NOISE CONTROL

DESIGN GUIDE

OWENS CORNING®

INNOVATIONS FOR LIVING™

Contents

Introduction

Excessive noise is almost everywhere - in homes, offices, schools, hospitals, institutional buildings and factories. Noise can be unsettling, cause fatigue, lower worker productivity, impair communication and in the extreme even cause hearing loss.

Owens Corning, a world leader in acoustical research and product manufacturing, is committed to providing designers, engineers, acoustical consultants, developers and owners with authoritative, useful data to aid them in planning quiet living and working environments.

Owens Corning conducts acoustic testing at its laboratory located in the Owens Corning Science and Technology Center in Granville, Ohio. The facility conducts basic and applied research for internal and external customers to help develop or refine new products, or test and evaluate new products or concepts. The laboratory evaluates different materials or systems to assist in selecting the best materials for different applications.

Owens Corning has been a major source of sound control research and acoustical products for over 30 years. The company is actively involved in standards writing groups such as the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI)-two groups whose test methods are nationally known and used by the majority of acousticians.

The company manufactures a wide range of products that can be utilized to reduce excessive noise levels. All products and applications detailed in this guide have been tested in facilities 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 used to generate and analyze product/application performance.

This guide is intended to serve as a working tool by providing a concise discussion of sound, methods for its control and acoustical values for a wide range of products. With this information engineers should be able to deal effectively and economically with many sound control problems.

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. Sound waves travel through the air as alternating regions of compressed and rarified air.These changes in density are detected as small variations in pressure above and below the mean atmospheric static pressure.

The effective sound pressure is the root mean square (rms) of the deviation in pressure over some time period. 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 and has units of Hertz (Hz.). A frequency of 1000 Hz. means 1000 cycles per second.

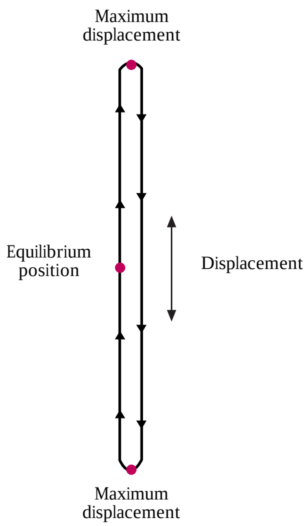


Figure 1: An air particle is made to vibrate about its equilibrium position by the energy of a passing sound wave.

Airborne and Structureborne Sound

Most noise is transmitted both as airborne and structureborne sound. For example, speech is airborne sound until it strikes a structure like a wall and becomes structureborne. Then by way of vibration, it is reradiated as airborne to the listener in an adjacent room or area.

Sound travels through the air at a constant speed at a given temperature of air. The speed of sound is 1,125 ft. per second (on a average 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.

As the sound wave moves outward, away from its source in all directions, the intensity of the wave decreases with 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 sound source and listener, the sound level decreases by 6 dB. Figure 2 depicts this loss. 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.

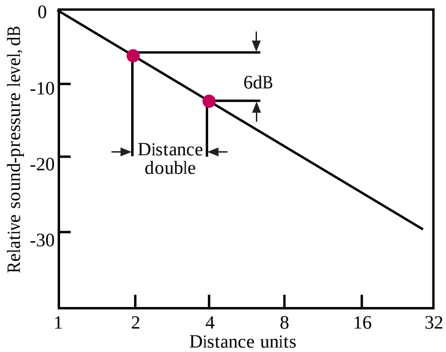


Figure 2: For every doubling of the existing distance between a sound source and a listener, there is a sound level decrease of 6 dB.

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 is increased.

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 of 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. And, secondly, the reflected sound travels a longer path than direct sound; thus energy is lost due to the greater distance traveled.

Figure 3: Direct sound travels an unobstructed path to the listener.

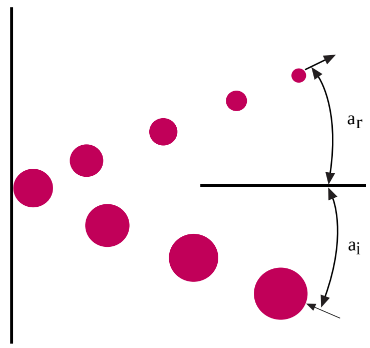


Figure 4: Reflected sound strikes surfaces on its way to the listener. The angle of reflection, ar, is equal to the angle of incidence ai.

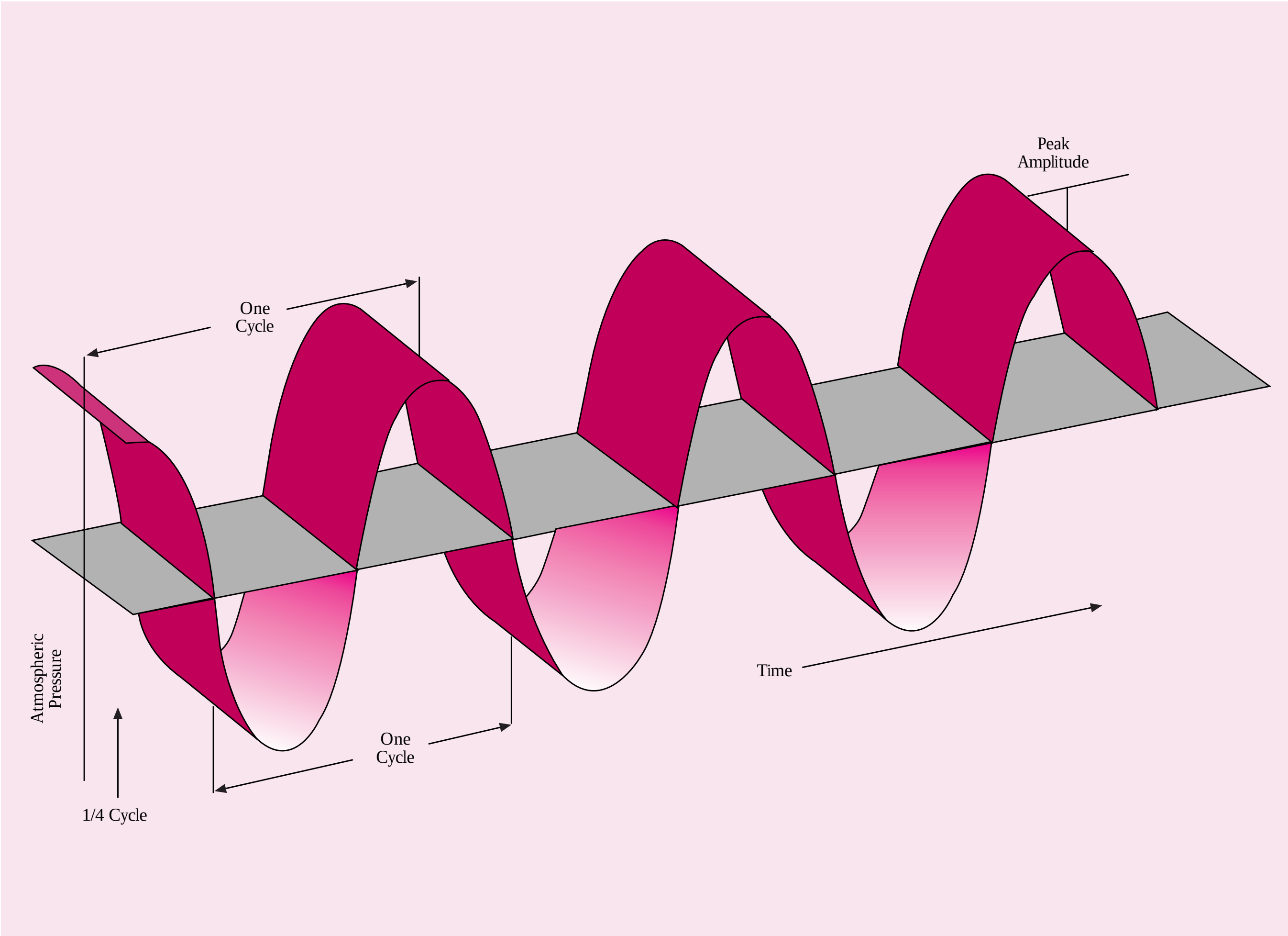


Figure 5: Wave length is the distance a wave travels in the time it takes to complete one cycle.

Basic Principles of Noise Control

There are three basic elements to be considered in controlling noise:

- Controlling noise at its source.
- Controlling noise along its path.
- Controlling noise at the receiver.

Thus, in noise control, reference is made to SPR (Source, Path, Receiver) control. Any noise control problem may require that one, two or all three of these basic control elements be taken into consideration.

Step-by-Step Control of Noise

The following four-step procedure will often provide a satisfactory solution to simple noise control problems. Before initiating these procedures, "A" weighted sound pressure level readings should be taken to determine the degree of excessive noise exposure.

1. Take octave band noise level readings. These will reveal which frequencies are most objectionable from the listener's standpoint, and will provide a basis for selecting acoustical materials whose absorption coefficients and/or sound transmission loss properties are best tailored to solving the particular noise problem.

2. Determine the true source of noise. Many times this is difficult to detect due to multiple noise sources. For example, a pump might be perceived to be the general noise source, but the underlying source might be one or more parts of the pump: a worn gear, loose couplings, air in the fluid being pumped or all three.

3. Determine whether the noise can be controlled at its source. It is most desirable, from an acoustical as well as an economic standpoint, to attenuate noise at the source before attempting to reduce noise transmission along its path, or to solve the problem at the receiver end.

4. Decide which of the three: source, path, or receiver, are to be considered first for noise control measures. Factors influencing this decision will include initial cost, ease of installation, access to equipment, effect on productivity, safety, and possibly others.

Specific noise control measures may then be designed with the assistance of the acoustical properties data included in this manual on pages 18 through 22.

Sound Pressure Measurement

A sound level meter is used to measure sound pressure level in decibels. It is equipped with scales designated "A" and linear. The "A" scale adjusts sound level readings to correspond closely to those heard by the human ear.

The "A" scale takes into consideration the fact that the human ear is less sensitive to low frequencies and is most sensitive to frequencies near 2000 Hz. Also, noise-induced hearing loss usually manifests itself in the frequency range from 1000 to 5000 Hz.

Effective noise control design cannot be achieved from "A" scale sound level meter readings alone. The frequency content as well as the sound level of the offending noise needs to be measured to ensure satisfactory performance of noise control measures. Therefore, in addition to taking "A" scale sound level meter reading, octave band noise level measurements should also be made (see Fig. 6). An octave band filter, used in conjunction with a sound level meter, measures the noise level of a group of frequencies (i.e., one octave.) Octave bands have center frequencies of 125, 250, 500, 1000, 2000 and 4000 Hz (also, sometimes, 8000 Hz). Thus, the product test data presented in this manual is given in octave bands in order to aid the proper selection and design of effective noise control measures.

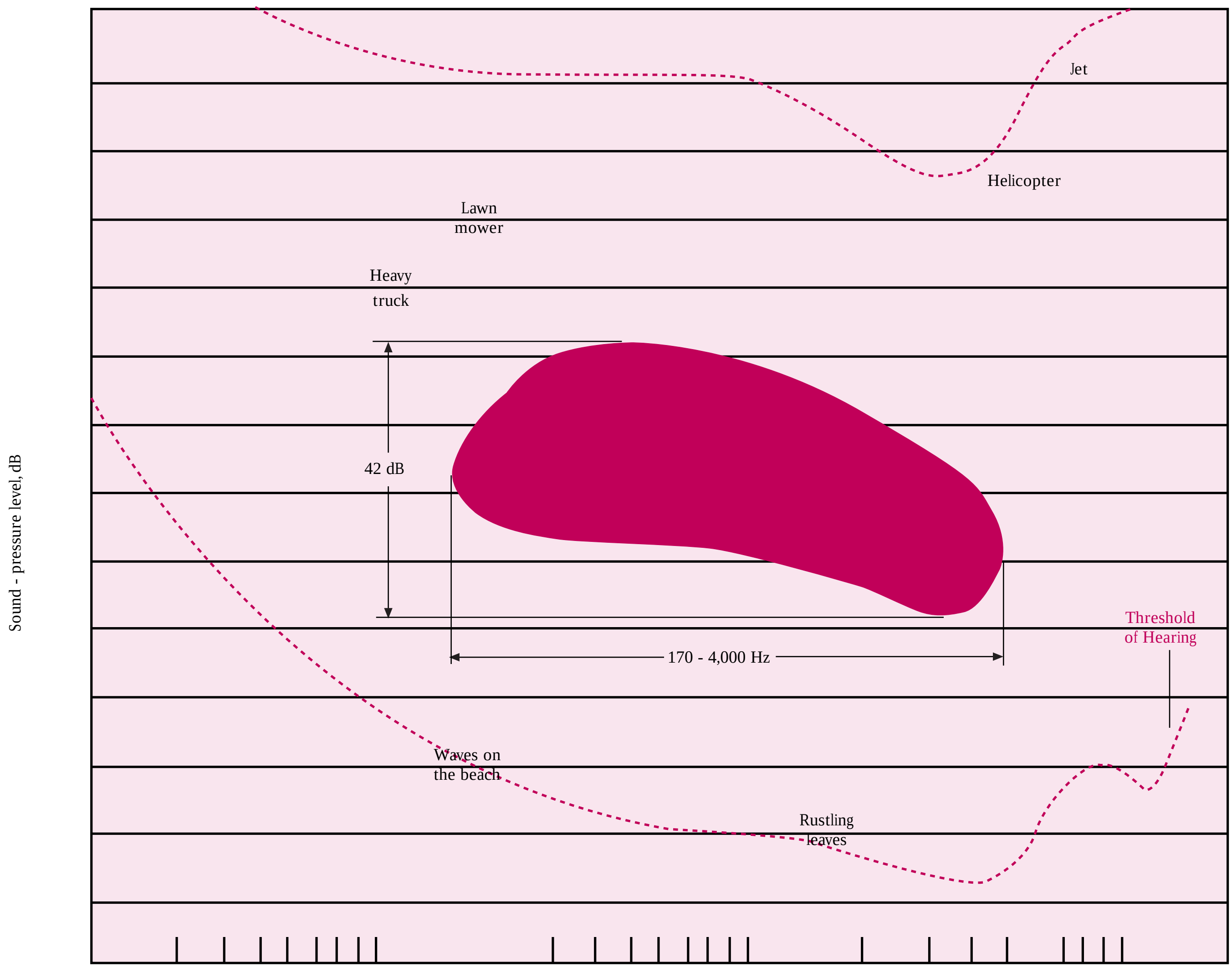
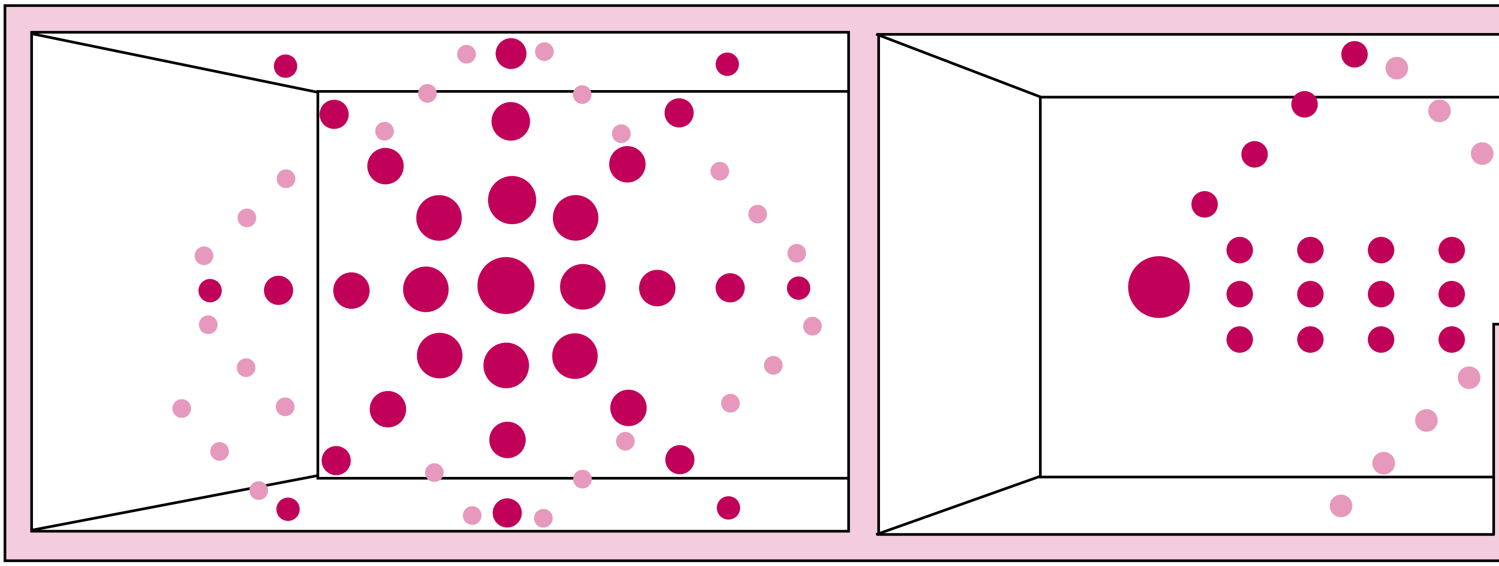


Figure 6: The auditory capability of the human ear is indicated by the dotted lines. The shaded area depicts common speech sounds.



