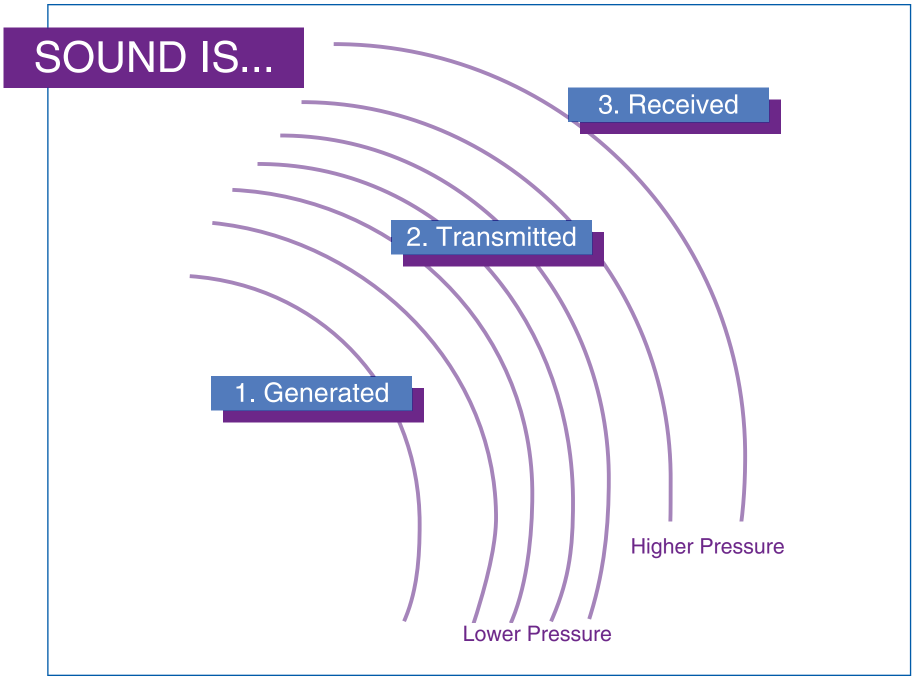
Freedom From Distraction

UNDERSTANDING THE ACOUSTICS OF OPERABLE WALLS

ACOUSTICS



In specifying operable partitions or planning multi-use space for your facility, no factor is more important than sound control.

This acoustical primer is published and distributed by Hufcor Laboratories, a nationally accredited NVLAP laboratory.

Hufcor Laboratories is a division of Hufcor, Inc., an industry leader in the design, manufacture and installation of acoustically effective operable partitions.

Sound is an energy which is
generated by a source,
transmitted through a medium, and
received by a receiver.

For example, a piano string vibrates when the key is struck, **generating** sound. The vibration alternately compresses and expands the surrounding air, **transmitting** the sound in waves of pressure changes. When the waves reach your ear, you **receive** the sound.

If you take away any of the above conditions, there is no sound. There's no sound in space, for example, since no medium exists to transmit sound waves. (The explosions in space movies are unrealistic.)

Sound has several measurable components:

1. **Frequency**
2. **Amplitude**
3. **Duration**

Let's look at them in more detail.

FREQUENCY is the rate of vibration, determining how high or low the pitch is. Frequency is measured in cycles per second, or Hertz (Hz). The wave length associated with a given frequency is the distance the sound travels in one cycle. It is related to the frequency like this:

$$\text{Wave Length} = \frac{\text{Speed of Sound}}{\text{Frequency}}$$

Healthy children can hear from 20 to 20,000 Hz, but the human ear is most sensitive in the range of 100 to 5000 Hz. In this range most of our music, speech, and other important sounds are found.

AMPLITUDE is the magnitude of the vibration, which determines how loud the sound is. In the piano example, the **size** of the change in air pressure would determine the amplitude. Amplitude (or loudness) is measured in decibels (dB), which can range from the threshold of hearing a 0 dB to the threshold of pain at around 140 dB.

