbreviations.

Absorption
When a sound wave enters a porous material, part of its energy is converted into heat by friction. This process is called "sound absorption." Sound absorption materials are used: (1) as finished surfaces of rooms to reduce reflections and lower noise levels within the room, and (2) in cavities of wall and floors to reduce transmission.

Airborne Noise
Noise produced by a source which radiates sound directly into the air, such as people talking, a dog barking or a radio playing.

Amplitude
The height of the wave or half the difference between its maximum and minimum value. Sound pressure is the fluctuation about the atmospheric pressure.

Background Noise
There is almost always some noise in a room, called "background noise," created by street traffic, outdoor sounds, ventilating noise, appliances, etc. If the level of background noise is higher than that of offending noise transmitted from other rooms, the background noise will mask or drown out the transmitted noise.

Decibel (dB)
A unit used to measure sound pressure or intensity. The greater the intensity, the higher the decibel level.

Frequency
The number of cycles per second of the source of sound is measured in hertz (Hz). Frequency is perceived by the ear as the pitch of a sound. High-pitched sounds have high frequencies. The audible frequency range is about 20 to 20,000 Hz. Music may cover most of this range, while speech extends from about 100 to 5,000 Hz. Most sounds consist of numerous frequencies at different, relative intensities.

Impact Noise
Structure-borne noise caused by a direct mechanical impact, such as a person walking, moving furniture or a dropped object. Another type of impact noise is caused by vibration of mechanical equipment coupled directly to the structure. The impact or vibration is transmitted through the structure and radiated from surfaces as airborne sound.

Level
Because sound pressures range over a very large range, levels are used to describe their amplitude. Sound pressure level is 20 times the logarithm of the sound pressure divided by a reference pressure. The units of levels are dB. Levels also correlate better with human response to sound than pressure.

Noise
Unwanted sound. Attitude toward sound turns it into noise. The most beautiful music, if unwanted, becomes annoying noise.

Sound
Pulsation of air pressure capable of being heard. It is generated by vibrating objects or surfaces (or by turbulent air). It travels outward in all directions as sound waves at a speed of 1,130 feet per second.

Sound Attenuation, Sound Insulation, Sound Isolation
These are all descriptive terms which denote the sound isolating performance of walls or floor/ceiling assemblies as sound travels from one room to another. The measure of isolation is transmission loss in the units of dB. Higher values denote better performance.

Sound Pressure Level (SPL)
The intensity of a sound. It is measured in dBs. The greater the intensity of sound, the higher the dB level.

Sound Transmission Class (STC)
Transmission loss is measured as a function of frequency. To give an assembly a single number rating. A protocol described by an American Society for Testing and Materials (ASTM) method is applied. (standard E413, titled, "Standard Classification for Determination of Sound Transmission Class." A detailed discussion of STC can be found in the Owens Corning Noise Control Design Guide, Publication No. 5-BL-11691.)

Tone
A tone is a sound with a single frequency such as a sine wave. A wave like this is described by its frequency, and its amplitude.

Transmission
Airborne or impact sound is transmitted through most walls and floors by setting the assembly to vibrate. This vibration generates sound waves on the other side. Airborne sound may also pass through porous materials cracks or holes in walls or floor/ceiling assemblies.

Transmission Loss (TL)
The ability of a material or system to block or attenuate the transmission of sound from one area to another. The higher the transmission loss, the more the material attenuates the sound. Transmission loss is measured at 1/3 octave band center frequencies from 125 Hz to 4000 Hz using broad band noise as described in ASTM E 90 and is reported in decibels (dB).

Sound Control

Introduction

The need for a more effective means of controlling noise problems has never been greater. Owens Corning, a world leader in acoustical products and related research, is committed to providing architects, developers, owners and other specifiers with authoritative, useful data to aid them in planning acoustically-efficient living and working environments.

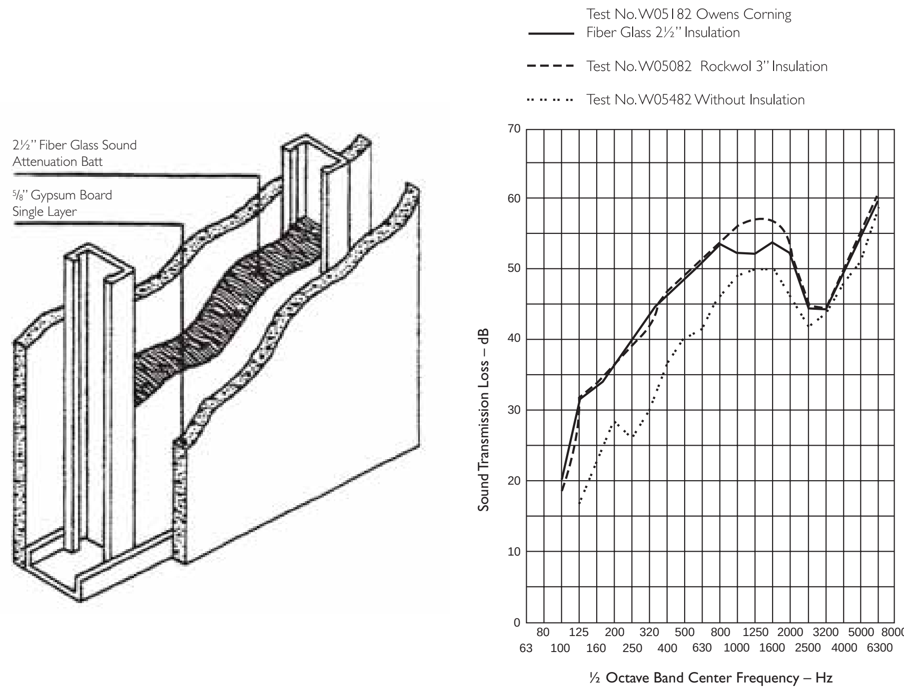
For over 20 years, Owens Corning has been a major source of sound control research and related product solutions. The company has been acti vely involved in standards writing groups such as the ASTM and the American National Standards Institute (ANSI) – two groups whose test methods are nationally known and used by the majority of acousticians across the country.

Owens Corning's acoustical products and applications have been laboratory-tested in facilities that meet the highest standards attainable— acoustical labs which were specifically designed and constructed to provide optimum conditions for acoustical testing and research.

Only the finest, state-of-the-art, computer-controlled data acquisition systems have been utilized to generate and analyze the performance of Owens Corning acoustical products and systems, assuring that even the most exacting criteria have been met.

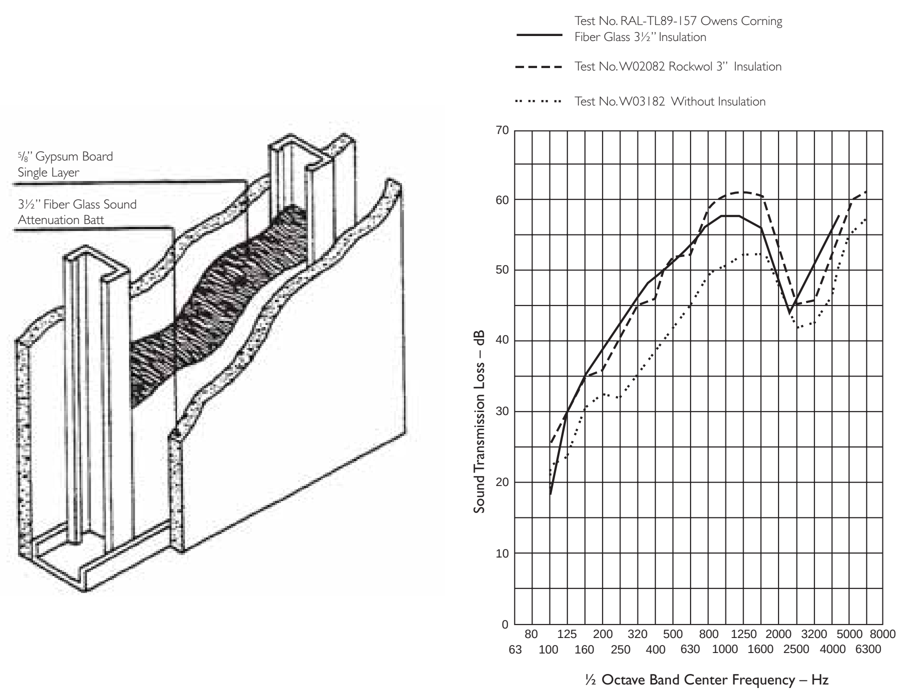
This Noise Control Guide is intended to serve as a design tool by supplying an in-depth view of the noise "problem" in as concise

Figure 1



Wall contruction detail and STC Value for 2½" steel stud partition with a single layer of 5/8" type "x" gypsum wallboard both sides, and 2½" thick Sound Attenuation batts.