Controlling Noise at its Source

The most effective means of reducing the noise level at a particular location is to reduce the noise emitted at the source. Noise reduction at the source may be accomplished in several ways:

- The noise source may be replaced by quieter equipment; modified to deliver the desired noise reduction; or repaired/ adjusted to reduce noise.
- The noise source may be moved to a location sufficiently distant from the noise-sensitive area to reduce the noise to an acceptable level.
- If it is found that vibrations are being transmitted to a building structure or housing, the noise source may be mounted on vibration isolators.
- The noise source may be coated with a damping compound to attenuate the sound energy radiating from vibrating surfaces.
- The noise source may be enclosed in an acoustically effective housing.

Housings for equipment may be built using glass fiber reinforced plastics (GRP). The housing's noise reduction can be further improved with the use of Fiberglas insulation. Insulation can be selected based on a wide range of performance attributes.

Where it is not feasible to utilize an equipment housing, it may be feasible to build an enclosure around the entire equipment area. Such enclosures are available from specialty manufacturers or may be constructed on-site using insulation, sheet metal, lead, drywall, plywood or masonry products.

Depending on insulation type, thickness, location and the noise source frequency band, the effective noise attenuation of the enclosure can be increased up to 12 dB.

Ducts are often major noise contributors. Owens Corning offers rigid duct board, duct wrap, and duct liners to reduce noise and provide an effective, energy-saving thermal barrier.

Fiberglas insulation can also be used to reduce noise emanating from pipes. A complete line of pipe insulation products is available to meet a wide range of thermal performance, temperature, fire safety, and durability requirements.

Controlling Noise along its Path

Sound travels to a listener by taking either a direct path, not striking any surface, or an indirect path, reflected from one or more surfaces. In most instances, both direct and indirect sound reaches the listener.

Direct Sound

An effective means of reducing direct sound is to install an effective acoustical barrier between the noise source and the receiver. Since by definition a barrier does not extend from the floor to the ceiling or roof, sound will be diffracted around the barrier in a manner similar to that in which light is diffracted around an object it strikes.

A sound barrier, to be most effective, must have two acoustical properties. One: the noise reduction capacity of the barrier must be high enough so sound is attenuated or blocked from passing through the barrier. Two: it must be sound absorptive so sound striking the barrier is absorbed and not reflected back into the area of the source.

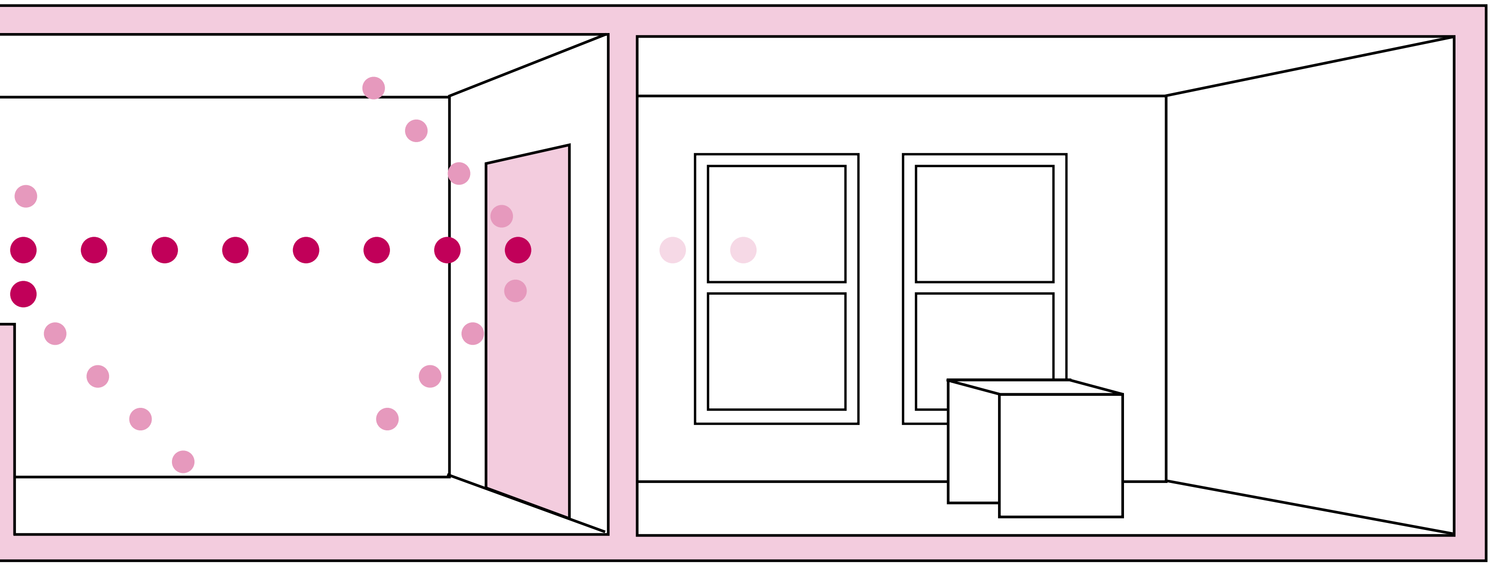


Figure 7: Noise can be controlled at the source, along its path and at the receiver.

Indirect Sound

The most effective means of reducing reflected sound is to install absorptive materials on the surfaces the sound strikes. Thus, when the sound strikes these surfaces, most is absorbed and very little reflected. Fiberglas insulations can absorb up to 99% of the sound striking their surface making them one of the most efficient sound absorptive materials available.

Where possible, the installation of an acoustical ceiling provides one of the most effective methods of reducing sound reflections. If this is not feasible then baffles may be used in the ceiling area; or acoustical treatments may be applied to side walls or to the underside of the roof deck.

Owens Corning offers a wide range of insulations that can be used to create acoustical treatments.These products can be covered by porous facings such as pegboard, expanded metal or cloth fabrics with little loss of sound absorption values.

Controlling Noise at the Receiver

The only permanent method to reduce noise at the receiver position is to build a partial or complete enclosure around the receiver or listener. An enclosure for a listener is very similar to an enclosure for a noise source.

The basic difference between the two is that an employee enclosure must provide an environment in which the employee can function efficiently and comfortably. This means that lights, windows, a door, and a ventilation system must be provided. These may degrade the overall acoustical performance of the enclosure due to sound leaks and to lower noise reduction values of doors and windows. Therefore, greater emphasis must be placed on the details of designing and building a receiver enclosure than in the case of a noise source enclosure.

The use of Fiberglas insulation in stud and joist cavities of an enclosure, plus liberal use of caulking to seal sound leaks, is an excellent start in the design of a worker enclosure. Locate doors and windows on the side away from the noise source, if possible. Ventilation systems should be located and installed to minimize the conduction of noise into the enclosure.

Choosing the Right Acoustical Materials

The hearing range of the human ear 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 1000 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 acoustical functions: Either they absorb sound, or they block (attenuate) its transmission. Most acoustical materials are either sound absorbers or have high sound transmission loss values. 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 transmissions, environmental noise control, construction design for interior wall acoustical control, and specific wall constructions and their STC (Sound Transmission Class) values.

Sound Absorption

What is Sound Absorption?

All Materials absorb sound energy to some degree. Whenever sound waves strike a material, part of the acoustical energy in the wave is absorbed and/or transmitted, 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 the sound absorption coefficient.

The Sound Absorption Coefficient

The sound absorption coefficient is the decimal fraction of the sound energy 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 reflected striking that material is absorbed, and 15 percent of the sound energy reflected.

Since all materials absorb different amounts of energy, depending on the frequency of the sound wave striking the material, 1/3 octave band sound absorption coefficients of a material are determined for center frequencies from 125 to 4000 Hz. These values are reported at octave band center frequencies, see tables 13 to 20. In architectural acoustics a pure, or a single frequency of noise is rarely 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 specified by the American Society for Testing and Materials (ASTM) test procedure C423. The latest revision of this standard should be used since changes are frequently made to the test standard.

Sound absorption coefficients greater than 1.00 cannot occur in theory but can be measured for materials highly sound absorptive. As recommended by the standard test method, coefficients greater than 1.00 are reported as measured and are not adjusted. The material's corresponding Noise Reduction Coefficient (NRC) may also be greater than 1.00.

The Noise Reduction Coefficient

A material's sound absorbing capabilities is frequently expressed in product literature and specifications by a single number NRC (Noise Reduction Coefficient) rating. The NRC is the average of the sound absorption coefficients measured at 250, 500, 1000, and 2000 Hz rounded off to the nearest 0.05.

The human ear normally cannot hear the acoustical difference between two sound absorbers whose NRC values differ by 0.05; thus, two materials with an NRC of 0.80 and 0.85 respectively will appear to absorb the same amount of sound.

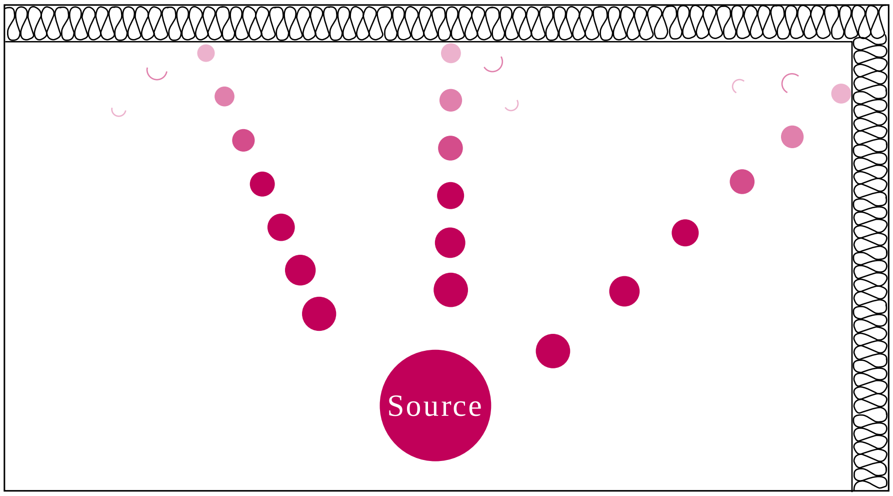
A material usually has an NRC value greater than 0.40 before it is called a sound absorber. Porous materials such as fibrous glass allow sound waves to penetrate into the material where the acoustical energy is converted to heat, due to friction between the air and the glass fibers. These materials can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

Total Sabins of Absorption

To determine how much the sound in a space will decrease with the addition of sound absorbing materials, the total sabins of absorption for the space must be calculated.

To calculate this number, one must multiply the sound absorption coefficients of all the different types of materials in a room – at a particular frequency – by the area of coverage of each material. The designers should always work with absorption coefficients for each frequency of concern and not use the NRC, which is a gross average. Refer to Table 2 for the sound absorption coefficients of various building materials.

Figure 8: When a sound wave strikes a surface, part of its acoustical energy is absorbed and the remainder is reflected.



Calculating Change in Sound Levels

Once the total sabins of absorption in a room are known, it is easy to calculate the change in sound pressure level (SPL) when one material is replaced with another. Calculate the SPL change by using the following equation:

ASPL = 10 log SA/SB

Where SA = sabins of absorption after treatment.

Where SB = sabins of absorption before treatment.

Table 1 shows the subjective perception and actual equivalent sound reduction in terms of changes in the sound level for the various decibel reductions.

Sample Problem

The following sample problem will help in determining the change in sound pressure level within a room.

Assume a room has the dimensions of 30 x 40 x 9 ft. The room has a gypsum board ceiling, and the walls are constructed of wood studs with gypsum wallboard. The floor is covered with linoleum. A new acoustical ceiling is to be installed with a NRC (noise reduction coefficient) of 0.60 at 500 Hz.

Based on this assumption the sabins of absorption in a room can be calculated by using the procedures shown in Example 1.

Example 1:

Procedure for calculating the sabins of absorption in a room at 500 Hz.

		Wall	Ceiling	Floor
1. List areas of room surface (sq. ft.)		1260	1200	1200
2. List sound absorption coefficient for each room surface. (See Table 2)		0.05	0.05	0.03
3. Multiply Line 2 by Line 1 to compute sabins.		63	60	36
4. Add results of Line 3 for total sabins, all room surfaces.		159		
5. List sabins for people in room.		—		
6. List sabins for free hanging baffles.		—		
7. Add Lines 5, 6, 7 to find total sabins for room.	S_B	159		

To determine the reduction in noise levels produced by adding sound absorbing material to a room, Example 2 can be used. The noise reduction in Line 5 can be further improved by adding more sound absorbing material to the room and again completing steps 2 thru 5. The practical upper limit for reduction of the noise levels is 10 to 12 dB. If estimates are in excess of this amount, they should be carefully analyzed.

Example 2:

Procedure for calculating the reduction in noise levels produced by adding sound absorbing material to a room.

1. Determine total sabins for untreated room.	SB	159
2. Determine total sabins for room with added acoustical treatment.	SA	819
3. Divide Line 2 by Line 1.		5.15
4. Take the logarithm of Line 3.		0.71
5. Multiply Line 4 by 10 to get reduction in noise level.		7.1dB

Calculating Reverberation Time

For most general applications, the reverberation time in a room should fall between 0.7 and 1.0 seconds, in order to avoid echoes that interfere with speech intelligibility.

A real time analyzer is used to measure the reverberation time, or the time in seconds it takes a sound to decrease 60 dB. The equation for reverberation time is:

$$T = \frac{0.05\,(V)}{A}\ \text{,sec.}$$

Where V = Volume of the room in cu. ft.