DURATION is the time the sound lasts, measured in seconds. The duration may indicate how long the source is vibrating or how much the sound is reverberating, or echoing. Some sound levels will cause immediate damage to an unprotected ear. But often damage will be caused only if the duration of the sound is too long.

SOUND CONTROL

In architectural acoustics, we are concerned with controlling the amplitude and/or the duration of sound. In walls and partitions, this is done by controlling **sound transmission loss** and **sound absorption**. When sound waves strike a partition, some are reflected from the surface, staying in the same room as the source of the sound. Some are absorbed by the material of the partition, being converted to heat energy. And some are transmitted to the other side.

SOUND TRANSMISSION LOSS (STL) is the effectiveness of a barrier at preventing sound from getting from one side to the other. It is measured in decibels (dB), the same as amplitude. To determine STL, one measures the sound level on the side of the barrier closer to the sound source (the source room), the level on the opposite side (the receive room), and the reverberation or absorption of the receive room. The result is given by:

$$\mathbf{STL = L_1 - L_2 + 10 \log (S/A)}$$

where L_1=source room sound level
L_2=receive room sound level
10 log (S/A)=correction for absorption

SOUND ABSORPTION is the effectiveness of a surface or material at preventing the reflection of sound. It does this by converting sound energy to heat. The more sound absorption, the less echoing will exist. The absorption of a material is measured in Sabines and is found by the equation:

$$A=.921\ Vd/c$$

where V=the room volume
d=the measured rate of decay in decibels per second
c=the speed of sound

It is important to note the difference between a barrier and an absorber. Typical barriers made of hard, dense material may actually increase the echoes in the room, while absorbent batts of insulation allow sound to pass through as if they weren't there. Generally speaking, you can't use a barrier to absorb sound, and you can't use an absorber to block sound.

OTHER TERMS are also valuable to understand. Please refer to the Glossary provided at the back of this pamphlet. It includes acoustical words and phrases not previously discussed, as well as the ones we've already seen.

LAB TESTING AND STC

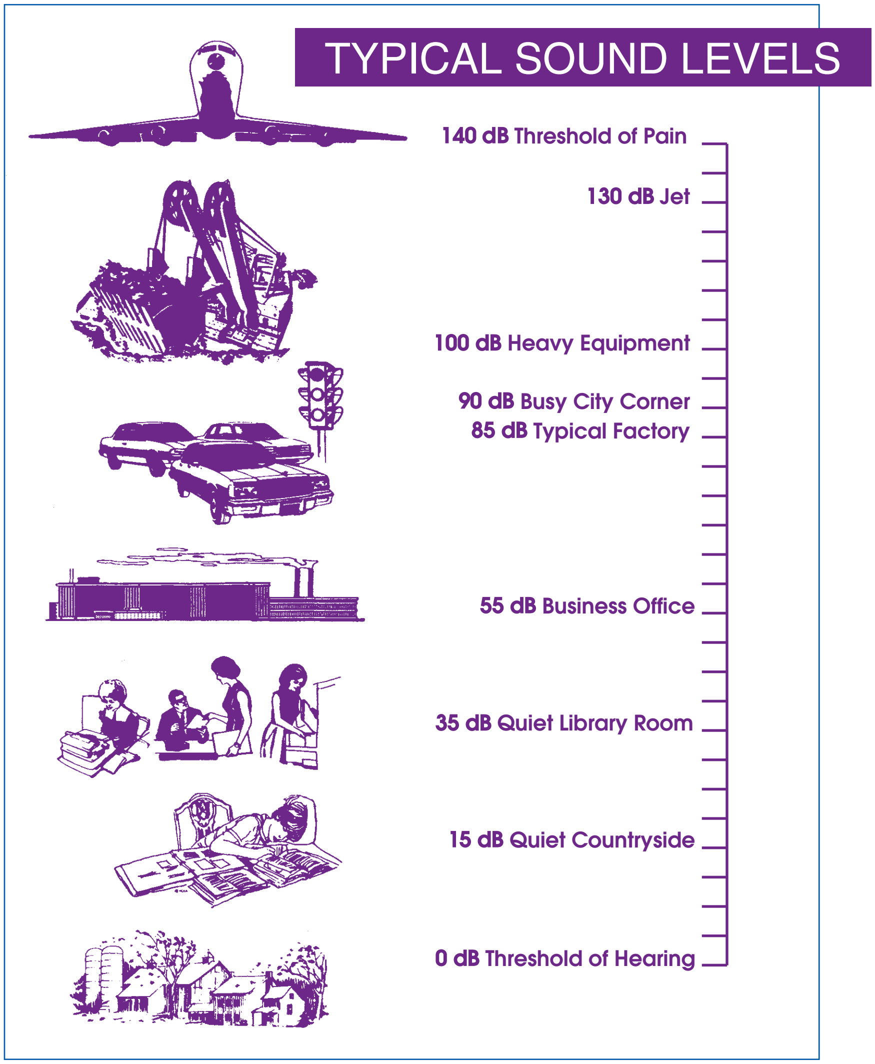
Currently, the most widely accepted standard for ranking the acoustical performance of accordion and operable partitions is **STC** or Sound Transmission Class. Virtually every manufacturer conducts laboratory tests.