Figure 2



Wall contruction detail and STC Value for 35/8" steel stud partition with a single layer of 5/8" type "x" gypsum wallboard both sides, and 3½" thick Sound Attenuation batts.

a manner as possible. It is designed to provide a total view of sound – from its elemental physics, to the various means available for controlling its wanted or unwanted presence.

Basic Principles of Sound

What is Sound?

Sound is produced by something vibrating. It travels in all directions from the source as a pressure wave in the air, much the same as waves travel through water in a pond when a pebble is dropped into it. These sound waves travel through the air in the form of very small changes in atmospheric air pressure, alternating above and below the normal or ambient air pressure. The root mean squared deviation in atmospheric pressure above or below the static pressure due to the sound waves is called sound pressure. This sound pressure, by vibrating the inner ear, produces the sensation of hearing and determines the loudness of the sound as judged by the listener.

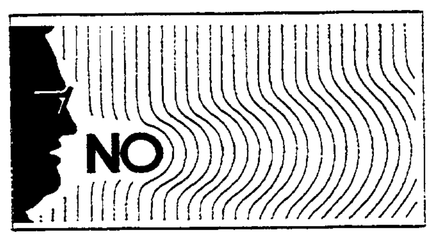
Another attribute of sound is frequency, or the number of times per second that the sound pressure alternates above and below atmospheric pressure. Frequency is measured in cycles per second, or in units called Hertz (Hz). A frequency of 1,000Hz means 1,000 cycles per second.

Noise is unwanted sound, regardless of the source. Noise is subjective in that what is pleasing to one individual may be disturbing to another.

Sound Pressure Measurement

The decibel (dB) is the measure of sound pressure or intensity. It is a logarithmic scale of sound pressure and compacts the wide range of sound levels the ear can detect. As the sound wave moves outward, away from its source in all directions, the intensity of the wave decreases in proportion to the distance from the source. Therefore, the sound or decibel level decreases in loudness as one moves away from the source. In fact, for every doubling of the existing distance between the sound source and the listener, the sound level decreases by 6 decibels. Figure 4 depicts this loss.

Figure 3



Sound waves travel through air, forming very small changes in atmospheric pressure.

Airborne and Structure-borne Sound

Most noise is transmitted both as airborne and structure-borne sound. For example, speech is airborne sound until it strikes a structure, like a wall, and becomes structure-borne. Then, by way of vibration, it is reverberated, becoming airborne to the listener in an adjacent room or area, repeating this cycle until is dissipates completely.

Sound travels through air at a constant speed at a given temperature of air. The speed of sound is 1,125 ft. per second (on a standard temperature day), or a little over one mile in 5 seconds. The speed at which it travels can be observed as the time lag between lightning and thunder, or as a delay in hearing an echo from a distant cliff or wall.

In an auditorium 100 ft. long, it takes about 1/10 second for the sound to reach the back row from the stage. This airborne sound may take either of two paths: a direct or reflected path.

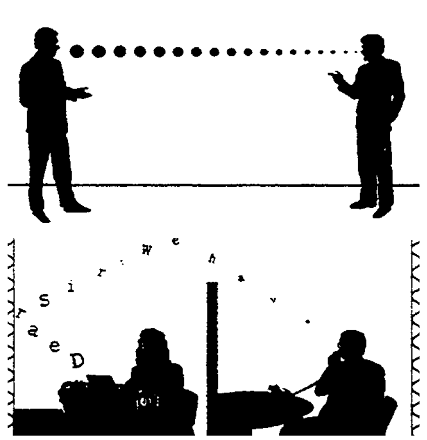
Direct and Reflected Sound

Direct sound travels in a direct path from its source to its receiver. It does not strike any surface in traveling from the source to the listener. Direct sound diminishes in intensity as the distance between source and receiver increases.

Reflected sound strikes a surface before reaching the receiver. When a sound wave strikes a surface, its direction changes in the same fashion as a ball bouncing off a wall. The loudness of reflected sound is always less than that of direct sound. This is because every time sound strikes a surface, some of its energy is absorbed. Also, the reflected sound travels a longer path than direct sound; thus, energy is lost due to the greater distance traveled.

Sound Control

Figure 5



Direct sound travels an unobstructed path to the listener. Reflected sound striles surfacs on its way to the listener.

Figure 4

For every doubling of the existing distance between a sound source and a listener, there is a sound level decrease of 6 dB.

Choosing the Right Acoustical Materials

The audible frequency is from 20 to 20,000 Hz., with the upper limit decreasing with age and the lower limit increasing with age. The ear is most sensitive to sound around 1,000 Hz., and is less sensitive to sounds above and below this frequency. Like the human ear, the acoustical performance of materials varies with frequency.

To control unwanted sound, acoustical materials perform one of two functions: Either they absorb sound, or they block (attenuate) its transmission. Sound absorbing materials are used to reduce the noise level and/or control the reverberation time within a room. Sound attenuating materials, or materials with a high sound transmission loss, are used to reduce noise as it passes from one space to another space.

Rarely do acoustical materials perform both functions of absorbing and attenuating sound. Therefore, the choice of materials depends on what the designer is trying to accomplish in a given situation: controlling noise within a room, or reducing the transmission of sound from one room or area to another. Many times, a designer needs to accomplish both objectives and must use two different products or systems to achieve this purpose.

Subsequent sections deal in greater depth with the principles involved in acoustical control: sound absorption, airborne sound transmission loss, ceiling sound transmission loss, impact sound transmission, environmental noise control, construction design for interior wall acoustical control, and specific wall constructions and their STC values.

Sound Absorption

What is Sound Absorption?

All materials absorb sound energy to some degree. Whenever sound waves strike something, part of the acoustical energy in the wave is absorbed, and the remainder is reflected. The reflected energy in the wave is always less than the incident energy, and the acoustical energy absorbed is transformed into another form of energy, usually heat. The amount of energy absorbed is expressed in terms of a sound absorption coefficient.

The Sound Absorption Coefficient

The sound absorption coefficient is the decimal fraction of the incident sound wave absorbed by the material. For example, if a material has a sound absorption coefficient of 0.85, it means that 85 percent of the sound energy striking that material is absorbed and only 15 percent of the incident energy is reflected.

Since all materials absorb different amounts of energy, depending on the frequency of the sound wave striking the material, sound absorption coefficients of a material are determined at several frequencies: 125, 250, 500, 1,000, 2,000, and 4,000 Hz. These frequencies are the center frequencies of a band of noise striking the material. Rarely in architectural acoustics is a pure or a single frequency of noise used to evaluate the acoustical property of a material.

The test method used by laboratories to measure the sound absorption coefficients of a material is ASTM test procedure C423. (The latest revision of this standard should always be used since significant changes are often made in revising the test standard.)

The Noise Reduction Coefficient

A numerical rating used in specifications and product literature to express the sound absorbing capabilities of a material is the Noise Reduction Coefficient (NRC). The NRC is the average of sound absorption coefficients measured at 250, 500, 1,000, and 2,000 Hz., which is rounded off to the nearest 0.05.

A material usually has to have an NRC value greater than 0.40 before it is called a sound absorber. Porous materials such as fibrous glass allow sound waves to penetrate deeply into the material, where the acoustical energy is converted to heat, due to friction between the trapped air and the glass fibers. These materials can have NRC values as high as 0.95 and 1.00, depending on their thickness.

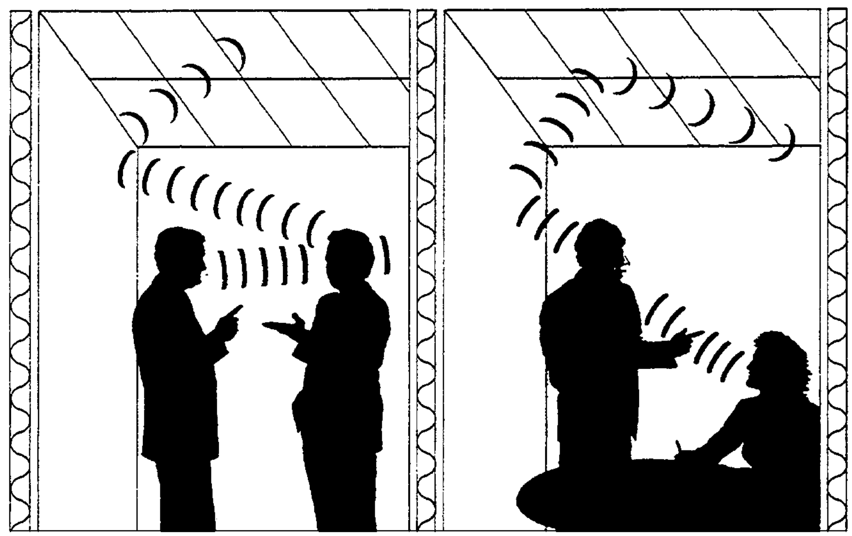
However, the human ear normally cannot perceive the acoustical difference between two sound absorbers whose NRC values differ by 0.05. Thus, two materials having an NRC of 0.80 and 0.85, respectively, will aurally seem to absorb the same amount of sound.