Where A = Absorption of the room in sabins

Sample Problem

By following the basic assumptions established in the preceding sample problem, the change in reverberation time within a room can be calculated by following the procedures in Example 3.

By following the criteria in Example 4, the amount of sound absorbing material to be added to a room to achieve a desired reverberation time can also be calculated.

Example 3:

Procedure for calculating reverberation time.

1. Calculate the volume of the room in cubic feet.	10800
2. Multiply Line 1 by .05	540
3. Determine total sabins for room	159
4. Divide Line 2 by Line 3 to obtain reverberation time in seconds.	3.40

Example 4:

Procedure for determining the amount of sound absorbing material to be added to a room in order to achieve a desired reverberation time.

1. Calculate the volume of the room in cubic feet.	10800
2. Multiply Line 1 by .05.	540
3. List desired reverberation time in seconds.	.70
3. Divide Line 2 by Line 3 to obtain total sabins required in room.	771
4. Determine sabins for untreated room.	1.59
5. Subtract Line 5 from Line 4 to get sabins of absorption to be added	612

Table 1:

Subjective perception and actual equivalent sound reduction in terms of changes in the sound level for various decibel reductions.

Level Change	Subjective Perception	Sound Change
0-3 dB	Barely perceivable	50%
4-5 dB	Perceivable and significant	69%
6 dB	Resultant sound level is 1/4 less than the original sound	75%
7-9 dB	Major reduction in sound level	87%
10 dB	Resultant sound is 1/2 less than the original sound	90%

Table 2:

Sound Absorption Coefficients of General Building Materials Table
from "Acoustical Ceilings – Use and Practice", Ceilings and Interior Systems Contractors Association (1978), p. 18.

	Octave Band Center Frequencies, Hz						
Materials	125	250	500	1000	2000	4000	NRC
Brick							
Unglazed	.03	.03	.03	. 04	.05	.07	.05
Unglazed, painted	.01	.01	.02	.02	.02	.03	.00
Carpet							
1/8" Pile height	.05	.05	.10	. 20	.30	.40	.15
1/4" Pile height	.05	.10	.15	.30	.50	.55	.25
3/16" Combined pile and foam	.05	.10	.10	.30	.40	.50	.25
5/16" Combined pile and foam	.05	.15	.30	.40	.50	.60	.35
Ceilings							
1/4" Mineral Board Ceiling	.31	.29	.51	.70	.71	.71	.55
5/8" Film Faced Fiberglass Ceiling	.66	.76	.60	.80	.89	.80	.75
1 1/2" Glass Cloth Faced Fiberglass Ceiling	.80	.96	.88	1.04	1.05	1.06	1.00
Concrete Block							
Unpainted	.36	.44	.31	.29	.29	.25	.35
Painted	.10	.05	.06	.07	.09	.08	.05
Fabrics							
Light velour, 10 oz. per sq. yd., hung straight in contact with wall	.03	.04	.11	.17	.24	.35	.15
Medium velour, 14 oz per sq. yd., draped to half area	.07	.31	.49	.75	.70	.60	.55
Heavy velour, 18 oz. per sq. yd., draped to half area	.14	.35	.55	.72	.70	.65	.60
Floors							
Concrete or terrazzo	.01	.01	.01	.02	.02	.02	.00
Linoleum, asphalt, rubber or cork tile on concrete.	.02	.03	.03	.03	.03	.02	.05
Wood	.11	.10	.07	.06	.07	.10	
Wood parquet in asphalt on concrete	.04	.04	.07	.06	.06	.07	.0
Glass							
1/4" sealed, large panes	.05	.03	.02	.02	.03	.02	.05
24 oz. operable window (in closed position)	.10	.05	.04	.03	.03	.03	.05
Gypsum Board							
1/2" nailed to 2x4 studs, 16: o.c., painted	.10	.08	.05	.03	.03	.03	.05
Marble or Glazed Tile	.01	.01	.01	.01	.02	.02	.00
Plaster, Gypsum or Lime							
Rough finish on lath	.02	.03	.04	.05	.04	.03	.05
Smooth finish on lath	.02	.02	.03	.04	.04	.03	.05
Hardwood Plywood Paneling							
1/4" thick, wood frame	.58	.22	.07	.04	.03	.07	.10
Wall Panels							
Fiberglass Wall Panels	.05	.30	.80	1.00	1.02	.95	.80
Water Surface							
As in swimming pool	.01	.01	.01	.01	.02	.03	.00
Wood Rough Decking							
Tongue-and-groove cedar	.24	.19	.14	.08	.13	.10	.15

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 sound transmission loss (TL).The higher the transmission loss, the more the material attenuates the sound. Sound transmission loss is measured at several test frequencies and is reported in decibels.

The sound transmission loss 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 E 90 (the latest revision of this standard should always be used since changes are often made in revising the standard).

Calculating Transmission Loss

The equation used to calculate sound transmission loss is:

TL = SPLs - SPLr + 10 log S/A, dB

Where:

SPLs = the average sound pressure level in the source room (i.e., the room with the sound source).

SPLr = the average sound pressure level in the receive room.

S = the surface area of the partition sq. ft.

A = the absorption, in sabins, in the receive room.

The last term (10 log S/A) in the above equation is called the normalizing factor. It adjusts the difference (SPLs – SPLr) in sound pressure levels measured across the test partition.This difference needs to be adjusted, or normalized, so that transmission loss values from different testing laboratories can be compared. It is used to adjust for the different size of test specimens tested in each laboratory and the amount of sabins of absorption in each receive room.

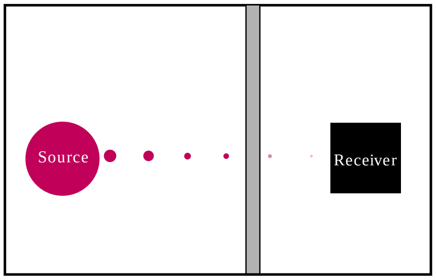


Figure 9: The higher a material's or system's sound transmission loss, the more the material attenuates the sound.

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 specified in the ASTM standard E 413 entitled, "Standard Classification for Determination of Sound Transmission Class."

The STC is determined from the sound transmission loss values of a partition measured in accordance with ASTM standard E 90.The sound transmission loss values must be measured at 16 one-third octave band frequencies, covering the range from 125 to 4000 Hz.

To determine the STC of a given specimen, its measured transmission loss values versus frequency are compared with a reference curve (STC contour), as shown in Figure 10.

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 any single test frequency shall not exceed 8 dB.
2. The sum of the deviations at all 16 frequencies of the test curve below the contour shall not exceed 32 dB.

The STC corresponds 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 2500 Hz., although the total deviation adds up to only 10 dB.

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 3 or 4 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 1 or 2 STC points.

However, two or three point differences in STC ratings between constructions are not significant. 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 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 transmission loss values at the frequencies of interest when determining the reduction of sound between two areas. By subtracting the sound transmission loss values from the dB levels of the noise in one room for each one-third octave band, the designer can predict what the resultant noise level will be in an adjacent room at each frequency.

Sound Insertion Loss

Another method of measuring the sound attenuation of a material or system is to determine its sound insertion loss, which is the difference in sound level with and without an enclosure in place. Many times an engineer is interested in the total attenuation or reduction provided by an enclosure.

The sound insertion loss of a single element or component such as sheet metal or plywood can also be determined. In most instances, a sound insertion loss test is conducted in lieu of a sound transmission loss test when the specimen is a complete enclosure or the specimen size is small.

The test is a simple comparison of the sound level at a given microphone location with and without the sample in place. First, the sound level is measured at the microphone location with no sample in place. Then, a sample is placed between the microphone and the sound field and the sound level recorded again.

The single number rating used to express the sound insertion loss of a panel is the Noise Isolation Class (NIC). The same procedures used for determining the STC are used to determine the NIC. The sound insertion loss values measured at the 16 one-third octave band test frequencies are compared to the standard STC contour described in ASTM E 413. The same precautions concerning the use of the STC rating also apply to the use of the NIC rating.

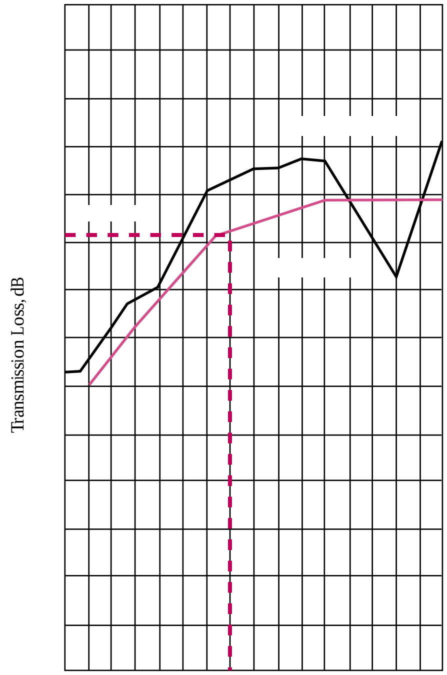


Figure 10: The STC is a method of rating the airborne sound transmission performance of a wall or floor / ceiling assembly.

Ceiling Sound Transmission Loss

Determining Ceiling Attenuation

Acoustical ceilings, in addition to providing sound absorption, also attenuate or reduce the transmission of noise from one office to another. Commercial acoustical ceiling products are evaluated for sound attenuation between two offices with a ceiling-height wall separating the offices. The test method used is ASTM standard E 1414. Sound is generated in the source room and goes through the test ceiling into 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 transmission loss 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 Attenuation Class

The ceiling's normalized attenuation values are graphed as a function of 16 one-third octave band frequencies covering the range from 125 to 4000 Hz. The CAC values are determined in the same manner as for partitions. (See Sound Transmission Class, page 12.)

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, 2 or 3 point differences in CAC values are not significant; the actual normalized attenuation factors should be examined when comparing two ceilings. It is important to note that the ceiling sound transmission loss 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 Attenuation Values

The sound attenuation of a ceiling can be improved by placing Fiberglas 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 CAC can be improved by 7 to 12 points.

As in the case of partitions, the effective sound attenuation 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 CAC 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 sound transmission loss values should be selected.

Designers should keep in mind what happens to the sound attenuation values of the ceiling system when lighting fixtures (luminaries) and air supply or return diffusers are installed. Many ceiling systems have luminaries 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 CAC values are for the ceiling board installed in a single tee grid system only, ceiling boards with luminaries are not tested. Therefore, the designer or specifier must realize that, on the job, the CAC value he specified will not be obtained. It will almost always be lower. How much lower will depend on the original CAC value of the ceiling assembly and the number and type of luminaires or return-air grills installed. It could be lower by 10 or 15 CAC points.

Figure 11: Acoustical ceilings help to attenuate sound transmission between rooms.

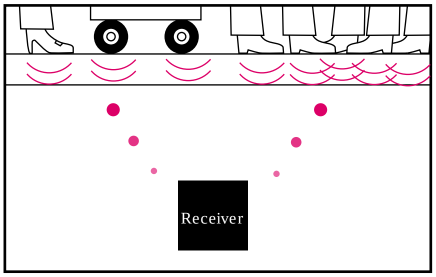


Figure 12: Direct mechanical contact with a floor or wall causes impact sound. The vibrations are transmitted through the structure and reradiated as sound in the adjoining space.

Impact Sound Transmission

What is Impact Sound?

Impact sound is caused by a floor or wall being set into vibration by direct mechanical contact. The sound is then radiated by the floor or wall surface. Floor vibrations may also be transmitted throughout the structure to walls and reradiated as sound in adjoining spaces.

Determining Impact Noise Transmission

The test method used for evaluating floor/ceiling assemblies for impact noise transmission is the ASTM test procedure E 492. Unlike the test procedure for measuring the airborne sound transmission loss of partitions, this test procedure does not require the measurement of the difference in sound pressure levels between a source and receive room. Only the receive room sound pressure levels at the 16 test frequencies are measured. The noise in the receive room is generated by placing a standard impact machine on flooring/ceiling assemblies. The impact noise is produced when metal cylinders in the tapping machine strike the floor surface.

The single-number rating used to express the degree of impact noise isolation provided by a floor/ceiling assembly is the Impact Insulation Class (IIC). It is determined in a similar manner to the partition STC. The method of determining the IIC is specified in ASTM standard E 989.

Determining the Impact Insulation Class

The IIC of the test specimen is determined by comparing the test curve with a reference frequency curve (IIC contour) as shown in Figure 13.

The IIC values on the right hand side of the test curve graph decreases in the upward direction. The right and left-hand scales coincide at 55 dB, and the two have the same scale factor (number of dB per division). The IIC contour is shifted vertically relative to the test data curve to as low of a positions possible, while fulfilling the following conditions.

1. The maximum deviation of the test curve above the contour at any single test frequency shall not exceed 8 dB.
2. The sum of the deviation at all 16 frequencies of the test curve above the contour shall not exceed 32 dB.

When the IIC contour is thus adjusted (in integral decibels), the IIC value is read from the right hand vertical scale of the test curve as the value corresponding to the intersection of the IIC contour and the 500 Hz. frequency line.

In Figure 13 the IIC value is 60 and is governed by the total deviation of 28 dB of the test curve above the IIC contour, rather than by a deviation of 8 dB at any one frequency.

Increasing Impact Noise Isolation

In commercial constructions where a suspended ceiling is utilized, adding Fiberglas insulation to the ceiling plenum will increase the impact noise isolation, as well as the airborne sound transmission loss. Resilient channels and Fiberglass insulation are recommended to reduce both impact noise and airborne sound transmission. The effective impact noise isolation of the floor/ceiling assembly can also be improved by adding sound absorptive materials to the receive room.

Figure 13: Charting the Impact Insulation Class.

However, the best method of improving the impact noise isolation provided by a floor/ceiling assembly is to install a carpet and pad on the floor. When a carpet and pad is placed on a floor, the impact hammers in the standard impact machine become isolated from the hard floor surface. Thus, very little impact noise is generated and transmitted to the lower or receive room. Although the IIC rating of the floor/ceiling assembly is greatly improved by adding a carpet and pad, the airborne STC value is changed very little because the carpet and pad do not attenuate the sound significantly.

Environmental Noise Control

Keeping Outside Noises Out

The reason for measuring the sound transmission loss and sound absorption coefficients of building materials or assemblies is to provide a means of predicting the expected noise level within a space. The noise in a given space or room may come from a noise source located in that space or from a noise source in an adjacent space. Previous discussions under Sound Transmission Loss and Sound Absorption have explained how the data can be used when designing interior spaces. This section will deal with noise sources generated outside of a building.

Determining the Influence of Outside Sources

The following equation can be used to predict the noise level in a building interior when the room is exposed to an outside noise source such as roadway traffic.

Lp(int) = Lp(ext)-TL+10 log S/A+ADJ

Where Lp(int) = predicted average sound pressure level in the building interior at a particular frequency, dB.

Lp (ext) = measured or predicted average sound pressure level at the building exterior for a particular frequency band, dB.

TL = the sound transmission loss of the exterior wall or roof at a particular, frequency band, dB.

S = total exposed exterior surface area of the room of interest, sq. ft.

A = total sabins of absorption in the room of interest at a particular frequency band.

The term ADJ is an adjustment factor which takes into consideration certain characteristics of the sound source. In general, for aircraft traverses or for sufficiently long lines of vehicle traffic, the sound field incident on the building façade is a reasonable approximation to the reverberant field condition in which the TL values were measured. For this case, the term ADJ=3 dB, which adjusts the exterior noise level for the effects of the building façade when constructed.