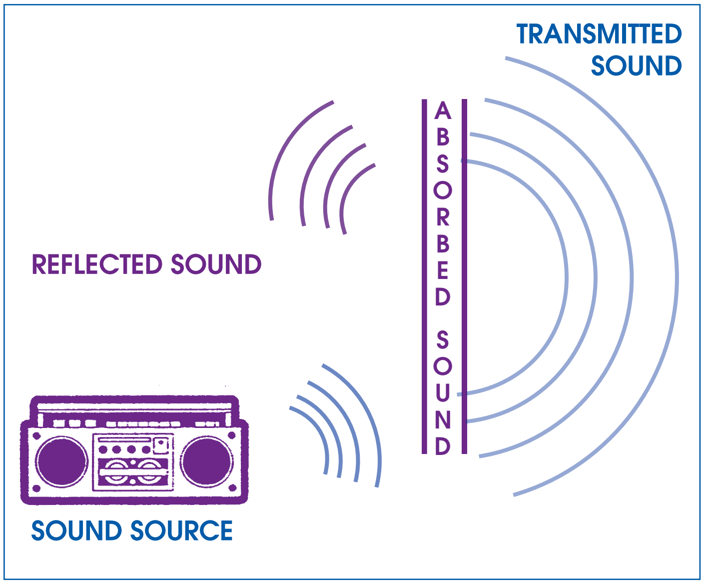
FINDING STC

Sound Transmission Class is a two-digit number describing the laboratory performance of a single building element in stopping the transmission of sound through it. It is found from individual STL figures of 16 frequencies between 125 and 4000 Hertz. The STLs are found through the formula described earlier, completely defined by ASTM Standard E90.

The procedure for finding the STC is defined in ASTM E413.* Refer to the graph on page 4 while following the steps below.

1. Plot the STLs on the graph.
2. Plot the standard STC curve.
3. Move this standard curve as high as possible so that:
   a. no frequency's STL falls below the standard curve by more than 8 dB. (Each dB below the curve is called a "deficiency".)





* See ASTM Glossary on back page.

b. total deficiencies do not exceed 32.

4. Locate the level on the standard curve corresponding to the 500 Hz frequency. This is the STC.

MORE ABOUT STC

HOW GOOD IS AN STC RATING?

Use the following chart to get a rough idea what various STC levels mean in terms of privacy afforded. Note that this is only a very rough guide.

STC	Privacy Afforded
25	Normal speech easily understood
30	Normal speech audible, but unintelligible
35	Loud speech understood
40	Loud speech audible, but unintelligible
45	Loud speech barely audible
50	Shouting barely audible
55	Shouting not audible

Source
U.S. Dept of Commerce / National Bureau of Standards Handbook 119, July, 1976: "Quieting: A Practical Guide to Noise Control"; Page 61.