Airborne Sound Transmission Loss

What is Sound Transmission Loss?

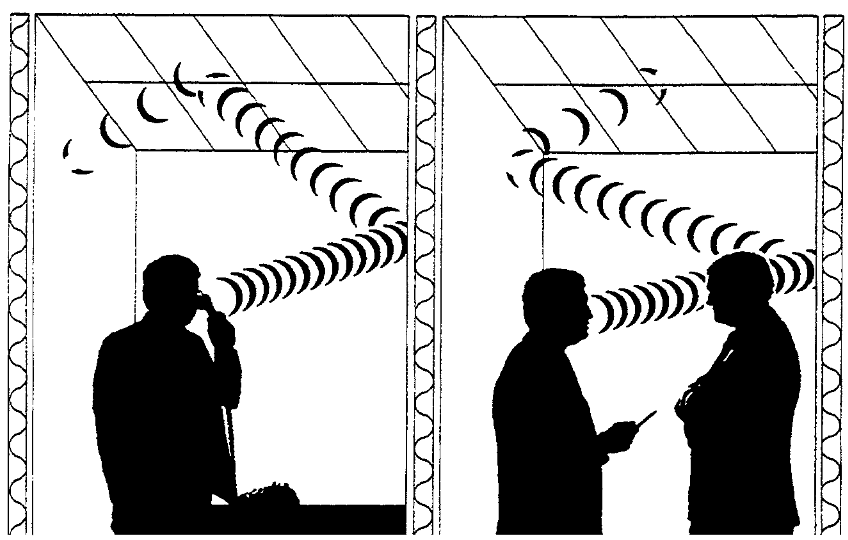
The ability of a material or system to block or attenuate the transmission of sound from one area to another is measured by transmission loss (TL). The higher the TL, the more the material attenuates the sound. TL is measured at several test frequencies and is reported in decibels.

Figure 6



To effectively control unwanted sound, an acoustical system must absorb ans attenuate its transmission.

Figure 7



When a sound wave strikes a surface, part of its acoustical energy is absorbed and the remainder is reflcected.

The TL of a wall or floor/ceiling assembly is measured between two reverberation chambers in an acoustical testing laboratory. The test method used by all laboratories is ASTM E90 (the latest revision of this standard should always be used since significant changes are often made in revising the standard).

Sound Transmission Class (STC)

The sound transmission class is a method of rating the airborne sound transmission performance of a wall or floor/ceiling assembly at different frequencies by means of a single number. The method of determining the STC is speci-

Sound Control

Table 1

Sound Absorption Coefficients of General Building Materials

	Octave Band Center Frequencies, Hz.						
Materials	125	250	500	1000	2000	4000	NRC*
Brick							
Glazed	0.03	0.03	0.03	0.04	0.05	0.07	0.05
Unglazed, painted	0.01	0.01	0.02	0.02	0.02	0.03	0.00
Carpet							
1/8" Pile height	0.05	0.05	0.10	0.20	0.30	0.40	0.15
¼" Pile height	0.05	0.10	0.15	0.30	0.50	0.55	0.25
3/16" Combined pile and foam	0.05	0.10	0.10	0.30	0.40	0.50	0.25
5/16" Combined pile and foam	0.05	0.05	0.30	0.40	0.50	0.60	0.35
Ceilings							
5/8" Mineral board ceiling	0.31	0.29	0.51	0.70	0.71	0.71	0.55
5/8" Film faced fiber glass ceiling	0.66	0.76	0.60	0.80	0.89	0.89	0.75
1½" Cloth faced fiber glass ceiling	0.80	0.96	0.88	1.04	1.05	1.06	1.00
Concrete block							
Unpainted	0.36	0.44	0.31	0.29	0.29	0.25	0.35
Painted	0.10	0.05	0.06	0.07	0.09	0.08	0.05
Fabrics							
Light velour, 10 oz. Per sq. Yd., Hung straight in contact with wall	0.03	0.04	0.11	0.17	0.24	0.35	0.15
Medium velour, 14 oz. Per sq. Yd., Draped to half area	0.07	0.31	0.49	0.75	0.70	0.60	0.55
Heavy velour, 18 oz. Per sq. Yd., Draped to half area	0.14	0.35	0.55	0.72	0.70	0.65	0.60
Floors							
Concrete or terrazzo	0.01	0.01	0.01	0.02	0.02	0.02	0.00
Linoleum, asphalt, rubber or cork tile on concrete	0.02	0.03	0.03	0.03	0.03	0.02	0.05
Wood	0.15	0.11	0.10	0.07	0.06	0.07	0.10
Wood parquet in asphalt on concrete	0.04	0.04	0.07	0.06	0.06	0.07	0.05
Glass							
¼" Sealed, large panes	0.05	0.03	0.02	0.02	0.03	0.02	?
24 oz., operable windows (in closed position)	0.10	0.05	0.04	0.03	0.03	0.03	0.05
Gypsum board							
½" Nailed to 2 x 4s, 16" o.c., painted	0.10	0.08	0.05	0.03	0.03	0.03	0.05
Marble or Glazed Tile	0.01	0.01	0.01	0.01	0.02	0.02	0.00
Plaster, Gypsum, or Lime							
rough finish on lath	0.02	0.03	0.04	0.05	0.04	0.03	0.05
smooth finish	0.02	0.02	0.03	0.04	0.04	0.03	0.05
Hardwood Plywood Paneling							
¼" thick, wood frame	0.58	0.22	0.07	0.04	0.03	0.07	0.10
Wall Panels							
fiber glass wall panels	0.05	0.30	0.80	1.00	1.02	0.85	0.80
Water Surface							
as in a swimming pool	0.01	0.01	0.01	0.01	0.02	0.03	0.00
Wood Roof Decking							
tongue-and-groove cedat	0.24	0.19	0.14	0.08	0.13	0.10	0.15

Table from "Acoustical Ceilings Use and Practice". Ceilings and Interior Systems Contractors Association (1978). p18.

fied in the ASTM standard E413 titled, "Standard Classification for Determination of Sound Transmission Class."

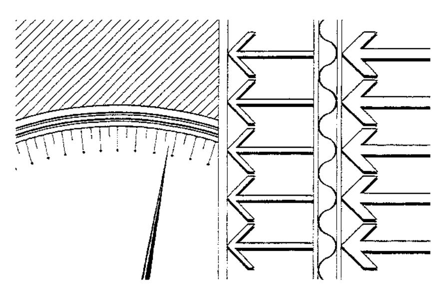
The STC is determined from the sound TL values of a partition measured in accordance with ASTM standard E90. An STC value may be determined for a ceiling assembly when it has been tested in accordance with the Acoustical Materials Association (AMA) test procedure 1-II, 1967. For both cases, the sound TL values must be measured at 16 one-third octave band frequencies covering the range from 125 to 4,000 Hz.

To determine the STC of a given specimen, its measured TL values are plotted against frequency and compared with a reference frequency curve (STC contour) as shown in Figure 9. The STC rating may then be determined by means of transparent overlay, on which the STC contour is drawn.

The STC contour is shifted vertically, relative to the test data curve to as high a position as possible, while fulfilling the following conditions:

1. The maximum deviation of the test curve below the contour at

Figure 8



Acoustical materials and sustems must be tested to measure their transmission loss values.

any single test frequency shall not exceed 8 dBs.

2. The sum of the deficiencies at all 16 frequencies of the test curve below the contour shall not exceed 32 dBs. This is an average deviation of 2 dBs.

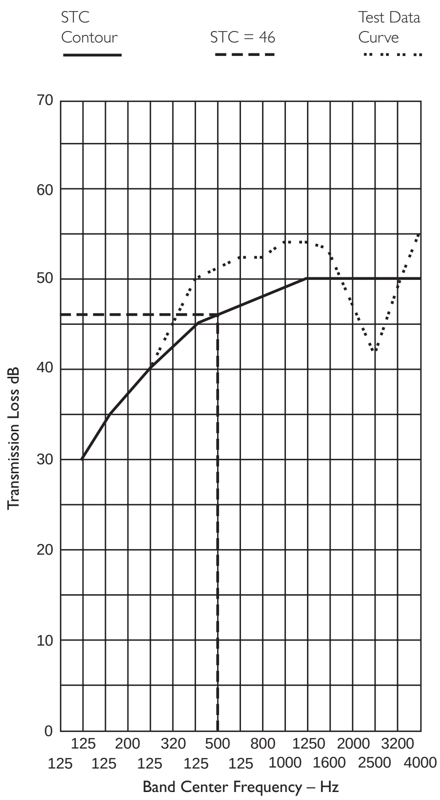
After the STC contour is adjusted (in integral decibels), the STC value is read from the vertical scale of the test curve as the TL value corresponding to the intersection of the STC contour and the 500 Hz. frequency line. In the example, the STC value, which is 46, is governed by the 8 dB deviation at 2,500 Hz., although the total deviation adds up to only 27 dBs.