The term ADJ is equal to 3 dB only when the sound field incident on the façade approximates a reverberant field condition. For those instances when this is not true, the term ADJ takes a more general form. Thus, ADJ=3 dB+G. "G" (in dB) is an air adjustment for the geometrical arrangement of the noise source relative to the building façade. The sound transmission loss of a building component is dependent on the angle of incidence of the sound wave striking the component. Since TL is determined with random incidence sound, adjustments must be made for the situations where the sound is incident from fixed angels, such as from a stationary source. Table 3 shows the value of "G" that should be used for different angles of incidence, with the angle being taken relative to the perpendicular of the building façade.

Table 3:

Adjustment "G" to allow for Primary Angles of Sound Incidence

Angle of Incidence, deg.	Adjustment (G), dB
0-30	-3
30-60	-1
Random	0
60-80	+2

Design Considerations

For the purpose of screening proposed façade constructions, a simplified equation for predicting interior noise levels can be used. In place of transmission loss (TL) values, the STC value of a construction can be used. In addition, other noise level descriptors such as "A"-weighted dB levels, day-night average level (Ldn, or community noise equivalent level (CNEL) may be used for the exterior noise levels (LP(ext)) in the

Equation for screening proposed façade constructions

L(int)= L(ext)-STC+10 log S/A+ADJ

Where L(int)= approximate interior noise level in the same unit as used for L(ext).

L(ext)= approximate exterior noise level in dB, dBA, Ldn or CNEL.

STC = sound transmission class of the exterior façade construction

ADJ = 3+G+F

Where G = values given in Table 3.

F = adjustment for frequency spectrum characteristics of the noise source, see Table 4.

Table 4:

Adjustment "F" to allow for the spectrum shape of common outdoor noise sources.

Noise Source	Adjustment F, dB
Jet Aircraft (less than 500 ft. from observer	0
Train wheel-rail noise	2
Road traffic (negligible trucks)	4
Jet Aircraft (at 3000 ft or more from observer	5
Road Traffic (more than 10% trucks)	6
Diesel-electric locomotives	6

The factor 10 log S/A can be approximated using Table 5 to determine the value "A"

This expression for determining interior noise levels is only an approximation and should be used only as a screening tool for design considerations. Engineering calculations for compliance with code requirements may necessitate the services of an acoustical consultant.

Determining the Sound Transmission Loss of a Composite Construction

The composite STC of a nonhomogenous wall can be estimated by using the graphical procedure shown in Figure 14, based on the transmission loss. If a wall consists of two elements, such as a wall with a door in it, the composite STC of the combination can be determined as follows. Calculate the difference between the STC of the two elements (tables 6, 7, and 8 can be used to obtain some of these STC values). Calculate the area percentage of the lower STC element to that of the total area. Using Figure 14 determine the adjustment to be subtracted from the higher STC value to give the composite STC of the two elements. This procedure can be reiterated if more than two elements are involved.

Substitution of the appropriate values (see Tables 5, 6, 7 and 8) into the equation on page 16 will then give a prediction of the interior noise level which can be compared to the appropriate criterion value. If the predicted interior noise intrusion is below the criterion, then the design is acceptable.

Comparing Component Contribution

Comparison of the individual noise contribution will indicate which element is the weak link. This component can either be changed in size or in type to reduce the sound transmission. Ideally, each separate wall component could be designed to contribute equally to the interior noise intrusion, giving the optimized design. This is not usually done, however, for other practical reasons of materials or architectural design.

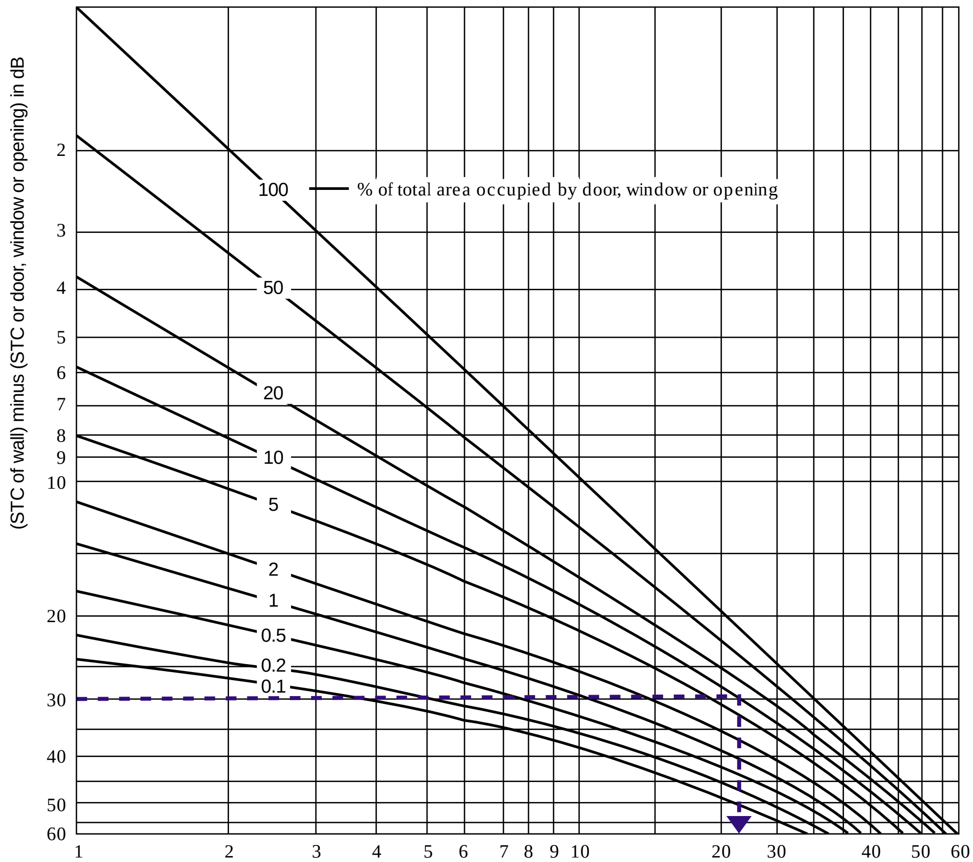


Figure 14: Nomograph for determining the STC of a composite structure.

Example 5:

Assume the structure is a stucco wall with insulation (STC 57 from Table 6, page 18).

The structure has a door in it (STC 27 from Table 7, page 18). The door area is 13 percent of the total wall area.

What is the resultant STC value of the composite structure?

1. Subtract the STC of the door from the STC of the wall = 57 – 27 = 30.
2. Refer to the Figure above. Find STC difference (30) on the vertical axis and move horizontally to 13% (the door's area). Then drop down to the horizontal axis to read the number to be subtracted from the wall STC.
   STC of composite wall = STC of wall minus adjustment from the Figure above: 57 – 23 = 34.

Table 5:

Multiplicative factors for estimating room absorption from the floor area; these factors are multiplied by the floor area to obtain the estimated total absorptions in the room.

	Type of office furnishings			
	Hard: sound reflective walls, floor and ceiling, no drapes	Standard: reflective walls, acoustical ceiling, hard floor	Soft: acoustical ceiling, carpet or drapes	Very Soft: acoustical ceiling, carpet or drapes and wall furniture
Factor for multiplying floor area to obtain normal absorption	0.3	0.8	0.9	1.0

Table: 6 [(A)]

Sound Transmission Class of Exterior Walls [(B)]

Construction details:

(1) Wood siding – 2 x 4 wood studs, 16” centers; $\frac{1}{2}$” wood fiberboard sheathing nailed to studs; $\frac{5}{8}$” x 10” redwood siding nailed through sheathing into studs; _” gypsum wallboard interior, screwed to studs or resilient channels.

(2) Stucco – 2 x 4 wood stud, 16” centers; No. 15 building felt and 1” wire mesh nailed to studs; stucco applied in three coats to $\frac{7}{8}$” total thickness, dry weight of stucco 7.-9 lb/sq.ft; $\frac{1}{2}$” gypsum wallboard interior, screwed to studs or resilient channels.

(3) Brick veneer – 2 x 4 wood studs, 16” centers; $\frac{3}{4}$” wood fiberboard sheathing nailed to studs; standard face brick $3\frac{1}{2}$” ” wide, spaced $\frac{1}{2}$” out from sheathing with metal ties nailed through sheathing into studs, dry weight of brick and mortar 41 lb/sq.ft.; $\frac{1}{2}$” gypsum wallboard interior, screwed to studs or resilient channels.

Taken from the U.S. Department of Commerce National Bureau of Standards Building Science Series 77.

Exterior	FinishCavity Insulation	Resilient Channel	STC
Wood Siding (1)	None	No	37
	$3\frac{1}{2}$” Fiberglas wood framing batt insulation	No	39
	None	Yes	43
	$3\frac{1}{2}$” Fiberglas wood framing batt insulation	Yes	47
Stucco (2)	$3\frac{1}{2}$” Fiberglas wood framing batt insulation	No	46
	None	Yes	49
	$3\frac{1}{2}$” Fiberglas wood framing batt insulation	Yes	57
Brick Veneer (3)	$3\frac{1}{2}$” Fiberglas wood framing batt insulation	No	56
	None	Yes	54
	$3\frac{1}{2}$” Fiberlgas wood framing batt insulation	Yes	58
Concrete Block	None	No	45

Table: 7

Sound Transmission Class of Exterior Doors

Construction Details:

(1)Flush solid core wood door – width $1\frac{3}{4}$” weight 78 lb., 3.9 lb/sq.ft.

(2)Flush steel door – width $1\frac{3}{4}$”; faces 0.028” steel, separated by plastic perimeter strip; core rigid polyurethane, 2 to $2\frac{1}{2}$” lb/cu.ft. foamed in place; weight 64 lb, 3.2 lb/sq.ft.

Taken from the U.S. Department of Commerce National Bureau of Standards. Building Science Series 77.

Door	Weather Strip	Normally Closed STC
Wood, flush solid core (1)	Brass	27
Wood, flush solid core (1)	Plastic	27
Steel, flush (2)	Magnetic	28

Table: 8

Sound Transmission Class of Windows

*Abbreviations:
ss = single strength
ds = double strength
d = divided lights
in = insulating glass of indicated overall thickness
lam = laminated safety glass of indicated thickness

Taken from the U.S. Department of Commerce National Bureau of Standards Building Science Series 77.

Material	Type	Size	Glazing*	Sealed STC	Locked STC	Unlocked STC
Wood	Double hung	3'x5'	ss	29		23
			ss-d	29		
			ds	29		
			ds-d	30		
			in $\frac{7}{16}$”	28	26	22
	Fixed Picture	6'x5'	ss-d	28		
			ds	29		
			in 1”	34		
Wood/Plastic	Double hung	3'x5'	ss	29	26	26
			in $\frac{3}{8}$”	26	26	25
	Storm sash		ds	30	27	
			in $\frac{3}{8}$”	28	24	
	Fixed casement		ds	31		
	Operable casement		ds	30	22	
	Sliding glass door		lam $\frac{3}{16}$”	31	26	26
Aluminum	Siding		ss	28	24	
	Operable casement		ds	31	21	17
	Single hung		in $\frac{7}{16}$”	30	27	25
Single pane $\frac{1}{4}$”	laminated glass					34

Table: 9

Sound Transmission Class of Metal Building Walls

Construction Type	Octave Band Center Frequencies, Hz 125	250	500	1000	2000	4000	STC
Metal building wall, 26 gauge [1]	12	14	15	21	21	25	20
Metal building wall + 3” insulation [2]	12	16	18	31	32	39	25
Metal building wall + 4” insulation [3]	11	17	21	34	35	42	27

Table: 10

Sound Insertion Loss, dB (1), of Fiberous Glass Reinforced Plasctics (2)

Product Type & Thickness	Octave Band Center Frequencies, Hz 125	250	500	1000	2000	4000	NIC
FRP, 1/8” thick, 1.13 lb/sq. ft. (3) [4]	15	18	25	26	29	36	27
FRP, 1/4” thick, 2.08 lb/sq. ft. [5]	19	22	28	31	32	25	29
FRP, 1/2” thick, 4.20 lb/sq. ft. [6]	21	27	29	34	27	36	29

Table: 11

Sound Insertion Loss, dB (1), of Typical Building Materials

Product Type & Thickness	Octave Band Center Frequencies, Hz 125	250	500	1000	2000	4000	NIC
Plywood, 1/2”, 1.33 lb/sq. ft. (3) [7]	17	20	23	23	23	24	21
Plywood, 3/4”, 2.00 lb/sq. ft. (3) [8]	19	23	27	25	22	30	24
Sheet metal, 16 gauge, 2.38 lb/sq. ft. [9]	18	22	28	31	35	41	31
Sheet metal, 20 gauge, 1.50 lb/sq. ft. [10]	16	19	25	27	32	39	27
Sheet metal, 24 gauge, 1.02 lb/sq. ft. [11]	13	16	23	24	29	36	25
Gypsum Board, 1/2”, 1.80 lb/sq. ft. [12]	18	22	26	29	27	26	26
Gypsum Board, 5/8”, 2.20 lb/sq. ft. [13]	19	22	25	28	22	31	26
Glass, single strength, 3/32”, 1.08 lb/sq. ft. [14]	15	18	25	26	28	29	26
Glass, double strength, 1/8”, 1.40 lb/sq. ft [15]	16	19	25	29	30	20	24
Glass, plate, 1/4”, 2.78 lb/sq. ft. [16]	20	25	26	30	23	30	27
Acrylic sheet, 1/8”, 0.75 lb/sq. ft. [17]	14	17	22	24	27	34	24
Acrylic sheet, 1/4”, 1.45 lb/sq. ft. [18]	16	19	26	27	30	29	27
Acrylic sheet, 1/2”, 2.75 lb/sq. ft. [19]	20	24	27	30	29	35	29
Lead vinyl, 1.25 lb/sq. ft. [20]	17	19	28	30	34	39	29

Table: 12

Sound Insertion Loss, dB (1), Plywood Enclosures

Construction Type	Octave Band Center Frequencies, Hz 125	250	500	1000	2000	4000	NIC
Plywood enclosure, 1/2” unlined [21]	13	11	12	12	13	151	13
Plywood enclosure, 1/2” lined with 703 insulation 1” thick [22]	18	17	23	30	38	40+	28
Plywood enclosure, 1/2” lined with 703 insulation 2” thick [23]	18	23	30	37	45	50+	34
Plywood enclosure, 1/2” lined with 703 insulation 4” thick [24]	19	29	38	47	58	60+	39
Plywood enclosure, 1/2” lined with 3 5/8” (R-13) insulation [25]	17	25	29	36	41	45+	34

(A) Notes to Tables 6-12

(1) All tests were conducted according to ASTM 423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method. NIC and STC ratings for each sample were measured over one-third octave bands and are reported at the preferred octave band center frequencies.

(2) The sound insertion loss data in these tables are the difference between sound pressure levels measured at the center of a 2 foot square opening in the wall of a reverberation chamber excited by sound before and after a material is inserted in the openings.

(3) The surface weight of each material in pounds per square foot has been listed. Materials weighing the same as these materials can be expected to provide generally similar results.

(B) Taken from the U.S. Department of Commerce National Bureau of Standards Building Science Series 77.