STCs OF FAMILIAR CONSTRUCTIONS

Listed below are some typical building items and materials, to give you an idea how the typical operable or accordion partition compares.

STC	Construction
18	Hollow-metal door without seals
22	Solid wood door without seals
26	1/4" plate glass
32	1/2" plate glass
38	1/2" drywall on wood studs, both sides
41	4" painted concrete block wall
42	5/8" drywall on steel studs, both sides
46	8" hollow concrete block
48	12" painted concrete block wall
50	Double 5/8" drywall on steel studs, insulated
53	12" poured solid concrete wall

FIELD TESTING AND NIC

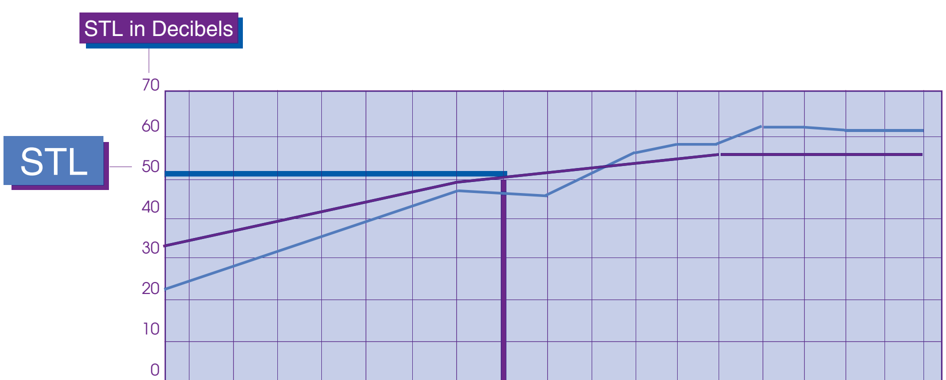
Perhaps the most practical way to state the acoustical performance of movable partitions already installed is Noise Isolation Class (NIC). This is a number describing the performance of ALL building elements in isolating one room from another. It is found from the Noise Reduction (NR) figures of the same 16 frequencies used in the laboratory STL. The same steps are used in the measurement and calculation, except the test is done in the field, and no effort is made to measure or use the absorption in the calculation.

The specific test procedure is defined by ASTM E336,* while the NIC value is found exactly the same way as STC, using ASTM E413, except the Noise Reduction figures are plotted, rather than STL.

*Note: In this type of testing the emphasis is on the overall isolation of one room from another, so no attempt is made to measure flanking paths or the effect of room absorption on the results. In effect it tells what the users of the room will experience.

Caution: It is very difficult to transfer the NIC obtained at an existing installation to a new facility. Very seldom are two buildings identically designed, and almost never do the same workmen build them. There are often major differences in ductwork, return air plenums, floor levelness, wall plumbness, etc. The only sure way to guarantee the results of a new installation is to require a field test for NIC upon completion.

*See ASTM Glossary on back page



Frequency in Hertz	100	125	160	200	250	315	400	500	630	800	1K	1.25K	1.5K	2K	2.5K	3.15K	4K	5K
STL Plot	23	27	32	37	40	44	48	48	48	53	57	59	59	62	62	61	61	61
Standard Curve	31	34	37	40	43	46	49	50	51	52	53	54	54	54	54	54	54	54
Deficiencies	0	7	5	3	3	2	1	2	3	0	0	0	0	0	0	0	0	0

STL Plot — Standard Curve

Also, one can expect NIC values to be 5 to 10 dB lower than the corresponding laboratory STC values for the same product.

WHY THE BIG DIFFERENCE BETWEEN LAB AND FIELD RATINGS?

STC is sort of like the EPA gas-mileage ratings for cars: you can use it for comparison but your actual acoustics will probably be worse.