Interpreting the STC

Many times, the same construction will have a spread of STC values, depending on what laboratory conducted the tests. It is not uncommon to have two different laboratories test the same construction and obtain STC values that differ by three or four points. This difference can be caused by several factors: (1) differences in laboratory equipment and test chambers, (2) differences in testing techniques, and (3) differences in materials used to construct the test specimens. Repeated tests within a given laboratory can vary one or two STC points.

However, two or three point differences in STC ratings between constructions are insignificant, as the human ear cannot detect this difference. Specifiers should not assume that a partition with a higher STC value is functionally any better than a partition

Figure 9



The STC is a method of rating the airborne sound transmission performance of a wall or floor/celing assembly.

with a slightly lower one. Like the NRC value for sound absorption, the STC should not be used for design or calculation purposes. It is intended only as a quick screening tool to compare different construction assemblies. The designer should use the actual sound TL values at the frequencies of interest when determining the reduction of sound between two areas.

Ceiling Sound Transmission Loss

Determining Ceiling Sound Transmission Loss

Acoustical ceilings, in addition to providing sound absorption, also attenuate or reduce the transmission of noise from one room to another. Commercial acoustical ceiling products are evaluated for sound TL between two offices with a ceiling-height wall separating the offices. The test method used is ASTM E 1414. Sound is generated in the source room and goes up through the test ceiling in the plenum area, across the top of the dividing partition, and then down through the ceiling in the receive room. Very little, if any, sound goes through the wall since it has a very high sound TL compared to the ceiling. The difference in levels between the source and receive rooms is then determined in the same manner as for partitions. This difference is then normalized to the amount of absorption in the receive room as compared to the typical office.

Interpreting Ceiling STC Values

The sound TL values of ceilings, or their normalized attenuation factors, are plotted as a function of 16 one-third octave band frequencies, covering the range from 125 to 4,000 Hz. The STC values are determined in the same manner as for partitions (See Sound Transmission Class).

As was the case for partition STC values, variations between different laboratories testing the same ceiling system, as well as repeatability variations in the same laboratory, are common. Therefore, two or three point differences in ceiling STC values are insignificant; the actual normalized attenuation factors should be examined when comparing two ceilings. It is important to note that the ceiling TL test method is a two-pass test; the sound, in traveling from one room to another, must pass through the ceiling twice – once in the source room and once in the receive room.

Improving Ceiling Sound Transmission Loss

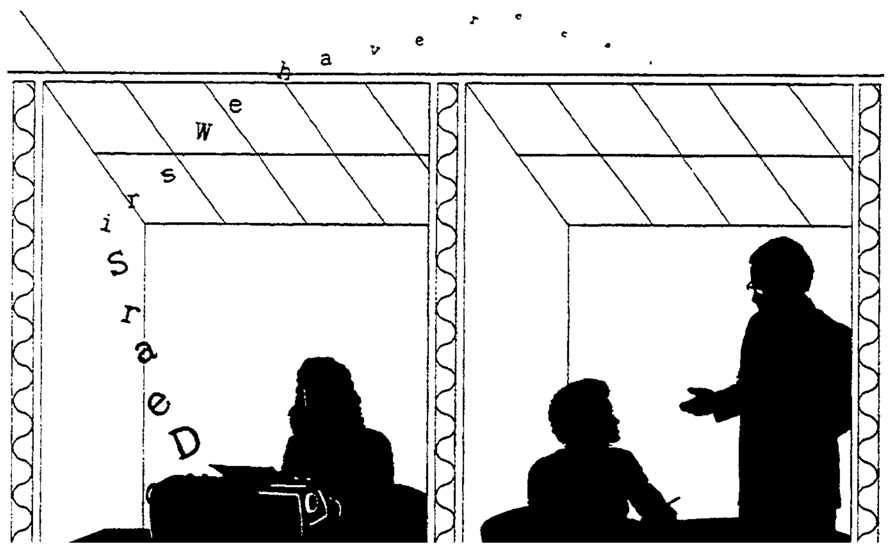
The sound TL of a ceiling can be improved by placing fiber glass insulation batts on the back of the ceiling panels. This has the same effect as putting insulation in the stud cavity of a wall; however, in this case, the insulation absorbs sound in the plenum area. Depending on the type of ceiling panels used, the STC can be improved by 7 to 12 points.

As in the case of partitions, the effective TL of a ceiling can also be improved by adding sound absorptive materials to both the source and receive rooms. For example, sound absorptive wall treatments could be installed in both rooms, thereby reducing the overall noise level in the room with the listener.

Design Considerations

In selecting a ceiling system and a wall assembly to separate two offices, the designer should take care to select compatible acoustical systems. Specifying a wall assembly with an STC 50 and a ceiling system with an STC 40 makes no sense. Sound will take the path of least resistance; thus, the overall reduction in noise between the two offices will be dependent on the values for the ceiling system. Little, if any, sound will go through the partition. A ceiling and wall system with approximately the same TL values should be selected.

Figure 10



Acoustical Celings help to attenuate sound transmission between rooms.

Designers should keep in mind what happens to the TL values of the ceiling system when lighting fixtures and air supply or return diffusers are installed. Many ceiling systems have lights and an unducted return-air system that normally opens into the plenum. These penetrations and openings greatly compromise the performance of the ceiling system. Published ceiling STC values are for the ceiling board installed in a single tee grid system only. Ceiling boards with light fixtures are not tested. Therefore, the designer or specifier must realize that, on the job, the STC value he specified will not be obtained; it will almost always be lower. How much lower will depend on the original STC value of the ceiling assembly and the number and type of light fixtures or return-air grills installed. It could be lower by 10 or 15 STC points.

Construction Designs for Interior Wall Acoustical Control

The goal of all acoustically "efficient" systems is to create a living or working environment that is comfortable and free from distraction or unwanted external noise. While the "ideal" acoustical environment has yet to be created, several construction designs for commercial installations do exist that promote an enhanced acoustical environment.

Improving the Effective Sound Transmission Loss of Wall Constructions

The sound TL of wall constructions can be improved by increasing mass, breaking the sound vibration path, and providing cavity absorption. In addition to these three methods, another alternative approach to reduce noise levels is to add sound absorbing materials to a room. The following discussion provides details of how each of these methods can be used to increase

Sound Control

Table 2

Sound Transmission Loss of Exterior Walls

Exterior Finish	Cavity Insulation	Resilient Channel	STC	Wall Construction Details	
Wood Siding	None	No	37	Framing	2" x 4" wood studs, 16" o.c.
	Fiber glass insulation 3½" R11 kraft faced	No	39	Sheathing	½" wood fiberboard insulation nailed to studs
	None	Yes	43	Siding	5/8" x 10" redwood nailed through sheathing into studs
	Fiber glass insulation 3½" R11 kraft faced	Yes	47	Interior	½" gypsum board screwed to studs or to metal resilient channels which were attached to the studs
Stucco	Fiber glass insulation 3½" R11 kraft faced	No	46	Framing	2" x 4" wood studs, 16" o.c.
	None	Yes	49	Sheathing	None
	Fiber glass insulation 3½" R11 kraft faced	Yes	57	Stucco	No. 15 felt building and 1" wire mesh nailed to studs.Stucco applied in 3 coats to 7/8" total thickness. Dry weight of stucco 7.9 lb/sq ft.
				Interior	½" gypsum board screwed to studs or resilient channel
Brick Veneer	Fiber glass insulation 3½" R11 kraft faced	No	56	Framing	2" x 4" wood studs, 16" o.c.
	None	Yes	54	Sheathing	¾" wood fiberboard insulation
	Fiber glass insulation 3½" R11 kraft faced	Yes	58	Brick	Standard face brick 3½" wide, spaced out ½" from sheathing with metal ties nailed through sheathing into studs. Dry weight of brick and mortar 41 lb/sq ft.
Concrete Block	None	No	45		
				Interior	½" gypsum board screwed to studs or resilient channel

Taken from the U.S. Department of Commerce National Bureau of Standards Building Science Series 77.
STC ratings of 50 or more are recognized as meeting the testing requirements set forth in Uniform Building Code Appendix, Chapter 35, ICBO ES Evaluation Report No. 2976P.

Table 3

Sound Transmission Loss of Exterior Doors

Door	Weather Strip	Normally Closed STC	Door Construction Details	
Wood, flush solid core	Brass	27	Width	1¾"
Wood, flush solid core	Plastic	27	Weight	78 lb, 3.9 lb,/sq. ft.
Steel, flush	Magnetic	27	Width	1¾"
			Faces	0.028" steel, separated by plastic perimeter strip
			Core	Rigid polyurethane, 2 to 2½ lb./cu ft., foamed in place
			Weight	64 lb., 3.2 lb./sq. ft.