Table: 13

Sound Absorption Coefficients, Sound Attenuation Batts

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
2 1/2" [26]	A	.21	.62	.93	.92	.91	1.03	.85
3 1/2" [27]	A	.48	1.00	1.12	1.03	.97	.96	1.05
2 1/2" [28]	E-405	.59	.84	.79	.94	.96	1.12	.90
3 1/2" [29]	E-405	.73	.98	.98	1.05	1.08	1.15	1.00

Table: 14

Sound Absorption Coefficients, Fiberglas Building Insulation

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
3 1/2" [30]	A	.48	1.00	1.12	1.03	.97	.96	1.05
3 1/2" [31]	A	.49	1.11	1.12	1.02	1.01	1.05	1.05
6 1/4" [32]	A	.67	1.22	1.08	1.04	1.05	1.05	1.10
3 1/2" [33]	E-405	.80	.98	1.01	1.04	.98	1.15	1.00
3 1/2" [34]	E-405	.92	1.07	1.05	1.03	1.03	1.08	1.05
6 1/4" [35]	E-405	.86	1.03	1.13	1.02	1.04	1.13	1.05
3 1/2" FRK faced [36]	A	.56	1.11	1.16	.61	.40	.21	.80
6 1/4" FRK faced [37]	A	.94	1.33	1.02	.71	.56	.39	.90

Table: 15

Sound Absorption Coefficients, Aeroflex® Plus Duct Liner

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
150, 1" [38]	A	.18	.19	.48	.65	.78	.88	.55
150, 1 1/2" [39]	A	.21	.35	.66	.81	.89	.95	.70
150, 2" [40]	A	.25	.47	.76	.94	.95	.98	.80
200, 1/2" [41]	A	.03	.10	.25	.40	.53	.69	.35
200, 1" [42]	A	.07	.25	.54	.73	.83	.95	.60
200 1 1/2" [43]	A	.17	.39	.72	.88	.95	.96	.75
200, 2" [44]	A	.24	.53	.83	.99	.98	1.00	.85
300, 1/2" [45]	A	.03	.14	.28	.46	.59	.69	.40
300, 1" [46]	A	.10	.25	.55	.79	.86	.96	.60

Table: 16

Sound Absorption Coefficients, Aeromat® Duct Liner

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
1/2" [47]	A	.06	.07	.28	.46	.56	.69	.35
1" [48]	A	.07	.26	.66	.78	.93	.93	.65
1 1/2" [49]	A	.14	.39	.81	.97	.98	1.00	.80
2" [50]	A	.30	.59	.98	1.07	1.01	1.05	.90

Table: 17

Sound Absorption Coefficients, Duct Liner Board

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
1" [51]	A	.03	.22	.60	.84	.98	.97	.65
1 1/2" [52]	A	.16	.39	.91	1.01	1.01	1.01	.85
2" [53]	A	.24	.79	1.13	1.13	1.04	1.05	1.00

Table: 18

Sound Absorption Coefficients, Fiberglas Duct Liner Board

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
475 FRK faced , 1" [54]	A	.08	.19	.69	.94	.99	.98	.70
800 FRK faced, 1 1/2" [55]	A	.12	.33	.92	1.04	1.03	1.02	.85

Table: 19

Sound Absorption Coefficients, Metal Building Insulation

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
MBI, vinyl facing, 3” [56]	A	.38	.98	1.20	.62	.42	.24	.80
MBI, vinyl facing, 4” [57]	A	.56	1.22	1.08	.64	.48	.23.	85
MBI, FSK facing 3” [58]	A	.50	1.18	1.20	.72	.42	.25	.90
MBI, FSK facing, 4” [59]	A	.64	1.30	1.21	.75	.48	.28	.95

Table: 20

Sound Absorption Coefficients, Fiberglas 700 Series Insulations

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
701, plain, 1” thick [60]	A	.17	.33	.64	.83	.90	.92	.70
701, plain, 2” thick [61]	A	.22	.67	.98	1.02	.98	1.00	.90
701, plain, 3” thick [62]	A	.43	1.17	1.26	1.09	1.03	1.04	1.15
701, plain, 4” thick [63]	A	.73	1.29	1.22	1.06	1.00	.97	1.15
701, plain, 1” thick [64]	E-405	.32	.41	.70	.83	.93	1.02	.70
701, plain, 2” thick [65]	E-405	.44	.68	1.00	1.09	1.06	1.10	.95
701, plain, 3” thick [66]	E-405	.77	1.08	1.16	1.09	1.05	1.18	1.10
701, plain, 4” thick [67]	E-405	.87	1.14	1.24	1.17	1.18	1.28	1.20
703, plain, 1” thick [68]	A	.11	.28	.68	.90	.93	.96	.70
703, plain, 2” thick [69]	A	.17	.86	1.14	1.07	1.02	.98	1.00
703, plain, 3” thick [70]	A	.53	1.19	1.21	1.08	1.01	1.04	1.10
703, plain, 4” thick [71]	A	.84	1.24	1.24	1.08	1.00	.97	1.15
703, plain, 1” thick [72]	E-405	.32	.32	.73	.93	1.01	1.10	.75
703, plain, 2” thick [73]	E-405	.40	.73	1.14	1.13	1.06	1.10	1.00
703, plain, 3” thick [74]	E-405	.66	.93	1.13	1.10	1.11	1.14	1.05
703, plain, 4” thick [75]	E-405	.65	1.01	1.20	1.14	1.10	1.16	1.10
705, plain, 1” thick [76]	A	.02	.27	.63	.85	.93	.95	.65
705, plain, 2” thick [77]	A	.16	.71	1.02	1.01	.99	.99	.95
705, plain, 3” thick [78]	A	.54	1.12	1.23	1.07	1.01	1.05	1.10
705, plain, 4” thick [79]	A	.75	1.19	1.17	1.05	.97	.98	1.10
705, plain, 1” thick [80]	E-405	.30	.34	.68	.87	.97	1.06	.70
705, plain, 2” thick [81]	E-405	.39	.63	1.06	1.13	1.09	1.10	1.00
705, plain, 3” thick [82]	E-405	.66	.92	1.11	1.12	1.10	1.19	1.05
705, plain, 4” thick [83]	E-405	.59	.91	1.15	1.11	1.11	1.19	1.10
703, FRK faced, 1” thick [84]	A	.18	.75	.58	.72	.62.	35	.65
703, FRK faced, 2” thick [85]	A	.63	.56	.95	.74	.60	.35	.75
703, FRK faced, 1” thick [86]	E-405	.33	.49	.62	.78	.66	.45	.65
703, FRK faced, 2” thick [87]	E-405	.45	.47.	97	.93	.65	.42	.75
705, FRK faced, 1” thick [88]	A	.27	.66	.33	.66	.51	.41	.55
705, FRK faced, 2” thick [89]	A	.60	.50	.63	.82	.45	.34	.60
705, FRK faced, 1” thick [90]	E-405	.29	.52	.33	.72	.58	.53	.55
705, FRK faced, 2” thick [91]	E-405	.50	.36	.70	.90	.52	.47	.60
703, ASJ faced, 1” thick [92]	A	.17	.71	.59	.68	.54	.30	.65
703, ASJ faced, 2” thick [93]	A	.47	.62	1.01	.81	.51	.32	.75
703, ASJ faced, 1” thick [94]	E-405	.27	.54	.57	.66	.58	.36	.60
703, ASJ faced, 2” thick [95]	E-405	.53	.44	.93	.77	.55	.35	.65
705, ASJ faced, 1” thick [96]	A	.20	.64	.33	.56	.54	.33	.50
705, ASJ faced, 2” thick [97]	A	.58	.49	.73	.76	.55	.35	.65
705, ASJ faced, 1” thick [98]	E-405	.24	.58	.29	.75	.57	.41	.55
705, ASJ faced, 2” thick [99]	E-405	.42	.35	.69	.80	.55	.42	.60

Notes to Tables 13-20

Mounting:
- Type A (formerly No. 4) – Material placed against a sold backing such as a block wall,
- E-405 (formerly No. 7) – Material placed over a 16-inch air space. Data include facings exposed to sound source, if specified.

Facings:
- FRK – Foil-faced laminate with glass fiber reinforcing and kraft backing.
- ASJ (All-Service Jacket) – An embossed laminate of white kraft facing with glass fiber reinforcing and a foil backing.

Procedures:
All tests were conducted according to ASTM C 423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method. Sound absorption coefficients for each sample were measured over one-third octave bands and are reported at the preferred octave band center frequencies. In some cases, the measured sound absorption coefficients are greater than 1.00. As recommended by the test method, these values are reported as measured and not adjusted. The corresponding NRC for a material may also be greater than 1.00 according to the ASTM test method. The sound absorption coefficients of these material are not significantly affected by coverings such as expanded sheet metal, metal lath, hardware cloth, screening or glass cloth. When other coverings having less open surfaces are required, consult an Owens Corning sales representative.

Table: 21

Owens Corning Duct Products and Attenuation in dB per Lineal Foot

Product Type & Thickness	1/2 inch	1 inch	1 1/2 inch	2 inch
Aeroflex Plus®				
150		x	x	x
200	x	x	x	x
300	x	x		
Aeromat®	x	x	x	x
Duct Liner Board		x	x	x
Fiberglas Duct Board				
475		x		
800			x	

Source: D.D. Reynolds and J.M. Bledsoe, Sound Attenuation of Unlined and Acoustically Lined Rectangular Duct, ASHRAE Transactions 95.

Restrictions on applying data: The data represents values determined from testing with no airflow in the ducts. Maximum calculated attenuation should be limited to 40 dB.

*P/A P/A: The inside perimeter of a lined duct in feet divided by the cross sectional area of the duct in square feet

Thickness	P/A* 1/ft	63	125	250	500	1000	2000	4000	8000
		Octave Band Center Frequencies, Hz							
1/2 inch [100]	8.00	0.71	0.73	0.80	1.46	7.62	7.48	3.98	2.60
	6.00	0.56	0.55	0.66	1.25	6.23	5.94	3.49	2.42
	5.00	0.50	0.48	0.59	1.14	5.49	5.13	3.21	2.32
	4.00	0.46	0.41	0.51	1.02	4.70	4.29	2.90	2.20
	3.00	0.44	0.35	0.44	0.88	3.85	3.41	2.54	2.06
	2.50	0.33	0.30	0.40	0.80	3.39	2.94	2.34	1.97
	2.00	0.27	0.24	0.34	0.71	2.90	2.46	2.11	1.87
	1.50	0.22	0.19	0.27	0.61	2.37	1.95	1.85	1.76
	1.00	0.16	0.13	0.19	0.50	1.79	1.41	1.54	1.60
1 inch [101]	8.00	1.08	1.24	1.60	2.98	7.62	7.48	3.98	2.60
	6.00	0.77	0.90	1.29	2.57	6.23	5.94	3.49	2.42
	5.00	0.65	0.74	1.12	2.34	5.49	5.13	3.21	2.32
	4.00	0.56	0.60	0.96	2.09	4.70	4.29	2.90	2.20
	3.00	0.50	0.48	0.79	1.81	3.85	3.41	2.54	2.06
	2.50	0.37	0.40	0.71	1.65	3.39	2.94	2.34	1.97
	2.00	0.30	0.32	0.59	1.47	2.90	2.46	2.11	1.87
	1.50	0.23	0.24	0.47	1.27	2.37	1.95	1.85	1.76
	1.00	0.16	0.16	0.34	1.03	1.79	1.41	1.54	1.60
1 1/2 inch [102]	8.00	1.43	1.74	2.42	4.57	7.62	7.48	3.98	2.60
	6.00	0.97	1.23	1.94	3.95	6.23	5.94	3.49	2.42
	5.00	0.79	1.00	1.69	3.60	5.49	5.13	3.21	2.32
	4.00	0.65	0.79	1.43	3.21	4.70	4.29	2.90	2.20
	3.00	0.55	0.61	1.16	2.78	3.85	3.41	2.54	2.06
	2.50	0.41	0.50	1.02	2.53	3.39	2.94	2.34	1.97
	2.00	0.32	0.39	0.85	2.26	2.90	2.46	2.11	1.87
	1.50	0.24	0.28	0.68	1.96	2.37	1.95	1.85	1.76
	1.00	0.17	0.18	0.49	1.60	1.79	1.41	1.54	1.60
2 inch [103]	8.00	1.77	2.23	3.27	6.20	7.62	7.48	3.98	2.60
	6.00	1.16	1.56	2.61	5.36	6.23	5.94	3.49	2.42
	5.00	0.92	1.25	2.26	4.89	5.49	5.13	3.21	2.32
	4.00	0.73	0.98	1.90	4.37	4.70	4.29	2.90	2.20
	3.00	0.60	0.73	1.53	3.78	3.85	3.41	2.54	2.06
	2.50	0.44	0.60	1.35	3.45	3.39	2.94	2.34	1.97
	2.00	0.34	0.46	1.12	3.08	2.90	2.46	2.11	1.87
	1.50	0.25	0.33	0.89	2.67	2.37	1.95	1.85	1.76
	1.00	0.17	0.21	0.64	2.18	1.79	1.41	1.54	1.60

Table 22

Owens Corning SelectSound™
Black Acoustic Boards

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
Mat faced, 1” thick [104]	A	.06	.25	.62	.91	.99	.98	.70
Mat faced, 2” thick [105]	A	.18	.71	1.12	1.12	1.03	1.02	1.00

Table 23

Owens Corning SelectSound™
Black Acoustic Blankets

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
Mat faced, 1” thick [106]	A	.10	.34	.64	.87	.91	.91	.70
Mat faced, 1.5” thick [107]	A	.12	.62	1.07	1.10	1.01	.95	.95
Mat faced, 2” thick [108]	A	.27	.80	1.12	1.07	1.02	1.01	1.00

Table 24

Owens Corning QuietZone™
Solserene™ Fabric Ceiling System

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
Fabric system w/ board, 1.5” thick [109]	A	.07	.32	.76	.99	1.05	1.06	.80
Fabric system w/ board, 1.5” thick [110]	E-400	.79	1.06	.81	1.04	1.08	1.10	1. 00