That is because real-life buildings are not as well built as laboratories. The floors are not as level, the permanent walls are not as plumb, the joints are not as well sealed, the structure is not as heavy, etc. In a laboratory, test specimens tend to fit perfectly because the lab is built just for that purpose.

Generally, it is not a good idea to design a building to be as good acoustically as a laboratory. Purely and simply, it costs too much. And money must be available for decor, effective HVAC, and fire safety.

RECOMMEND PROFESSIONALS

On any job of significant size, the architect should involve an independent acoustical consultant at the early stages, if only to provide a few suggestions. The acoustician's fee may seem to be an unnecessary expense, but the money can easily be earned. If the job is done right the first time, it won't need to be rebuilt. The acoustician may also recommend a lower-rated partition than might have seemed necessary. And there is peace of mind for the architect when he has used the services of a professional.

WHAT TO LOOK FOR IN TESTS

When acoustical tests are performed in laboratories, they are conducted under well-defined ASTM standards. Only a handful of labs across the U.S. have received accreditation from the National Bureau of Standards under the National Voluntary Laboratory Accreditation Program (NVLAP). When requesting a lab test for STL and STC, you should look for a NVLAP-accredited lab, or at least one with an excellent national reputation.
Generally, the same sensitive equipment used in the lab can be carried to the job site for a field test. Some on-site preparation is necessary to determine the noise source location and proper microphone paths. To assure a completely unbiased test, the procedure should be witnessed by an independent acoustical consultant. If one was hired in the planning stages, he or she would be the ideal choice for the final test. Otherwise, to find an acoustician in your area, check the Yellow Pages under "Acoustical Consultants" or contact:

National Council of Acoustical Consultants
66 Morris Avenue, Suite 1A
Springfield, NJ 07081-1409
Phone: 973-564-5859; Fax: 973-564-7480
E-mail: info@ncac.com

On jobs so small that the cost of a test by an independent acoustician cannot be justified, consider requiring the manufacturer to conduct the test, with his own equipment, in the presence of the owner's representative.

FLANKING PATHS

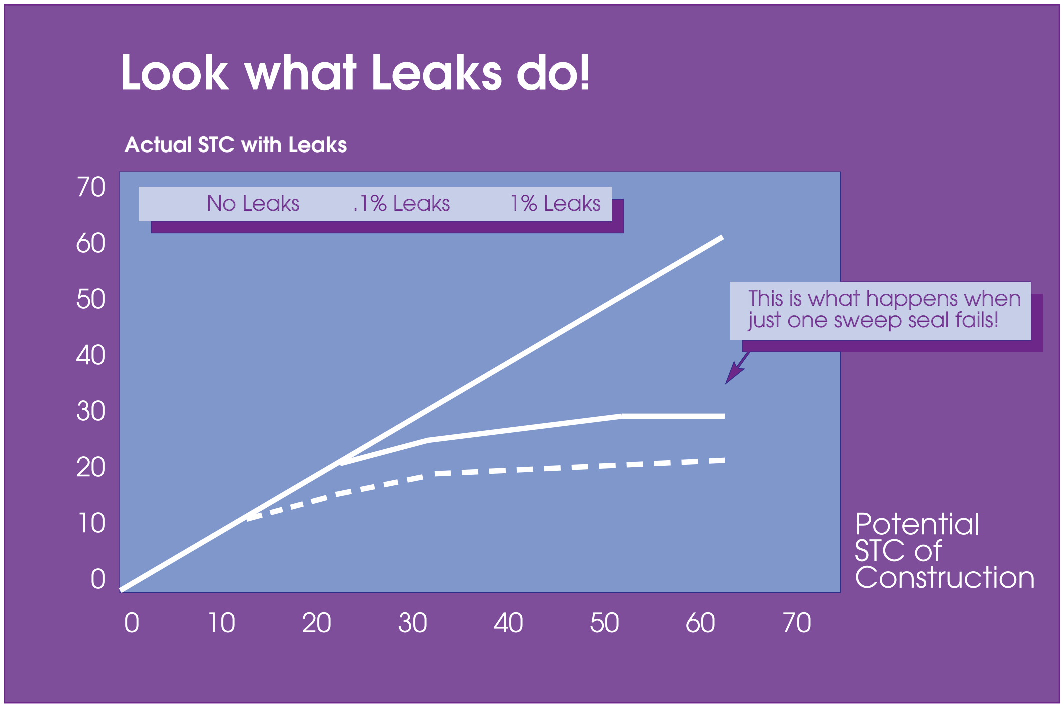
Sound, like water, follows the path of least resistance. If there are leaks in the surrounding construction, even the best movable partition will not provide a good sound barrier. Shoddy construction, customary construction practices, or poor installation of the partition can all contribute to the leaks, known as "flanking paths".