Table 4

Sound Transmission Loss of Windows

Material	Type	Size	Glazing[1]	Sealed STC	Locked STC	Unlocked STC
Wood	Double hung	3' x5'	ss	29		23
			ss-d	29		
			ds	29		
			ds-d	30		
			in-7/16"	28	26	22
	Fixed Picture	6' x 5'	ss-d	28		
			ds	29		
			in-1"	34	STC	STC
Wood-Plastic	Double hung		ss	29	26	26
			in-3/8"	26	26	25
	Storm sash		ds	30	27	
			in-3/8"	28	24	
	fixed casement		ds	31		
	Operable casment		ds		30	22
	Sliding glass door		lam-3/16"	31	26	26
Aluminum	Sliding		ss	28	24	
	Operable Casement		ds	31	21	17
	Single hung		in-7/16"	30	27	25
Single Pane	¼" lamintaed glass					34

[1]ss = single strength, ds = double strength, d = divided lights, in = insulating glass of indicated overall thickness, lam = laminated safety glass of indicated overall thickness
Taken from the U.S. Department of Commerce National Bureau of Standards Building Science Series 77

the effective acoustical performance of walls.

Increasing Mass
Heavier materials block sound better than light materials. For example, adding another layer of gypsum wallboard provides increased sound TL.

As a general rule, every doubling of the weight of the wall increases sound TL by an additional 5-6 dBs. Heavier walls, however, are obviously not the most economical or most aesthetic solution to sound control requirements.

Breaking Vibration Path
Walls transmit sound most effectively when they can transmit vibrations from one face to another through structural elements such as metal or wood studs. Anything that can be done to interfere with the transmission of vibration between one wall surface and the other will help reduce sound transmission. An effective technique is to stagger wood studs, reducing sound transmission through them.

Metal studs are more resilient than wood studs and reduce the transmission of vibrations between one wall surface and the other. In wood stud constructions, resilient metal channels can be used between the gypsum wall board and the stud to break the vibration path.

Cavity Absorption
The sound TL of a wall can also be increased by filling the wall cavity with sound absorbing materials such as fiber glass building insulation. The use of fiber glass insulation in a typical metal stud wall, staggered wood stud or other wall with isolated faces, can increase sound TL by about 8 dBs – an improvement that is readily noticeable.

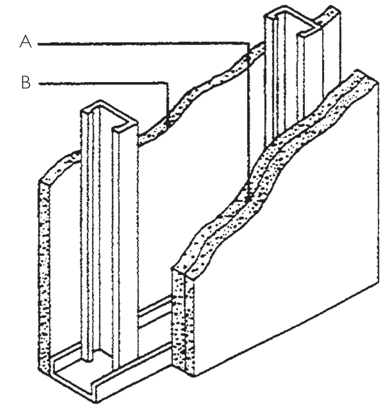
The key point to remember, however, is that the insulation is performing a sound absorption function in the stud cavity. It does not add any significant weight or mass to the partition. Within a range of densities from 0.6 to 6.0 pounds per cu. ft. for cavity insulation, there is no significant difference in the sound absorbing properties. Therefore, the sound absorption effectiveness of an insulation should be the key to its selection, not density. (See "The Density Myth.")

Adding Sound Absorbing Materials To Source and Receive Areas
Another method of increasing the effective sound TL between two rooms is to add sound absorbing materials to each room. By doing this, the overall noise level in each room is reduced, which results in a corresponding reduction of the sound level in any adjacent area.

By adding sound absorbing materials to both the source and receive room, one can obtain a significant reduction of the noise level in the receive room. The net effect is a significant reduction in intruding noise, with no change to the separating partition.

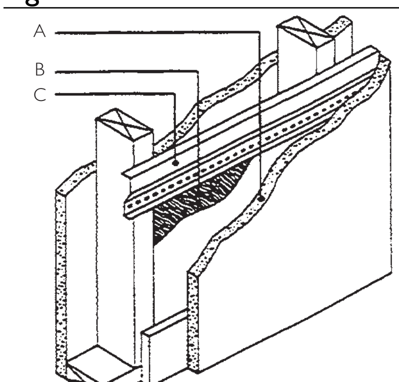
Detail Design and Construction Considerations
The effective acoustical performance of walls can be greatly affected by a number of design and construction details. These details include sealing the perim-

Figure 11



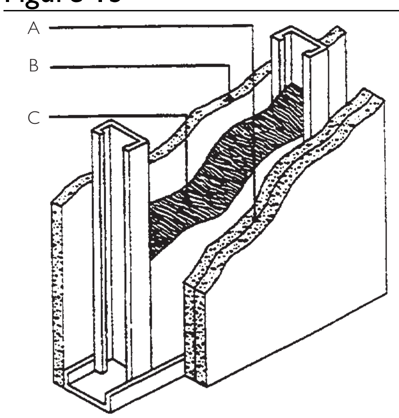
The addition of a layer of gypsum board to one surface effectively increases wall mass.
A- ¾" Gypsum Board Double Layer
B- ¾" Gypsum Board Single Layer

Figure 12



Resilient channels over wood studs break the vibrating path, helping to increase sound transmission loss.
A- ¾" Gypsum Board Single Layer
B- 3½" Fiber Glass Wood Framing Batt Insulation
C- Resilient Channel

Figure 13



Insulating wall cavities noticeably improves sound transmission loss by providing cavity absorption.
A- ¾" Gypsum Board Double Layer
B- ¾" Gypsum Board Single Layer
C- 3½" Fiber Glass Sound Attenuation Batt

eter of walls, construction details at wall intersections, size and placement of windows, and the location and proper installation of doors, electrical outlets, ducts and mechanical equipment. The following discussion provides some important suggestions to insure acoustical performance.

Perimeter Sealing
An air seal should be used around the perimeter of the wall to effect a proper acoustical seal. A non-hardening, permanently resilient caulking such as butyl rubber-based compound is recommended for both sides of the partition at applicable locations, such as at the bottom and top plates. Joint compound and tape will seal effectively in corners if multiple layers of wallboard are properly staggered.

Figure 14 provides construction details for framing sound insulating walls at corners and intersections.

Doors
Where optimum noise control is desired, solid wood core doors or metal doors should be used. Door tops and sides should be gasketed with a soft type weather stripping. Use of threshold closures at the bottom of the door or air seals will reduce sound transmission.

Sliding doors should be avoided where optimum noise control is desired. Doors opening upon hallways should not open across from one another.

Windows
Windows normally have lower TL values than the surrounding wall. Therefore, it is advantageous to reduce window area for increased noise control.

Additional measures that can be taken to increase noise control are the reduction of windows facing noisy areas and the separation of windows to reduce cross-talk. Give consideration to the use of thick or insulated glass (as well as double glazing) to help reduce sound transmission. Weather stripping windows will assure that they close tight, and thus, reduce the transmission of outside sound sources.

Electrical
Electrical installations must be given due consideration to assure they do not create a noise control problem. Light switches and outlets should not be constructed back-to-back. Ceiling fixtures should be surface mounted and openings around boxes should be sealed airtight.

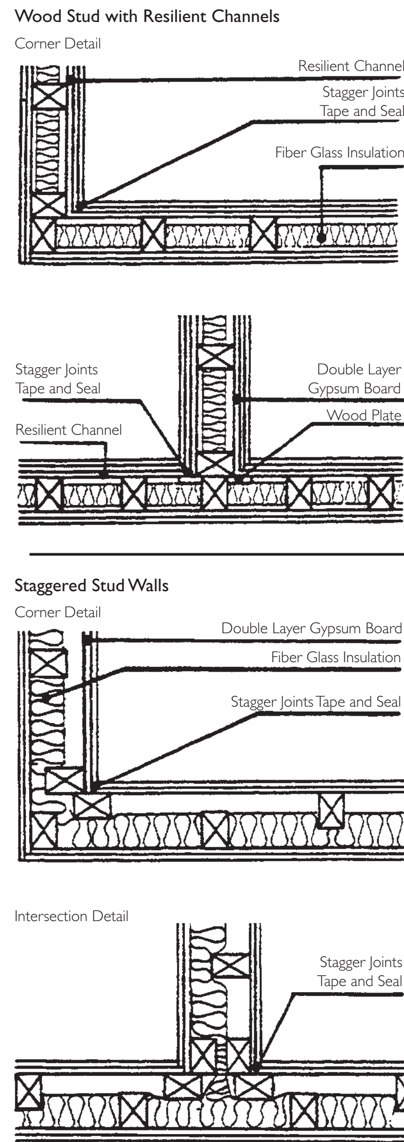
Electrical distribution panels, as well as telephones, bells, intercoms or audio built-ins should be installed on well-insulated interior walls only, and never on party or corridor walls.

Each living/working unit (when possible) should be wired as a complete unit, and vibrating equipment should be connected with flexible wiring.

Plumbing
Various acoustical design considerations come into play when installing plumbing.

Pipe runs should be designed with swing arms so expansion and contraction can occur without binding, thus eliminating any unwanted sound. Also, piping should be isolated from surrounding structures with resilient mounts. Air chambers should be provided at each outlet to eliminate water hammer due to the abrupt stopping of flowing water, and consideration should be given to oversized pipes and reduced water pressure.