Table 25

Owens Corning QuietZone™ Industrial Noise Control Products

Product Type & Thickness	Mounting	125	250	500	1000	2000	4000	NRC
		Octave Band Center Frequencies, Hz						
QZAB, Absorption Baffle, 1.5" thick [111]	A	.15	.38	.74	.98	.76	.48	0.70
QZAB, Absorption Baffle, 1.5" thick [112]	J (Sabins:)	2.0	4.0	6.4	9.3	10.6	7.5	
QZCC-5QQ, Quilted Barrier, 1 lb/sq.ft [113]	A	.17	.45	.51	.91	.67	.36	0.65
QZCC-5QQ, Quilted Barrier, 1 lb/sq.ft. [114]	J	.15	.59	.85	.94	.63	.35	0.75
QZCC-10QQ, Quilted Barrier, 1.3 lb/sq.ft. [115]	A	.21	.31	.55	.91	.65	.34	0.60
QZCC-10QQ, Quilted Barrier, 1.3 lb/sq.ft. [116]	J	.09	.66	.86	.95	.62	.33	0.75
QZCC-20QQ, Quilted Barrier, 2.3 lb/sq.ft. [117]	A	.26	.23	.61	.89	.64	.32	0.60
QZCC-20QQ, Quilted Barrier, 2.3 lb/sq.ft. [118]	J	.16	.57	.85	.94	.61	.32	0.75
QZAS-QQ, Framed Screen, 1.3 lb/sq.ft. [119]	A	.21	.31	.55	.91	.65	.34	0.60
QZAS-QQ, Framed Screen, 1.3 lb/sq.ft. [120]	J	.09	.66	.86	.95	.62	.33	0.75
QZC10Q F/B, Quilted Absorber, 1" thick [121]	A	.00	.28	.75	.95	.60	.32	0.65
QZC10Q F/B, Quilted Absorber, 1" thick [122]	J	.05	.37	.94	.87	.54	.34	0.70
QZC10Q F/F, Quilted Absorber, 1" thick [123]	A	.05	.22	.76	.93	.59	.34	0.65
QZC10Q F/F, Quilted Absorber, 1" thick [124]	J	.10	.32	.94	.74	.55	.35	0.65
QZC10Q S/B, Quilted Absorber, 1" thick [125]	A	.04	.25	.90	.47	.23	.11	0.45
QZC10Q S/B, Quilted Absorber, 1" thick [126]	J	.02	.49	.65	.43	.22	.10	0.45
QZC20Q F/B, Quilted Absorber, 2" thick [127]	A	.07	.63	.84	.81	.62	.41	0.75
QZC20Q F/B, Quilted Absorber, 2" thick [128]	J	.09	.65	.92	.83	.60	.42	0.75
QZC20Q F/F, Quilted Absorber, 2" thick [129]	A	.11	.79	1.02	.73	.50	.32	0.75
QZC20Q F/F, Quilted Absorber, 2" thick [130]	J	.11	.80	1.01	.77	.54	.35	0.80
QZWA (1"), Wrapped Absorber, 1" thick [131]	A	.02	.30	.79	1.05	.65	.31	0.70
QZWA (1"), Wrapped Absorber, 1" thick [132]	J	.05	.35	.95	.97	.81	.31	0.75
QZWA (1"), Wrapped Absorber, 1" thick [133]	E400	.56	.88	.72	.95	.84	.41	0.85
QZWA (2"), Wrapped Absorber, 2" thick [134]	A	.18	.80	1.19	1.00	.71	.39	0.70
QZWA (2"), Wrapped Absorber, 2" thick [135]	J	.18	.78	1.25	1.12	.76	.42	1.00
QZWA (2"), Wrapped Absorber, 2" thick [136]	E400	.55	.93	1.02	1.03	.73	.47	0.95
QZWA (4"), Wrapped Absorber, 4" thick [137]	A	.52	1.22	1.18	1.01	.75	.42	1.05
QZWA (4"), Wrapped Absorber, 4" thick [138]	J	.37	1.20	1.33	1.17	.86	.38	1.15
QZWA (4"), Wrapped Absorber, 4" thick [139]	E400	.50	1.04	1.13	1.01	.78	.49	1.00

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 Sound Transmission Loss of Wall Constructions

The sound transmission loss 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 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 transmission loss.

As a general rule, every doubling of the weight of the wall increases sound transmission loss by an additional 5-6 dB. 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 transmission loss of a wall can also be increased by filling the wall cavity with sound absorbing materials such as Fiberlgas building insulation. The use of Fiberglas building insulation in a typical metal stud wall, staggered wood stud or other walls with isolated construction features such as QuietZone™ Acoustic Wall Framing, can increase sound transmission loss by about 8 – 10 dB, an improvement that is readily noticeable if this is the dominate path.

Adding Sound Absorbing Materials to Source and Receive Areas

Another method of increasing the effective sound transmission loss 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.

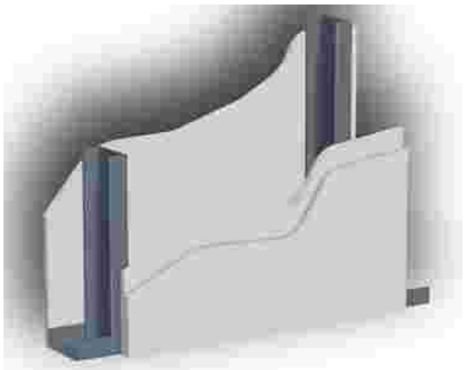


Figure 15: The addition of a layer of gypsum board to one surface effectively increases wall mass.

Figure 16: Resilient channels over metal studs break the vibrating path, helping to increase sound transmission loss.

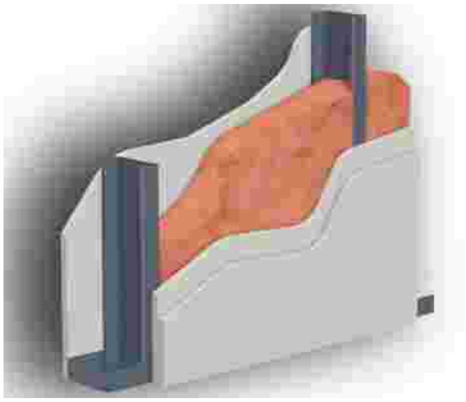
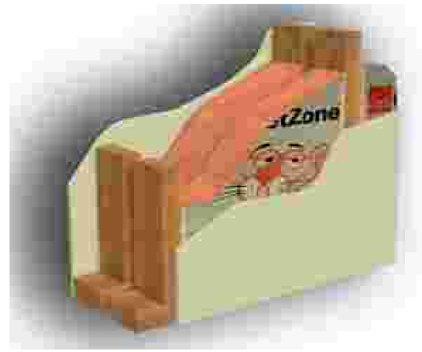


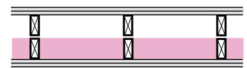
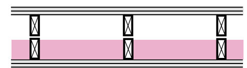
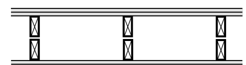
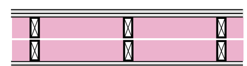
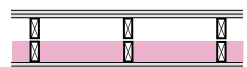
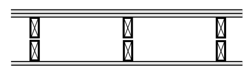
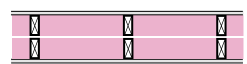
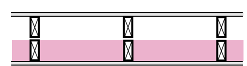
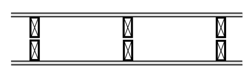
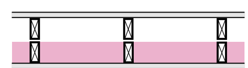
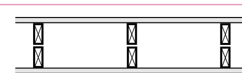
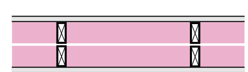
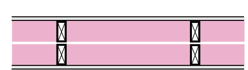
Figure 17: Insulating wall cavities noticeably improves sound transmission loss by providing cavity absorption.

Wall System Selection Chart for Wood Stud Walls



Double Wood Studs

Double Wood Studs

Fire[a] Rating	STC[b]	Construction Description	
1 Hr.*	64	Double wood studs 16" o.c.; double layer 1/2" type "x" gypsum drywall each side; one thickness, 3 1/2" thick Wood Framing Batt insulation [140]	
2 Hr.	62	Double wood studs 16" o.c.; double layer 1/2" type "x" gypsum drywall each side; one thickness, 3 1/2" thick Wood Framing Batt Insulation [141]	
1 Hr.*	54	Double wood studs 16" o.c.; double layer 1/2" type "x" gypsum drywall each side; no insulation [142]	
1 Hr.*	60	Double wood studs 16" o.c.; double layer 1/2" gypsum drywall one side, single layer other side; two thicknesses, 3 1/2" thick Wood Framing Batt insulation [143]	
N.A.	57	Double wood studs 16" o.c.; double layer 1/2" type "x" gypsum drywall one side, single layer other side; two thicknesses, 3 1/2" thick Wood Framing Batt insulation [144]	
N.A.	48	Double wood studs 16" o.c., double layer 1/2" type "x" gypsum drywall one side, single layer other side; no insulation [145]	
1 Hr.	59	Double wood studs 16" o.c.; single layer 1/2" gypsum drywall each side; two thicknesses, 3 1/2" thick Wood Framing Batt Insulation [146]	
N.A.	56	Double wood studs 16" o.c.; single layer 1/2" type "x" gypsum drywall each side; one thickness, 3 1/2" thick Wood Framing Batt Insulation [147]	
N.A.	47	Double wood studs 16" o.c., single layer 1/2" type "x" gypsum drywall each side; no insulation [148]	
1 Hr.*	56	Double wood studs 16" o.c.; single layer 5/8" type "x" gypsum drywall each side; one thickness, 3 1/2" thick Wood Framing Batt Insulation [149]	
1 Hr.*	45	Double wood studs 16" o.c.; single layer 5/8" type "x" gypsum drywall each side; no insulation [150]	
1Hr.	60	Double wood studs 24" o.c.; single layer 5/8" type "x" gypsum drywall each side; two thicknesses 3 1/2" thick Wood Framing Batt Insulation [151]	
N.A.	57	Double wood studs 24" o.c.; single layer 1/2" type "x" gypsum drywall each side; two thicknesses 3 1/2" thick Wood Framing Batt Insulation [152]	

[a] Some of the test results on this page and following pages are estimated, and are marked with an asterisk (*).

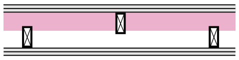
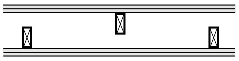
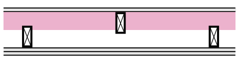
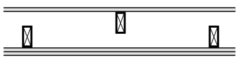
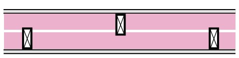
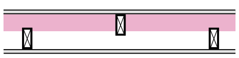
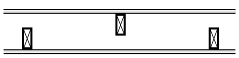
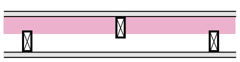
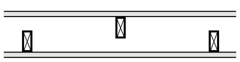
[b] Some of the test results on this page and following pages are estimated, and are marked with an asterisk (*). Where specific test references are available, they will be provided upon request.

Owens Corning Metal Framing Batts and Wood Framing Batts are manufactured from Fiberglas insulation. ??

Staggered Wood Studs

Wall System Selection Chart for Wood Stud Walls

Staggered Wood Studs

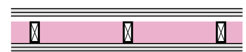
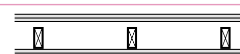
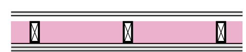
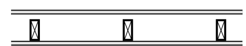
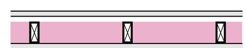
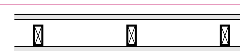
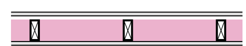
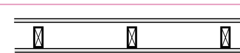
Fire Rating	STC	Construction Description	
1 Hr.*	55	Staggered wood studs 24" o.c.; double layer 1/2" type "x" gypsum drywall each side; one thickness, 3 1/2" thick Wood Framing Batt Insulation [153]	
1 Hr.*	52	Staggered wood studs 24" o.c.' double layer 1/2" type "x" gypsum drywall each side; no insulation [154]	
N.A.	53	Staggered wood studs 24" o.c.; double layer 1/2" type "x" gypsum drywall one side, single layer other side; one thickness, 3 1/2" thick Wood Framing Batt Insulation [155]	
N.A.	47	Staggered wood studs 24" o.c.; double layer 1/2" type "x" gypsum drywall one side, single layer other side; no insulation [156]	
1 Hr.	51	Staggered wood studs 16" o.c.; single layer 1/2" gypsum drywall each side; two thicknesses, 3 1/2" thick Wood Framing Batt Insulation [157]	
N.A.	51	Staggered wood studs 16" o.c.; single layer 1/2" type "x" gypsum drywall each side; one thickness, 3 1/2" thick R-11 Wood Framing Batt Insulation [158]	
N.A.	39	Staggered wood studs 16" o.c.; single layer 1/2" type "x" gypsum drywall each side; no insulation [159]	
1 Hr.*	46	Staggered wood studs 16" o.c.; single layer 5/8" type "x" gypsum drywall each side; one thickness, 3 1/2" thick Wood Framing Batt Insulation [160]	
1 Hr.*.	43	Staggered wood studs 16" o.c.; single layer 5/8" type "x" gypsum drywall each side; no insulation [161]	

Single Wood Studs with Resilient Channel

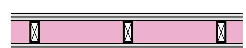
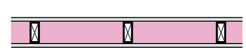
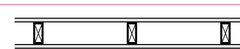
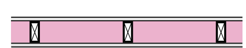
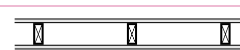
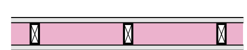
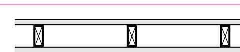
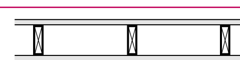
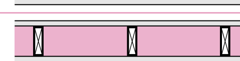
Single Wood Studs with Resilient Channel

Single Wood Studs

Single Wood Studs with Resilient Channel

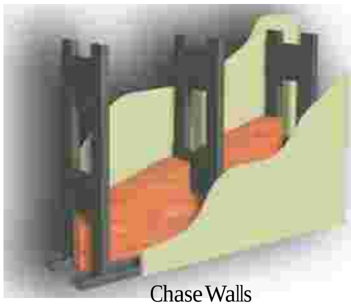
Fire Rating	STC	Construction Description	
1 Hr.*	56	Single wood studs, resilient channel; double layer ½" type “x” gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation [162]	
1 Hr.*	52	Single wood studs, resilient channel; double layer ½" type “x” gypsum drywall each side; no insulation [163]	
N.A.	52	Single wood studs, resilient channel; single layer ½" type “x” gypsum drywall one side, double layer other side; one thickness, 3½" thick Wood Framing Batt Insulation [164]	
N.A.	44	Single wood studs, resilient channel; single layer ½" type “x” gypsum drywall one side, double layer other side; no insulation [165]	
1 Hr.	50	Single wood studs, resilient channel; single layer ⅝" type “x” gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation [166]	
1 Hr.*	40	Single wood studs, resilient channel; single layer ⅝" type “x” gypsum drywall each side; no insulation [167]	
N.A.	46	Single wood studs, resilient channel; single layer ½" type “x” gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation [168]	
N.A.	39	Single wood studs, resilient channel; single layer ½" type “x” gypsum drywall each side; no insulation [169]	

Single Wood Studs

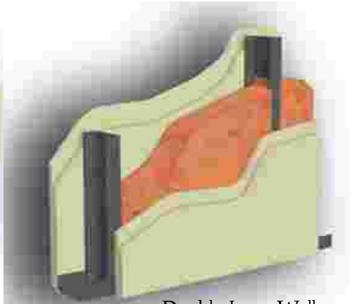
Fire Rating	STC	Construction Description	
1 Hr.*	45	Single wood studs 16" o.c.; double layer ½" type “x” gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation [170]	
N.A.	40	Single wood studs, 16" o.c.; double layer ½" type “x” gypsum drywall one side, single layer other side; one thickness, 3½" thick Wood Framing Batt Insulation [171]	
N.A.	38	Single wood studs, 16" o.c.; double layer ½" type “x” gypsum drywall one side, single layer other side; no insulation [172]	
N.A.	39	Single wood studs; 16" o.c.; single layer ½" type “x” gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation [173]	
N.A.	35	Single wood studs, 16" o.c.; single layer ½" type “x” gypsum drywall each side; no insulation [174]	
1 Hr.	36	Single wood studs, 16" o.c.; single layer ⅝" type “x” gypsum drywall each side; one thickness, 3½" thick Wood Framing Batt Insulation [175]	
1 Hr.	34	Single wood studs, 16" o.c.; single layer ⅝" type “x” gypsum drywall each side; no insulation [176]	
1 Hr.	36	Single 2x6 wood studs, 16" o.c.; single layer ⅝" type “x” gypsum drywall each side; no insulation [177]	
1 Hr.	40	Single 2x6 wood studs, 16" o.c.; single layer ⅝" type “x” gypsum drywall each side; 5½" thick QuietZone batt insulation [178]	

Listed in the Gypsum Association Fire Resistance Design Manual.