The chart on page 6 shows how flanking paths limit even a 55 STC partition to a 30 STC performance when a path one tenth of one percent of the total area exists.

KEEPING AN EYE ON DETAILS

Flanking paths can be present even when the surrounding construction is of good quality. Direct HVAC ductwork between rooms, common lobbies and corridors, and open plenums above suspended ceilings are all perfect escape routes for sound. The ceiling tiles themselves, whose porous properties help prevent reverberation, allow sound to pass through easily.

Uneven floors and out-of-plumb walls also contribute to leaks as do recessed lighting, access panels, projection and lighting booths, and other design details.



BEATING FLANKING PATHS

In dealing with sound transmission, there's no substitute for quality construction materials: simple mass is what stops sound waves. Naturally stud-and-drywall construction is going to have a higher STC than 1/4" hardboard paneling. Extra attention to quality techniques will pay off in sound control and ensure a good fit for the partitions.

Above all, the best defense against flanking paths is careful planning in the early stages of the project. ASTM Recommended Practice E557* is an excellent guide to installation conditions. It includes such issues as:

1. flat, level floors.
2. level track suspended from a non-sagging structure.
3. sealed, insulated plenum barrier.
4. plumb end walls or adjustable jambs.
5. indirect HVAC ducts.

Using a screed directly under the track line when pouring a ballroom floor keeps the floor even and level for the seals.

Building a barrier in the plenum above the partition track with a construction as good as the partition itself, will prevent sound from leaking over the top.

The permanent walls with which the movable partitions intersect must be vertical and braced so that the horizontal pressure does not force the partition to become uneven. (ASTM Recommended Practice E497* is helpful for designing and building stud-and-drywall walls for acoustical performance.)

Although wall insulation (glass or mineral wool) is not an effective barrier, adding it in the cavity of wall greatly improves its performance. It is also useful above the suspended ceiling to reduce reverberation.

Both the supply and return air ducts should branch from main lines outside the rooms containing movable partitions, rather than running directly from one side to the other. If this is impossible, at least using lined ducts with several zig-zags will help some.

PUTTING YOUR KNOWLEDGE TO PRACTICAL USE

The theories and terminology of acoustics come into practical application when you begin to plan the division of space with movable walls. What and how you specify relies on how you answer some very critical questions:

* See ASTM Glossary on back page.

1. WHAT WILL THE ROOMS BE USED FOR?

The intended use of the building or room versus the use of the surrounding areas will, in part, determine the amount of sound control you need. For example, a folding wall dividing a high school science classroom from a student lab doesn't need to have as good a barrier as an operable partition between meeting rooms in a hotel. New offices near a heavily traveled corridor will need nearly as much sound control as a children's day care center adjacent to the worship area of a church.

2. WHAT WILL THE LEVEL OF AMBIENT NOISE BE?

It's important to realize that there is no such thing as "sound proof". There will always be some sort of ambient or background noise in a room. However, we can use that fact to our advantage. Let's take the case of the offices on the noisy corridor. The constant hum of a computer, or the woosh of the HVAC system can actually make the offices seem quieter, since these everyday sounds will partially mask the outside noise.