Figure 14

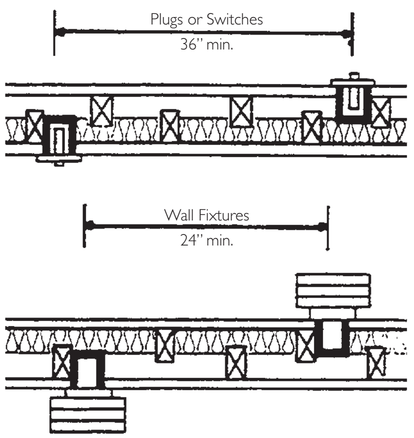


Framing of Sound Insulation Walls at Corners and Intersections.

Sound Control

Installation of fixtures back-to-back should be avoided. In all cases, openings made in walls and floor surfaces should be caulked to insure optimum acoustical integrity.

Figure 15



Caulk all openings to insure acoustical integrity.

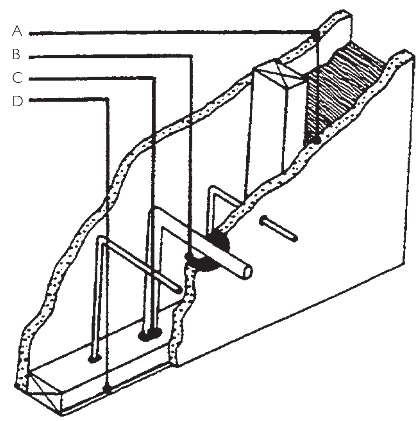
Ducts

Duct design should be given special consideration when planning the layout of a new or retrofit commercial construction, since ducts can easily transmit sound.

Installation of sufficiently thick metal ducts, lined with sound attenuating duct liner insulation, and the use of duct wrap materials will reduce sidewall transmission of unwanted sound, as well as reduce fan noise in the duct. The use of quality, quiet appliances, air conditioners and furnaces with well-balanced motors and fans is recommended to reduce duct-carried noise.

In addition to offering noise-absorbing, energy-saving thermal barriers, Owens Coming offers a variety of duct wraps, liners and

Figure 16



Caulk all openings to insure acoustical integrity.

other systems that effectively reduce duct noise.

Equipment Noise

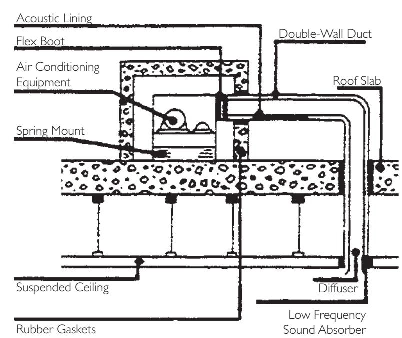
Before buying large equipment, be sure to inquire about equipment noise levels. Insist on quiet units.

Whenever possible, isolate furnaces, air conditioners and other HVAC units away from "quiet" areas. Enclose these units in a well-insulated room, and utilize a solid core door when equipment rooms are accessible to building interiors.

Also, when installing equipment likely to vibrate, use vibration isolators.

Vertical ducts or ventilation risers mounted on the exterior of buildings frequently are the cause of noise complaints. Such devices often rattle in windy areas or snap, crackle and pop (owing to thermal expansion and contraction) with outdoor temperature variation. Further, the outdoor noise of aircraft, traffic, etc. are easily transmitted by the thin-walled duct and carried into the building interior. All exterior ductwork should be of double-wall construction with acoustical lining and silencers. Staggered Wood Studs

Figure 17

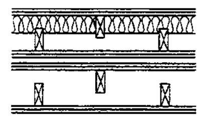
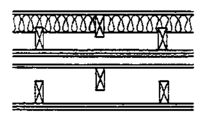
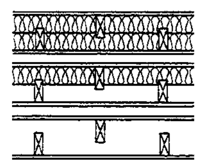
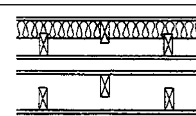


When possible, noisy equipment should be acoustically enclosed.

INNOVATIONS FOR LIVING™

Sound Control

Staggered Wood Studs

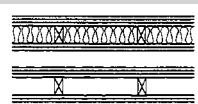
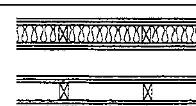
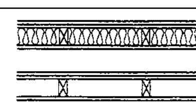
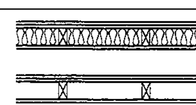
Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
DL	W4869	55	Staggered wood studs 24" o.c.; double layer ½" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		1 hr.[1]	UL U309
DL	W4669	52	Staggered wood studs 24" o.c.; double layer ½" type "x" gypsum drywall each side; no insulation		1 hr.[1]	UL U309
UB	W4769	53	Staggered wood studs 24" o.c.; double layer ½" type "x" gypsum drywall one side, single layer other side; one thickness, 3½" thick Wood Framing Batt Insulation		N.A.	—
UB	W4569	47	Staggered wood studs 24" o.c.; double layer ½" type "x" gypsum drywall one side, single layer other side; one thickness, no insulation		N.A.	—
SL	OC5FC	51	Staggered wood studs 16" o.c.; single layer ½" type "x" gypsum drywall each side; two thicknesses, 3½" thick Wood Framing Batt Insulation		1 hr.	OSU 4970
SL	W01486	51	Staggered wood studs 16" o.c.; single layer ½" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		N.A.	—
SL	OC3FC	39	Staggered wood studs 16" o.c.; single layer ½" type "x" gypsum drywall each side; no isulation		N.A.	—
SL	W5769	46	Staggered wood studs 24" o.c.; double layer ⅝" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		1 hr.[1]	UL U305
SL	W5869	43	Staggered wood studs 24" o.c.; double layer ⅝" type "x" gypsum drywall each side; no isulation		1 hr.[1]	UL U305

DL=double layers of gypsum drywall UB=unbalanced layers of gypsum drywall SL=single layers of gypsum drywall

[1]Rating is estimated from tests using thinner assemblies of fewer layers of gypsum drywall. Specific test references are available and will be provided upon request.

Owens Corning Metal Framing Batts and Wood Framing Batts are manufactured from fiber glass insulation.

Single Wood Studs with Resilient Channel

Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
DL	W0569	56	Single wood studs 16" o.c.; resilient channel; double layer ½" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		1 hr.[1]	OSU T-3127
DL	W1369	52	Single wood studs 16" o.c.; resilient channel; double layer ½" type "x" gypsum drywall each side; one thickness, no insulation		1 hr.[1]	UL U305
UB	W0669	52	Single wood studs 16" o.c.; resilient channel; single layer ½" type "x" gypsum drywall one side, double layer other side; one thickness, 3½" thick Wood Framing Batt Insulation		N.A.	—
UB	W1469	44	Single wood studs 16" o.c.; resilient channel; single layer ½" type "x" gypsum drywall one side, double layer other side; one thickness, no insulation		N.A.	—
SL	WP3230[2]	50	Single wood studs 16" o.c.; resilient channel; single layer ⅝" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		1 hr.[1]	OSU T-3127
SL	OCF431	40	Single wood studs 16" o.c.; resilient channel; single layer ⅝" type "x" gypsum drywall each side; one thickness, no insulation		1 hr.[1]	UL U305
SL	W0769	46	Single wood studs 16" o.c.; resilient channel; single layer ½" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		N.A.	—
SL	W0969	39	Single wood studs 16" o.c.; resilient channel; single layer ½" type "x" gypsum drywall each side; one thickness, no insulation		N.A.	—

DL=double layers of gypsum drywall UB=unbalanced layers of gypsum drywall SL=single layers of gypsum drywall

[1]Rating is estimated from tests using thinner assemblies of fewer layers of gypsum drywall. Specific test references are available and will be provided upon request.

[2]Listed in the Gyspum Association *Fire Resistance Design Manual*

Owens Corning Metal Framing Batts and Wood Framing Batts are manufactured from fiber glass insulation.

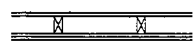
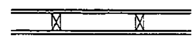
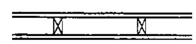
OWENS CORNING®

INNOVATIONS FOR LIVING™

Wall System Selection Chart For Wood Stud Walls

Sound Control

Single Wood Studs

Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
DL	W2569	45	Single wood studs 16" o.c.; double layer ½" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		1 hr.[1]	UL U305
UB	W4769	53	Single wood studs 16" o.c.; double layer ½" type "x" gypsum drywall one side, single layer other side; one thickness, 3½" thick Wood Framing Batt Insulation		N.A.	—
UB	W2269	38	Single wood studs 16" o.c.; double layer ½" type "x" gypsum drywall one side, single layer other side; no insulation		N.A.	—
SL	W2069	39	Single wood studs 16" o.c.; single layer ½" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		N.A.	—
SL	W2169	35	Single wood studs 16" o.c.; single layer ½" type "x" gypsum drywall each side; no insulation		N.A.	—
SL	W5769	46	Single wood studs 16" o.c.; single layer ⅝" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		1 hr.[1]	UL U305
SL	W5869	43	Single wood studs 16" o.c.; single layer ⅝" type "x" gypsum drywall each side; no insulation		1 hr.[1]	UL U305

DL=double layers of gypsum drywall UB=unbalanced layers of gypsum drywall SL=single layers of gypsum drywall

[1]Rating is estimated from tests using thinner assemblies of fewer layers of gypsum drywall. Specific test references are available and will be provided upon request.