*Refer to page 24 for additional footnotes.



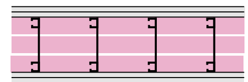
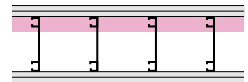
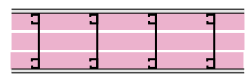
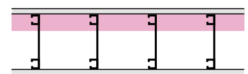
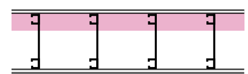
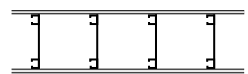
Chase Walls



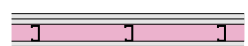
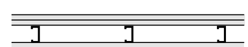
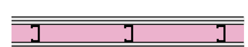
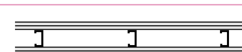
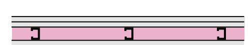
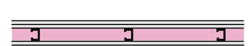
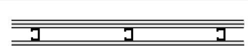
Double Layer Walls

Wall System Selection Chart for Metal Stud Walls

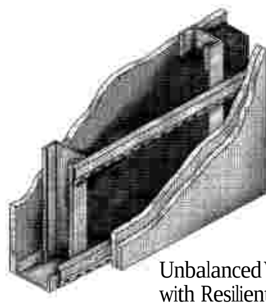
Chase Walls

Fire Rating	STC	Construction Description	
2 Hr.	60	Chase wall, double layer 5/8" type “x” gypsum drywall; 1 5/8" steel stud; three thicknesses, 3 1/2" thick Sound Attenuation Batt Insulation [179]	
2 Hr.	57	Chase wall, double layer 5/8" type ‘x” gypsum drywall; 1 5/8" steel stud; one thickness, 2 1/2" thick Sound Attenuation Batt Insulation. Secure insulation with supplemental support [180]	
N.A.	55	Chase wall, 1/2" type “x” gypsum drywall; 1 5/8" steel stud; three thicknesses, 3 1/2" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation [181]	
1 Hr.	53	Chase wall, 5/8" type “x” gypsum drywall; 1 5/8" steel stud; one thickness, 3 1/2" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation. Secure insulation with supplemental support [182]	
N.A.	52	Chase wall, 1/2" type “x” gypsum drywall; 1 5/8" steel stud; one thickness, 3 1/2" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation. Secure insulation with supplemental support [183]	
N.A.	42	Chase wall, 1/2" type “x” gypsum drywall; 1 5/8" steel stud; no insulation [184]	

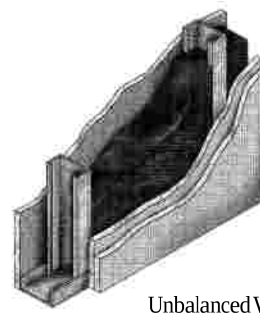
Double Layer Walls

Fire Rating	STC	Construction Description	
2 Hr.	58	Double layer wall, 5/8” type “x” gypsum drywall; 3 5/8” steel stud; one thickness, 3 1/2” thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation [185]	
2 Hr.	52	Double layer wall, 5/8” type “x” gypsum drywall; 3 5/8” steel stud; no insulation [186]	
2 Hr.	56	Double layer wall 1/2” type “x” gypsum drywall; 3 5/8” steel stud; one thickness, 3 1/2” thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation [187]	
2 Hr.	50	Double layer wall, 1/2” type “x” gypsum drywall; 3 5/8” steel stud; no insulation [188]	
2 Hr.	57	Double layer wall, 5/8” type “x” gypsum drywall; 2 1/2” steel stud; one thickness, 2 1/2” thick Sound Attenuation Batt Insulation [189]	
2 Hr.	54	Double layer wall, 1/2” type “x” gypsum drywall; 2 1/2” steel stud; one thickness, 2 1/2” thick Sound Attenuation Batt Insulation [190]	
2 Hr.	45	Double layer wall, 1/2” type “x” gypsum drywall; 2 1/2” steel stud; no insulation [191]	

Wall System Selection Chart for Metal Stud Walls

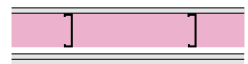
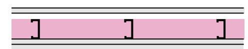


Unbalanced Walls with Resilient Chann

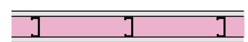
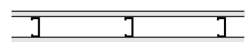
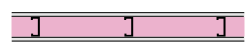
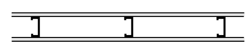
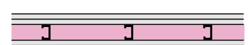
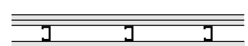
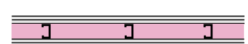
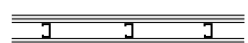


Unbalanced Walls

Unbalanced Walls with Resilient Channel

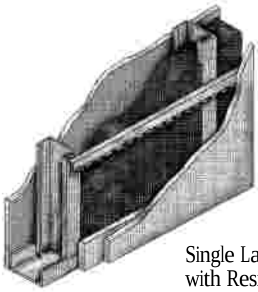
Fire Rating	STC	Construction Description	
1 Hr. †*	60	Unbalanced wall, 5/8" type "x" gypsum drywall, single layer one side; double layer and resilient channel other side; 6" steel stud; one thickness, 6 1/4" thick Metal Framing Batt Insulation [192]	
1 Hr. †*	58	Unbalanced wall, 5/8" type "x" gypsum drywall, single layer and resilient channel one side; double layer other side; 3 5/8" steel stud; one thickness, 3 1/2" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation [193]	

Unbalanced Walls

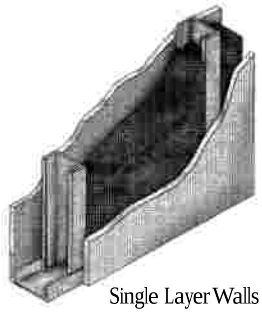
Fire Rating	STC	Construction Description	
1 Hr. *	55	Unbalanced wall, 5/8" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3 1/2" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation [194]	
1 Hr. *	47	Unbalanced wall, 5/8" type "x" gypsum drywall; 3 5/8" steel stud; no insulation [195]	
N.A.	52	Unbalanced wall, 1/2" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3 1/2" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation [196]	
N.A.	41	Unbalanced wall, 1/2" gypsum drywall; 3 5/8" steel stud; no insulation [197]	
1 Hr. *	52	Unbalanced wall, 5/8" type "x" gypsum drywall; 2 1/2" steel stud; one thickness, 2 1/2" thick Sound Attenuation Batt Insulation [198]	
1 Hr. *	44	Unbalanced wall, 5/8" type "x" gypsum board; 2 1/2" steel stud; no insulation [199]	
N.A.	50	Unbalanced wall, 1/2" type "x" gypsum drywall; 2 1/2" steel stud; one thickness, 2 1/2" thick sound Attenuation Batt Insulation [200]	
N.A.	39	Unbalanced wall, 1/2" gypsum board; 2 1/2" steel stud; no insulation [201]	

†Based on a single layer test.

*Refer to page 24 for additional footnotes.



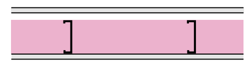
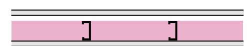
Single Layer Walls with Resilient Channel



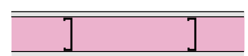
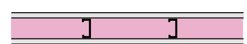
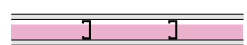
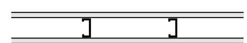
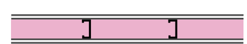
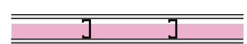
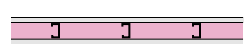
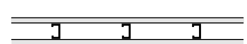
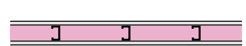
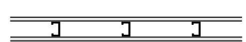
Single Layer Walls

Wall System Selection Chart for Metal Stud Walls

Single Layer Walls with Resilient Channel

Fire Rating	STC	Construction Description	
1 Hr. †*	55	Single layer wall, resilient channel; 5/8" type "x" gypsum drywall; 6" steel stud; one thickness, 6 1/4" thick Metal Framing Batt Insulation [202]	
1 Hr. †*	54	Single layer wall, resilient channel; 5/8" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3 1/2" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation [203]	

Single Layer Walls

Fire Rating	STC	Construction Description	
1 Hr. *	51	Single layer wall, 5/8" type "x" gypsum drywall; 6" steel stud; one thickness, 6 1/4" thick Metal Framing Batt Insulation [204]	
1 Hr.	50	Single layer wall, 5/8" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3 1/2" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation [205]	
1 Hr.	48	Single layer wall, 5/8" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 2 1/2" thick Sound Attenuation Batt Insulation [206]	
1 Hr.	43	Single layer wall, 5/8" type "x" gypsum drywall; 3 5/8" steel stud; no insulation [207]	
N.A.	47	Single layer wall, 1/2" type "x" gypsum drywall; 3 5/8" steel stud; one thickness, 3 1/2" thick Metal Framing Batt Insulation, or Sound Attenuation Batt Insulation [208]	
N.A.	44	Single layer wall, 1/2" gypsum drywall; 3 5/8" steel stud; one thickness, 2 1/2" thick Sound Attenuation Batt Insulation [209]	
N.A.	36	Single layer wall, 1/2" gypsum drywall; 3 5/8" steel stud; no insulation [210]	
1 Hr.	47	Single layer wall, 5/8" type "x" gypsum drywall; 2 1/2" steel stud; one thickness, 2 1/2" thick Sound Attenuation Batt Insulation [211]	
1 Hr.	40	Single layer wall, 5/8" type "x" gypsum drywall; 2 1/2" steel stud; no insulation [212]	
N.A.	44	Single layer wall, 1/2" gypsum drywall; 2 1/2" steel stud; one thickness, 2 1/2" thick Sound Attenuation Batt Insulation [213]	
N.A.	34	Single layer wall, 1/2" gypsum drywall; 2 1/2" steel stud; no insulation [214]	

†Based on a single layer test.

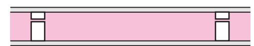
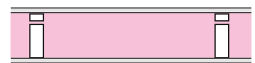
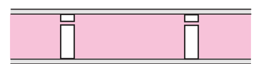
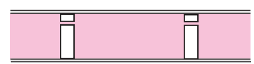
*Refer to page 24 for additional footnotes.

Wall System Selection Chart For QuietZone™ Acoustic Wall Framing

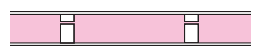
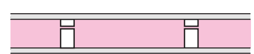
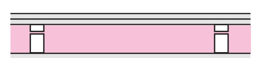
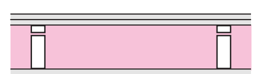
Single Layer Gypsum Drywall

Unbalanced Layers Gypsum Drywall

Single Layer Gypsum Drywall

Fire Rating	STC	Construction Description	
N.A.	49	2x4 QuietZone™ Acoustic Framing on 16" centers, single layer 1/2" type X gypsum drywall each side. 3 1/2" thick QuietZone™ Acoustic Batts [215]	
N.A.	50	2x4 QuietZone™ Acoustic Framing on 24" centers, single layer 5/8" type X gypsum drywall each side. 3 1/2" thick QuietZone™ Acoustic Batts [216]	
N.A.	54	2x6 QuietZone™ Acoustic Framing on 24" centers, single layer 5/8" type X gypsum drywall each side. 5 1/2" thick QuietZone™ Acoustic Batts [217]	
N.A.	52	2x6 QuietZone™ Acoustic Framing on 16" centers, single layer 5/8" type X gypsum drywall each side. 5 1/2" thick QuietZone™ Acoustic Batts [218]	
N.A.	53	2x6 QuietZone™ Acoustic Framing on 16" centers, single layer 1/2" type X gypsum drywall each side. 5 1/2" thick QuietZone™ Acoustic Batts [219]	

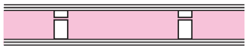
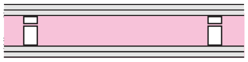
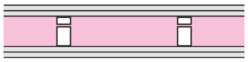
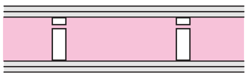
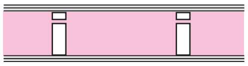
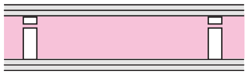
Unbalanced Layers Gypsum Drywall

Fire Rating	STC	Construction Description	
1 Hr.	53	2x4 QuietZone™ Acoustic Framing on 16" centers, double layers 1/2" type X gypsum drywall one side, single layer 1/2" type X gypsum drywall other side. 3 1/2" thick QuietZone™ Acoustic Batts [220]	
1 Hr.	54	2x4 QuietZone™ Acoustic Framing on 16" centers, double layers 5/8" type X gypsum drywall one side, single layer 5/8" type X gypsum drywall other side. 3 1/2" thick QuietZone™ Acoustic Batts [221]	
1 Hr.	55	2x4 QuietZone™ Acoustic Framing on 24" center, double layers 5/8" type X gypsum drywall one side, single layer 5/8" type X gypsum drywall other side. 5 1/2" thick QuietZone™ Acoustic Batts [222]	
1 Hr.	59	2x6 QuietZone™ Acoustic Framing on 24" center, double layers 5/8" type X gypsum drywall one side, single layer 5/8" type X gypsum drywall other side. 5 1/2" thick QuietZone™ Acoustic Batts [223]	
1 Hr.	55	2x6 QuietZone™ Acoustic Framing on 16" center, double layers 5/8" type X gypsum drywall one side, single layer 5/8" type X gypsum drywall other side. 5 1/2" thick QuietZone™ Acoustic Batts [224]	

Wall System Selection Chart For QuietZone™ Acoustic Wall Framing

Double Layer
Gypsum Drywall

Double Layer Gypsum Drywall

Fire Rating	STC	Construction Description	
1 Hr.	57	2x4 QuietZone™ Acoustic Framing on 16" centers, double layers 1/2" type X gypsum drywall each side, 3 1/2" thick QuietZone™ Acoustic Batts [225]	
1 Hr.	58	2x4 QuietZone™ Acoustic Framing on 24" centers, double layers 5/8" type X gypsum drywall each side, 3 1/2" thick QuietZone™ Acoustic Batts [226]	
1 Hr.	58	2x4 QuietZone™ Acoustic Framing on 16" center, double layers 5/8" type X gypsum drywall each side, 5 1/2" thick QuietZone™ Acoustic Batts [227]	
1 Hr.	60	2x6 QuietZone™ Acoustic Framing on 16" center, double layers 5/8" type X gypsum drywall each side, 5 1/2" thick QuietZone™ Acoustic Batts [228]	
1 Hr.	60	2x6 QuietZone™ Acoustic Framing on 16" center, double layers 1/2" type X gypsum drywall each side, 5 1/2" thick QuietZone™ Acoustic Batts [229]	
1 Hr.	63	2x6 QuietZone™ Acoustic Framing on 24" center, double layers 5/8" type X gypsum drywall each side, 5 1/2" thick QuietZone™ Acoustic Batts [230]	

Floor/Ceiling Systems Selection Chart

Wood Floors With Various Toppings (all on 2” x 10” joists, @ 16” o.c.)