3. WHAT TYPES OF MATERIALS WILL BE USED IN THE ROOM?

The materials used in building and furnishing the room can either absorb or reflect the sound. Ideally there will be some of both. The walls, floors, ceiling decks, and doors should be able to block the sound from passing through.

Soft surface treatments like carpet, drapes, wall hangings, etc., will reduce unwanted reverberation. In rooms where it is difficult to include adequate soft decor, such as a gym or hospital room, a better barrier may be needed to offset the extra loudness due to echoes.

GETTING THE SOUND CONTROL YOU NEED

Now that you've been exposed to the basics of sound control and testing, it should be apparent that acoustics is a science. It's not guesswork. The same applies to selecting acoustical movable partitions. Here's a basic checklist that should help you get an installation suitable to the occupants and building management.

___ 1. Determine the use of the room or rooms to be divided.

___ 2. Determine the use of the surrounding areas and the ambient noise of each.

___ 3. Hire an independent acoustician when sound control is critical or the existing construction is in question.

___ 4. Take the necessary steps in design and construction to avoid flanking paths.

___ 5. If flanking paths are unavoidable, specify a realistic STC for the partitions, keeping it in balance with the surrounding construction.

___ 6. Specify the STC needed, realizing that your actual installed NIC will be 5 to 10 dB lower.

___ 7. Select the appropriate type of partition, keeping in mind the application, construction quality, ease of operation, seals, and guarantee.

___ 8. Ask for references and published tests to ensure that the partition supplier has achieved the needed level of sound control in past installations.

___ 9. Make sure the partitions are installed by qualified, professional installers.

___ 10. In large, important installations, demand an ASTM E336 field test to make sure the desired NIC is achieved.

___ 11. Have operating personnel fully trained to move, store, and adjust partitions properly.

___ 12. Utilize top and bottom mechanical seals to ensure ease of partition movement and a positive acoustical seal.

Achieving freedom from distraction requires teamwork among the acoustical consultant, the architect, the general contractor, the partition installer, and all other trades. When approached as a team effort, the results can be spectacular.

GLOSSARY OF ACOUSTICAL TERMS

ABSORPTION
The reduction of reverberating sound by the use of porous, non-dense materials.

AMBIENT NOISE
The ongoing regular noise of a given environment. Also known as background noise.

DECIBEL
(dB) - Common unit of loudness, actually a logarithmic ratio of sound pressure level to a reference level.

FLANKING PATH
See discussion on pages 5 and 6.

FREQUENCY
See discussion on page 2.

HERTZ
Unit of frequency. One Hertz equals one cycle per second. Abbreviated Hz.

NIC
(Noise Isolation Class) - See discussion on pages 4 and 5.

NR
(Noise Reduction) - difference between the sound levels in the source and receive rooms.

NRC
(Noise Reduction Coefficient) - average of absorption coefficients at four key frequencies. Rating of the absorptive characteristic of a surface.

PINK NOISE
Broadband noise with equal power at each constant-percentage bandwidth, often used for acoustic testing.

RECEIVING ROOM
Room opposite the room with the sound source, in acoustic measurement.

REVERBERATION
The reflection of sound from hard surfaces. Contributes to loudness.

SOURCE ROOM
In architectural acoustic measurements, the room that contains the sound source.

STC
(Sound Transmission Class) - see discussion on pages 3 and 4.

STL
(Sound Transmission Loss) - see discussion on pages 2 and 3.

Form No. F-3542G TP

ASTM
(Formally American Society for Testing and Materials) Organization which establishes standards for testing and application in many areas including acoustics. Standards mentioned in this brochure include:

E90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions

E336 Method for Measurement of Airborne Sound Insulation in Buildings

E413 Classification for Rating Sound Insulation

E497 Practice for Installing Lightweight Partitions

E557 Standard Practice for Architectural Application and Installation of Operable Partitions.

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