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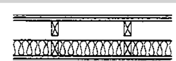
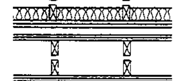
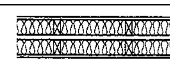
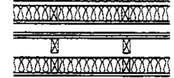
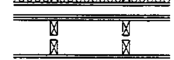
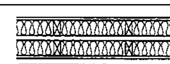
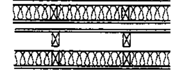
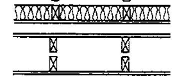
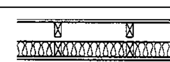
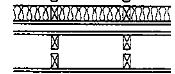
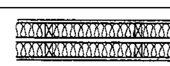
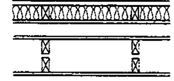
Double Wood Studs

Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
DL	W01480	64	Double wood studs 16" o.c.; double layer ½" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		1 hr.[1]	UL U305
DL	W4069	62	Double wood studs 16" o.c.; double layer ⅝" type "x" gypsum drywall each side; one thickness, 2½" thick Wood Framing Batt Insulation		2 hr.	WP 3820[2]
DL	W01580	54	Double wood studs 16" o.c.; double layer ½" type "x" gypsum drywall each side; one thickness, no insulation		1 hr.[1]	UL U305
UB	W0180	60	Double wood studs 16" o.c.; double layer ½" gypsum drywall one side, single layer other side; two thicknesses, 3½" thick Wood Framing Batt Insulation		1 hr.[1]	OSU 4936
UB	W01180	57	Double wood studs 16" o.c.; double layer ½" type "x" gypsum drywall one side, single layer other side; one thickness, 3½" thick Wood Framing Batt Insulation		N.A.	—
UB	W00980	48	Double wood studs 16" o.c.; double layer ½" type "x" gypsum drywall one side, single layer other side; one thickness, no insulation		N.A.	—
SL	W2869	59	Double wood studs 16" o.c.; double layer ½" type "x" gypsum drywall each side; two thicknesses, 3½" thick Wood Framing Batt Insulation		1 hr.[1]	OSU 4936
SL	W2969	56	Double wood studs 16" o.c.; single layer ½" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		N.A.	—
SL	W3469	47	Double wood studs 16" o.c.; single layer ½" type "x" gypsum drywall each side; no insulation		N.A.	—
SL	OCF448	56	Double wood studs 16" o.c.; single layer ⅝" type "x" gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation		1 hr.[1]	UL U305
SL	W4369	45	Double wood studs 16" o.c.; single layer ⅝" type "x" gypsum drywall each side; no insulation		1 hr.[1]	UL U305
SL	W02985	60	Double wood studs 24" o.c.; single layer⅝" type "x" gypsum drywall each side; two thicknesses, 3½" thick Wood Framing Batt Insulation		1 hr.	UL U341
SL	W03685	43	Double wood studs 24" o.c.; single layer ⅝" type "x" gypsum drywall each side; no insulation		1 hr.	UL U309

DL=double layers of gypsum drywall UB=unbalanced layers of gypsum drywall SL=single layers of gypsum drywall

[1]Rating is estimated from tests using thinner assemblies of fewer layers of gypsum drywall. Specific test references are available and will be provided upon request.

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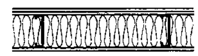
INNOVATIONS FOR LIVING™

Wall System Selection Chart For Metal Stud Walls

Sound Control

Single Layer Walls with Resilient Channel

Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
SL	RAL-TL89-293	55	Single layer wall, resilient channel; 5/8" type "x" gypsum drywall; 6" steel stud; one thickness, 6¼" thick Metal Framing Batt Insulation		1 hr.[1]	UL U465
SL	RAL-TL90-344	54	Single layer wall, resilient channel; 5/8" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 6¼" thick Metal Framing Batt Insulation		1 hr.	UL U465

DL=double layers of gypsum drywall UB=unbalanced layers of gypsum drywall SL=single layers of gypsum drywall
[1]Rating is estimated from tests using thinner assemblies of fewer layers of gypsum drywall. Specific test references are available and will be provided upon request.
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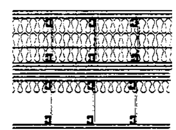
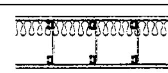
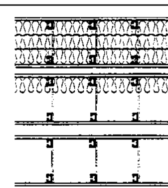
Chase Walls

Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
DL	W1268	60	Chase wall; double layer 5/8" type "x" gypsum drywall; 1 5/8" steel stud; three thicknesses, 3½" thick Sound Attenuation Batt Insulation		2 hr.	UL U436
DL	RAL-TL90-350	57	Chase wall; double layer 5/8" type "x" gypsum drywall; 1 5/8" steel stud; three thicknesses, 3½" thick Sound Attenuation Batt Insulation		2 hr.	UL U420
SL	RAL-TL90-349	53	Chase wall; 5/8" type "x" gypsum drywall; 1 5/8" steel stud; one thickness, 3½" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation		1 hr.	UL U420
SL	W1068	55	Chase wall; ½" type "x" gypsum drywall; 1 5/8" steel stud; three thicknesses, 3½" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation		N.A.	—
SL	W468	52	Chase wall; ½" type "x" gypsum drywall; 1 5/8" steel stud; one thickness, 3½" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation		N.A.	—
SL	W368	42	Chase wall; ½" type "x" gypsum drywall; 1 5/8" steel stud; no insulation		N.A.	—

DL=double layers of gypsum drywall UB=unbalanced layers of gypsum drywall SL=single layers of gypsum drywall
[1]Rating is estimated from tests using thinner assemblies or fewer layers of gypsum drywall. Specific test references are available and will be provided upon request.
Owens Corning Metal Framing Batts and Wood Framing Batts are manufactured from fiber glass insulation.

Shaftwalls

Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
UB	NGC-2626[2]	47	Unbalanced wall, 1" shaftliner one side, 2 layers ½" type "x" gypsum drywall other side; 2½" I-studs, 1½" Shaftwall Insulation		2 hr.	WP 7080[1]
UB	NGC-2617[2]	45	Unbalanced wall, 1" shaftliner and 1 layer ½" type "x" gypsum drywall one side, 1 layer ½" type "x" gypsum drywall other side; 2½" I-studs, 1½" Shaftwall Insulation		2 hr.	WP 7079[1]
SL	NGC-2542[2]	42	Single layer wall, 1" shaftliner one side, 5/8" type "x" gypsum drywall other side; 2½" I-studs, 1½" Shaftwall Insulation		1 hr.	FM WP-755[2]

DL=double layers of gypsum drywall UB=unbalanced layers of gypsum drywall SL=single layers of gypsum drywall
[1]Listed in the Gyspum Association *Fire Resistance Design Manual.*
[2]Reprinted with permission of National Gypsum Company.
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Wall System Selection Chart For Metal Stud Walls

Sound Control

Unbalanced Walls with Resilient Channel

Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
UB	RAL-TL89-285	60	Unbalanced wall, 5/8" type "x" gypsum drywall; single layer one side; double layer and resilient channel other side; 6" steel stud; one thickness, 6¼" thick Metal Framing Batt Insulation		1 hr.[1]	UL U465
UB	RAL-TL90-345	58	Unbalanced wall, 5/8" type "x" gypsum drywall; single layer and resilient channel one side; double layer other side; 6" steel stud; one thickness, 3½" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation		1 hr.[1]	UL U465

DL=double layers of gypsum drywall UB=unbalanced layers of gypsum drywall SL=single layers of gypsum drywall
[1]Rating is estimated from tests using thinner assemblies of fewer layers of gypsum drywall. Specific test references are available and will be provided upon request.
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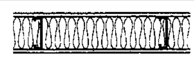
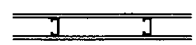
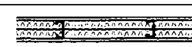
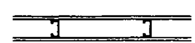
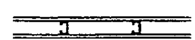
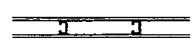
Single Layer Walls

Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
SL	RAL-TL89-288	51	Single layer wall, 5/8" type "x" gypsum drywall; 6" steel stud; one thickness, 6¼" thick Metal Framing Batt Insulation		1 hr.	UL U465
SL	RAL-TL89-157	50	Single layer wall, 5/8" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3½" thick Metal Framing Batt Insulation or Sound Attenuation Batt Insulation		1 hr.	UL U465
SL	W03582	48	Single layer wall, 5/8" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 2½" thick Sound Attenuation Batt Insulation		1 hr.	UL U465
SL	W03182	43	Single layer wall, 5/8" type "x" gypsum drywall; 3 5/8" steel stud; no insulation		1 hr.	UL U465
SL	RAL-TL87-394	48	Single layer wall, ½" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3½" thick **Firecore 60® Type FB Sound Attenuation Batt Insulation**		1 hr.	UL U468
SL	RAL-T87-392	47	Single layer wall, ½" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3½" thick Metal Framing Batt Insulation or Sound Attenuation Batt Insulation		N.A.	—
SL	W03682	44	Single layer wall, ½" gypsum drywall; 3 5/8" steel stud; one thickness, 2½" thick Sound Attenuation Batt Insulation		N.A.	—
SL	W00582	36	Single layer wall, ½" gypsum drywall; 3 5/8" steel stud; no insulation		N.A.	—
SL	W05182	47	Single layer wall, 5/8" type "x" gypsum drywall; 2½" steel stud; one thickness, 2½" thick Sound Attenuation Batt Insulation		1 hr.	UL U468
SL	W05482	40	Single layer wall, 5/8" type "x" gypsum drywall; 2½" steel stud; no insulation		1 hr.	SP 1340[2]
SL	RAL-TL91-306	45	Single layer wall, ½" type "x" gypsum drywall; 2½" steel stud; one thickness, 3½" thick ***Firecore 60* Type FB Sound Attenuation Batt Insulation**		1 hr.	UL U468
SL	RAL-TL91-309	44	Single layer wall, ½" gypsum drywall; 2½" steel stud; one thickness, 2½" thick Sound Attenuation Batt Insulation		N.A.	—
SL	W04382	34	Single layer wall, ½" gypsum drywall; 2½" steel stud; no insulation		N.A.	—

DL=double layers of gypsum drywall UB=unbalanced layers of gypsum drywall SL=single layers of gypsum drywall
[1]Listed in the Gyspum Association *Fire Resistance Design Manual.*
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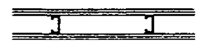
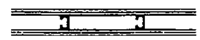
INNOVATIONS FOR LIVING™

Wall System Selection Chart For Metal Stud Walls

Sound Control

Double Layer Walls

Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
DL	W02584	58	Double layer wall; 5/8" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3½" thick Metal Framing Batt Insulation or Sound Attenuation Insulation		2 hr.	UL U411
DL	W02982	52	Double layer wall; 5/8" type "x" gypsum drywall; 3 5/8" steel stud; no insulation		2 hr.	UL U411
DL	W02184	56	Double layer wall; ½" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3½" thick Metal Framing Batt Insulation or Sound Attenuation Insulation		2 hr.	WP 1545[1]
DL	W-780	50	Double layer wall; 5/8" type "x" gypsum drywall; 3 5/8" steel stud; no insulation		2 hr.	WP 1545[1]
DL	W02784	57	Double layer wall; 5/8" type "x" gypsum drywall; 2½" steel stud; one thickness, 2½" thick Sound Attenuation Insulation		2 hr.	UL U411
DL	W03084	54	Double layer wall; ½" type "x" gypsum drywall; 2½" steel stud; one thickness, 2½" thick Sound Attenuation Insulation		2 hr.	WP 1545
DL	W04582	45	Double layer wall; ½" type "x" gypsum drywall; 2½" steel stud; no insulation		2 hr.	WP 1545[1]

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[1]Listed in the Gyspum Association *Fire Resistance Design Manual.*
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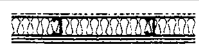
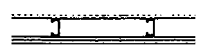
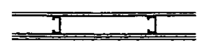
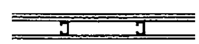
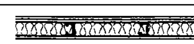
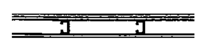
Unbalaced Walls

Layer	STC Test No.	STC	Construction Description		Fire Rating	Fire Test
UB	W02484	55	Unbalanced wall; 5/8" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3½" thick Metal Framing Batt Insulation or Sound Attenuation Batt Insulation		1 hr.[1]	UL U465
UB	W03082	47	Unbalanced wall; 5/8" type "x" gypsum drywall; 3 5/8" steel stud; no insulation		1 hr.[1]	UL U465
UB	W02284	52	Unbalanced wall; ½" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3½" thick Metal Framing Batt Insulation or Sound Attenuation Batt Insulation		N.A.	—
UB	W00682	41	Unbalanced wall; ½" gypsum drywall; 3 5/8" steel stud; no insulation		N.A.	—
UB	W02884	52	Unbalanced wall; 5/8" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3½" thick Metal Framing Batt Insulation or Sound Attenuation Batt Insulation		1 hr.[1]	UL U494
UB	W05382	44	Unbalanced wall; 5/8" type "x" gypsum drywall; 2½" steel stud; no insulation		1 hr.[1]	WP 1340[2]
UB	W02984	50	Unbalanced wall; ½" type "x" gypsum drywall; 2½" steel stud; one thickness, 2½" thick Sound Attenuation Batt Insulation		N.A.	—
UB	W04482	39	Unbalanced wall; ½" gypsum drywall; 2½" steel stud; no insulation		N.A.	—

DL=double layers of gypsum drywall UB=unbalanced layers of gypsum drywall SL=single layers of gypsum drywall
[1]Rating is estimated from tests using thinner assemblies or fewer layers of gypsum drywall. Specific test references are available and will be provided upon request.
[2]Listed in the Gyspum Association *Fire Resistance Design Manual.*
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Sound Control

1. Does the density of insulation affect the acoustical performance of a wall system?
   A. Yes
   B. No

2. Does the thickness of the insulation affect the acoustical performance of a wall system?
   A. Yes
   B. No

3. The measure of sound pressure or intensity is called a(n):
   A. Decibel
   B. Frequency
   C. Impact

4. Unwanted sound, regardless of the source is called:
   A. Heavy metal
   B. Noise
   C. Vibrations

5. The ear is most sensitive to sound around __ Hz.
   A. 5,000 Hz.
   B. 2,000 Hz.
   C. 1,000 Hz.

6. The amount of sound energy absorbed by an object is expressed in terms of:
   A. Sound Absorption Coefficient
   B. Noise Reduction Coefficient
   C. Sound Transmission Class

7. A material with a sound absorption coefficient of .85 means that ____% of the sound energy striking the materials is reflected.
   A. 85%
   B. 15%
   C. 50%

8. The single number rating system describing the sound absorbing power of a material is defined as the:
   A. Noise Reduction Coefficient
   B. Sound Transmission Class
   C. Sound Absorption Coefficient

9. Any material defined as a sound absorber must have an NRC value of _______ or greater.
   A. 0.20
   B. 0.30
   C. 0.40

10. The human ear cannot perceive acoustical differences between two sound absorbers whose NRC values differ by ________:
    A. 0.05
    B. 0.80
    C. 0.85

11. Can the human ear detect an NRC difference of .80 and .90 of two different materials?
    A. Yes
    B. No

12. The NRC of unpainted concrete block is:
    A. .27
    B. .44
    C. .35

13. The ability of a material or system to block or attenuate the transmission of sound from one area to another is measured by:
    A. Noise Gain
    B. Transmission Loss
    C. Sound Attenuation

14. The test method used by all laboratories in determining sound transmission loss is ASTM:
    A. E90
    B. C124
    C. D356

15. The ___________is a method of rating the air-borne sound transmission performance of a wall or ceiling assembly at different frequencies by means of a single number.
    A. Noise Reduction Coefficient
    B. Sound Transmission Class
    C. Hz. rating

16. How can the STC of a ceiling be improved?
    A. By placing fiber glass insulation batts on the backs of the ceiling panels
    B. By drilling holes into the ceiling panels
    C. By using a white noise machine

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Sound Control

17. Typically, when fiber glass insulation is placed on top of an existing commercial ceiling, the STC can be improved by 7 to __ points.
    A. 11
    B. 12
    C. 15

18. A difference in STC rating of 3 points is audible to the human ear.
    A. Yes
    B. No

19. Different laboratories testing for STC often get different readings when using the same assemblies.
    A. Yes
    B. No

20. What is the STC rating of a wood sided exterior wall with 3 ½" R-11 insulation? (No resilient channel)
    A. 21
    B. 29
    C. 39

21. As a general rule, doubling the weight of a wall system increases sound transmission loss by an additional 5-6 dBs.
    A. Yes
    B. No

22. Resilient channel reduces the efficiency of the sound reduction of a wall system.
    A. Yes
    B. No

23. Windows in walls typically have a lower transmission loss value than the surrounding wall.
    A. Yes
    B. No

24. When designing a wall for increased acoustical performance and absorption, minimizing doors, windows and electrical outlets in the wall is beneficial.
    A. Yes
    B. No

25. The use of fiber glass building insulation in a typical metal stud wall, staggered wood stud wall, or other wall with isolated faces can increase sound transmission loss by about 8 dBs.
    A. Yes
    B. No

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