IIC	Fire Rating	STC	Construction Description
73	1 Hr	55	Carpet and pad, 3/8” particle board surface, 5/8” plywood subfloor; single layer 1/2” type “x” gypsum ceiling on resilient channel; one thickness, 3 1/2” thick Wood Framing Batt Insulation [231]
60	N.A.	42**	Carpet and pad, 3/8” particle board surface, 5/8” plywood subfloor; single layer 1/2” type “x” gypsum ceiling; no insulation [232]
32	1 Hr.	35-39	19/32” plywood finish floor, 15/32” interior plywood subfloor, 2x10 wood joists, 16” o.c., single layer 1/2” thick type “x” gypsum (GA # FC5410 Generic) [233]
32	1 Hr.	35-39	19/32” plywood finish floor, 15/32” interior plywood subfloor, 2x10 wood joists, 16” o.c., single layer 5/8” thick type “x” gypsum (GA # FC5420 Generic) [234]
38	1 Hr.	40-44	5/8” plywood finish floor, 15/32” interior plywood subfloor, 2x10 wood joists, 16” o.c., resilient channel 24” o.c., single layer 1/2” thick type “x” gypsum (GA # FC5300 Generic) [235]
47***	N.A.	54***	OSB decking, 11 7/8” engineered wood I joists, 16” o.c., 6” insulation, resilient channel 16” o.c., 2 layers 5/8” thick type “x” gypsum [236]
49***	N.A.	54***	Vinyl covering, OSB decking, 11 7/8” engineered wood I joists, 16” o.c., 6” insulation, resilient channel 16” o.c., 2 layers 5/8” thick type “x” gypsum [237]
39***	N.A.	64***	1 1/2” thick concrete, OSB decking, 11 7/8” engineered wood “I” joists, 16” o.c., 6” insulation, resilient channel 16” o.c., 2 layers 5/8” thick type “x” gypsum [238]
49***	N.A.	64***	Vinyl covering, 1 1/2” thick concrete, OSB decking, 11 7/8” engineered wood “I” joists, 16” o.c., 6” insulation, resilient channel 16” o.c., 2 layers 5/8” thick type “x” gypsum [239]
41***	N.A.	67***	1 1/2” thick concrete, layer of 10 lb. tarpaper, OSB decking, 11 7/8” engineered wood “I” joists, 16” o.c., 6” insulation, resilient channel 16” o.c., 2 layers 5/8” thick type “x” gypsum [240]
49***	N.A.	67***	Vinyl covering, 1 1/2” thick concrete, layer of 10 lb. tarpaper, OSB decking, 11 7/8” engineered wood “I” joists, 16” o.c., 6” insulation, resilient channel 16” o.c., 2 layers 5/8” thick type “x” gypsum [241]
56***	N.A.	69***	1 1/2” thick concrete, 3/8” thick layer of QuietZone™ Acoustic Floor Mat, OSB decking, 11 5/8” engineered wood “I” joists, 16” o.c., 6” insulation, resilient channel 16” o.c., 2 layers 5/8” thick type “x” gypsum [242]
58***	N.A.	69***	Vinyl covering, 1 1/2” thick concrete, 3/8” thick layer of QuietZone™ Acoustic Floor Mat, OSB decking, 11 7/8” engineered wood “I” joists, 16” o.c., 6” insulation, resilient channel 16” o.c., 2 layers 5/8” thick type “x” gypsum [243]
55	N.A.	63	Wood parquet flooring, 2 layers 3/8” exterior grade A/C plywood, 3/8” thick layer of QuietZone™ Acoustic Floor Mat, 1/2” plywood subfloor, 2x10 wood joists, 16” o.c., 6” insulation, resilient channel 24” o.c., 2 layers 5/8” thick type “x” gypsum [244]
63	N.A.	73	Tile flooring, 2 layers 3/8” exterior grade A/C plywood, 3/8” thick layer of QuietZone™ Acoustic Floor Mat, 1/2” plywood subfloor, 2x10 wood joists, 16” o.c., 6” insulation, resilient channel 24” o.c., 2 layers 5/8” thick type “x” gypsum [245]

Wood Floors With Various Toppings

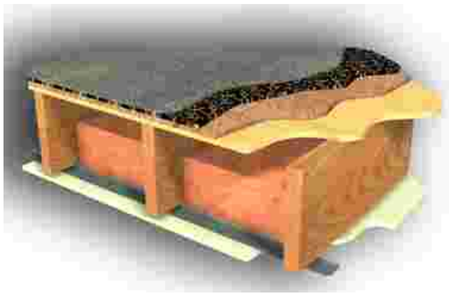
**STC tests performed on assembly without carpeting and pad.

*** Ratings reflect FSTC and FIIC taken at the National Research Council of Canada test facility.

Floor/Ceiling Systems Selection Chart

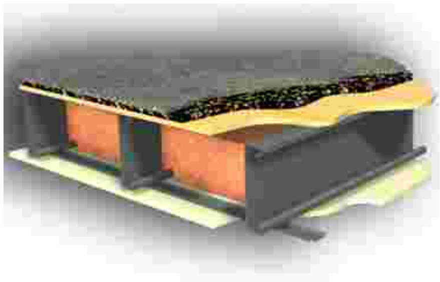
Lightweight (Cellular) Concrete Floors With Toppings (all on 2" x 10" joists, @ 16" o.c.)

IIC	Fire Rating	STC	Construction Description
74	1 Hr*	58	Carpet and pad, 1 1/2" lightweight (cellular) concrete floor, 5/8" plywood subfloor; single layer 1/2" type "x" gypsum ceiling on resilient channel; one thickness, 3 1/2" thick Wood Framing Batt Insulation [246]
59	1 Hr*	47	Carpet and pad, 1 1/2" lightweight (cellular) concrete floor, 5/8" plywood subfloor; single layer 1/2" type "x" gypsum ceiling no insulation [247]



Steel Joist Floors With Toppings (7 1/2" x 18 gauge, @ 24" o.c.)

IIC	Fire Rating	STC	Construction Description
71	N.A.	56	Steel joists, carpet and pad, 1/2" T & G plywood subfloor; single layer 5/8" type "x" gypsum board attached to ceiling joists by resilient channel; one thickness, 3 1/2" thick Metal Framing Batt Insulation, or sound Attenuation Batt Insulation [248]
57	N.A.	43	Steel joists, carpet and pad, 1/2" T & G plywood subfloor; single layer 5/8" type "x" gypsum board attached directly to the joists; no insulation [249]
69	1 Hr.	50-54	Carpet & padding, 5/8" plywood subfloor, 8" deep 18 gauge steel joist, 16" o.c., 3 1/2" insulation, resilient channels, 16" o.c., 2 layers 1/2" type "x" gypsum board. (GA # FC4340 Generic) [250]



Concrete Slab Floors With Various Toppings

IIC	Fire Rating	STC	Construction Description
59	N.A.	59	Vinyl floor covering, 1 1/2" thick reinforced mortar bed, 3/8" QuietZone™ Acoustic Floor Mat, 6" reinforced concrete slab, QuietZone™ Acoustic Batt insulation, resilient channel 24" o.c., single layer of 5/8" type "x" gypsum board [251]
58	N.A.	59	Laminate wood floor covering, 1 1/2" thick reinforced mortar bed, 3/8" QuietZone™ Acoustic Floor Mat, 6" reinforced concrete slab, QuietZone™ Acoustic Batt insulation, resilient channel 24" o.c., single layer of 5/8" type "x" gypsum board [252]
57	N.A.	58	Ceramic tile floor covering, 1 1/2" thick reinforced mortar bed, 3/8" QuietZone™ Acoustic Floor Mat, 6" reinforced concrete slab, QuietZone™ Acoustic Batt insulation, resilient channel 24" o.c., single layer of 5/8" type "x" gypsum board [253]

Refer to page 24 for additional footnotes.

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

Acoustic Sealant Performance Chart (1/4" gap 158" in length along 120"x 168" partition wall)
Sound Transmission Class of Wall Assembly With & Without Acoustic Sealant

Construction Type	Octave Band Center Frequencies, Hz 125	250	500	1000	2000	4000	STC
Base Partition Wall with 1/2" gap [254]	34	38	36	23	23	27	24
Base Partion Wall w/ single bead QuietZone™ Sealant in 1/2" gap [255]	40	55	51	44	45	54	46
Base Partion Wall w/ double bead QuietZone™ Sealant in 1/2" gap [256]	42	57	59	60	61	68	60

Perimeter Sealing

A tight air seal should be used around the perimeter of the wall to provide a proper acoustical seal. A non-hardening, permanently resilient caulking such as QuietZone™ Acoustic Sealant or a 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 effectively seal corners if multiple layers of gypsum board are properly staggered.

Figure 18 provides construction details for framing sound insulating walls around the perimeter and at corners and intersections.

Doors

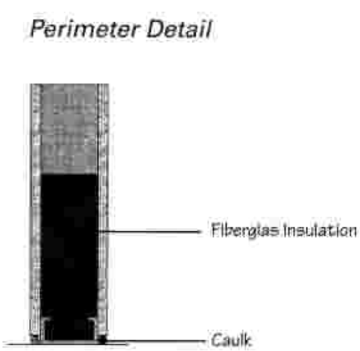
Where optimum noise control is desired, solid core wood doors or metal doors should be used. The top and sides of doors should be gasketed with a soft weather stripping. Use of threshold closures at the bottom of the door or air seals will also help reduce sound transmission.

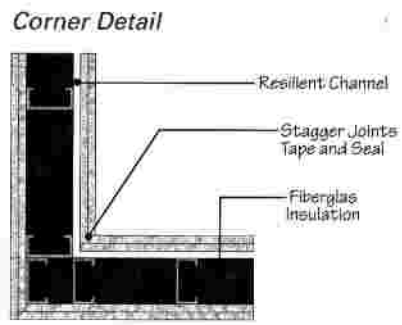
Sliding doors should be avoided where noise control is desired. Do not locate hallway doors across from one another.

Windows

Windows normally have lower transmission loss 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 crosstalk. Give consideration to the use of thick or insulated glass as well as double glazing to help reduce sound transmission. Weather stripping windows assures tight closure and thus reduces sound transmission.

Metal Stud Wall with Resilient Channel





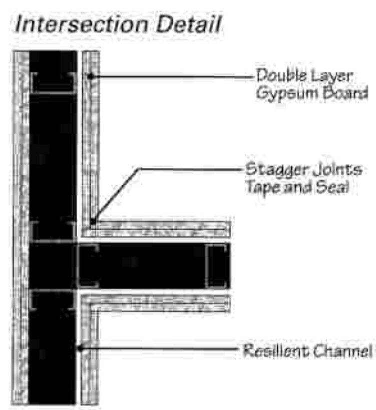


Figure 18: Framing of sound insulating metal stud walls at perimeters, corners and intersections.

Electrical

Proper electrical installation is important for effective acoustical control. Light switches and outlets should not be located back-to-back. Use surface mounted ceiling fixtures. Openings around all electrical boxes should be sealed air tight.

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.

When possible, each living/working unit 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.

Plumbing noise can be reduced by designing pipe runs with swing arms so expansion and contraction can occur without binding. Piping should also be isolated from surrounding structures with resilient mounts. Water hammer noise, due to the abrupt stop of water flow, can be eliminated by using air chambers at each outlet. Consideration should also be given to utilizing over-sized pipes and reducing water pressure.

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

Ducts

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

Installation of Fiberglas ducts or metal ducts lined with sound-attenuating duct liner insulation will reduce sidewall transmission of unwanted sound, as well as reduce fan noise in the duct.

The use of quiet high quality air conditioners and furnaces with well-balanced motors and fans is recommended to reduce duct carried noise.

Owens Corning offers a complete line of duct board, duct liners, and duct wrap products that effectively reduce noise.

Equipment Noise

Inquire about equipment noise levels before specifying. Insist on quiet units.

Whenever possible, isolate furnaces, air conditioners and HVAC units away from "quiet" areas. Install 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 are frequently the cause of noise complaints. These devices often rattle in windy areas or snap and pop due to thermal expansion and contraction. Further, the outdoor noise of aircraft, traffic, etc., is easily transmitted by the thin-wall duct and are carried into the building interior. All exterior duct work should be of double wall construction with acoustical lining and silencers.

Figure 19: Use surface mounted ceiling fixtures and caulk openings to insure acoustical integrity.

Figure 20: Stagger switches and outlets to eliminate sound "leaks". Caulk openings to insure acoustical integrity.

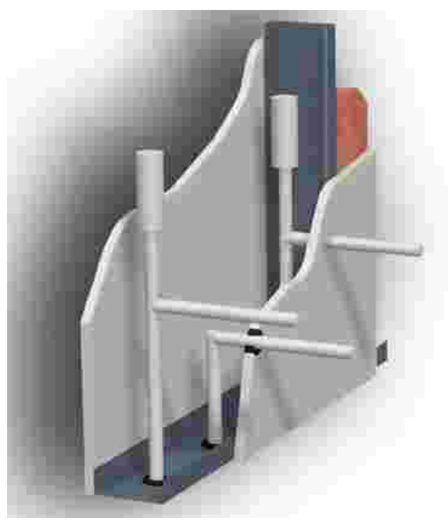


Figure 21: Isolate piping from surrounding structures with resilient mounts.

Glossary of Acoustical Terms

"A" Weighting
a frequency response that approximates the hearing response of the human ear.

Anechoic Chamber
a room with surfaces that absorb all of the sound that strikes them.

Articulation Index
a rating from 0 to 1 that can be related to speech intelligibility for a given voice level and background level.

ASTM
The American Society for Testing and Materials, an organization that standardizes acoustical test methods.

ASTM C 423
the test method for determining sound absorption coefficients by reverberation room method.

ASTM E 90
the test method for measuring transmission loss of partitions.

Attenuation
reduction in sound level.

Broadband Noise
noise that contains sound over a wide frequency range.

Complex Tone
a sound made up of many different frequencies.

dBA
the level in decibels when an "A" weighting curve is used to simulate the frequency response of the human ear.

Decibel
a unit used to express differences of sound pressure or intensity abbreviated dB.

Diffraction
the bending of sound waves around an obstacle or barrier.

Filter
an instrument that separates sound on the basis of their frequencies.

Free Field
a sound field where the sound level is attenuated by 6 dB for each doubling of distance from the source. A sound source located outdoors and away from reflective surfaces is in a free field.

Frequency
the number of cycles per second of a sound wave, measured in units of Hertz and abbreviated Hz.

Impact Insulation Class (IIC)
single number rating that indicates the amount of impact noise isolation provided by a floor / ceiling assembly. The higher the number the better the floor / ceiling assembly.

Live Room
a room with surfaces that reflect all of the sound that strikes them.

Loudness
the subjective response to a sound level.

Masking
the addition of sound in order to raise the overall level of the background sound.

Noise
unwanted, bothersome, or distracting sound.

Noise Criteria Curves
curves which describe sound levels over a range of frequencies that are acceptable for a given environment.

Noise Isolation Class
a single number rating used to express the sound insertion loss of a panel.

Noise Reduction Coefficient
the average of the individual sound absorption coefficients at 250, 500. 1000, and 2000 Hz. to the nearest .05, abbreviated NRC.

Octave Band
a frequency band with an upper frequency limit equal to twice the lower limit. Octave band center frequencies used in architectural acoustics are 125, 250, 500, 1000, 2000, and 4000 Hz.

Pink Noise
sound that has equal energy per band-width over a broad frequency range.

Pitch
the subjective response to sound at a certain frequency.

Pure Tone
a sound having only on frequency.

Random Noise
a broadband noise over a frequency range from 20 Hz.. to 20,000 Hz.

Rate of Decay
the time for a sound level to decrease a certain number of decibels. The rate of decay is used to determine the reverberation time.

Reverberation Chamber
a room with surfaces that reflect sound and that is used for sound absorption measurements.

Data Point References

Data Point References

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