Johns Manville

THE BASICS OF SOUND CONTROL

"QUIET" IS POWERFUL

A quiet environment can boost productivity, promote safety, ease tension, improve concentration, and foster creativity.

PLEASING SOUND VS. IRRITATING NOISE

Many factors influence an individual's noise tolerance. We are more likely to regard unexpected, unnecessary, or inappropriate sounds as intolerable noise than predictable, pleasing sounds accompanying a valued purpose or enjoyable activity. Most of us prefer steady sounds comprising a broad range of frequencies with a smooth decrease in sound level from low to high frequencies. Objectionable sounds are often pure tones (the whine of a saw blade or the drone of an electrical transformer) or sounds with extreme loudness variances, such as an earthmover's back-up warning or a banging shutter. These are offensive even at very low sound pressure levels.

SOUND AND NOISE

SOUND LEVELS

When the frequency of air pressure wave vibrations ranges from 20 to 20,000 cycles per second, our ears detect these vibrations as sound. When these vibrations reach the ears of those who don't want to hear them, they are noise. A sound source may vibrate with low or high intensity depending on the amount of force emitting the vibration. Loudness is the measurement of sound pressure in decibels (dB). Decibels follow a logarithmic scale, and dB ratings range from 0 dB (the threshold of human hearing) to over 120 dB (the threshold of pain).

EXAMPLES OF SOUND LEVELS

Decibel	Sensory Response	Type of Sound	Frequency
180	Can be fatal to humans and cause structural damage to buildings	Some rocket engines	20
120	Threshold of pain	Nearby jet exhaust	
110	Deafening	Nearby riveter or auto horn	
90	Very loud	Noisy factory	
70	Loud	Average TV/radio	
50	Moderate	Average office or typical conversation	
30	Faint	Rustling of leaves, a whisper	
10	Very faint	Threshold of human hearing	4000+

Johns Manville is committed to creating healthier environments by reducing unwanted clatter and chatter with proven noise-control products so you can enjoy the power of QUIET.

FREQUENCY

In addition to loudness, sound comes in a wide range of frequencies, from deep rumbles to high-pitched squeaks. Frequency is measured in cycles-per-second, or Hertz(Hz). Our hearing tends to be most sensitive to sounds in the mid to high frequency range (1000 to 3000 Hz). Different frequencies of sound require different approaches and levels of effort to control.

PERCEPTIONS OF DECIBEL CHANGES

Changes in Level	Subjective Response
1 dB	Imperceptible
3 dB	Barely perceptible
5 dB	Clearly noticeable
10 dB	About twice as loud
20 dB	About four times as loud

NOISE BASICS

Before determining the best way to control sound, engineers establish an acceptable noise level corresponding to the space's intended function. One measure of this is Noise Criterion, NC, a single-number rating determined from sound pressure level measurements made in several frequency bands. Since NC considers the frequency content of noise, it more accurately reflects the suitability of a space for speech than a single broadband measure of sound pressure such as A-weighted sound pressure level—dBA.

OVERALL NOISE AND DECIBELS

Frequency, spectral complexity, duration, context, and listener preferences influence subjective loudness perceptions (see chart to the left). dBA is a weighted single-number measure of sound pressure designed to account for the human ear's relative insensitivity to low frequencies. The A-weighted sound pressure levels (dBA) are often found in code and regulatory documents.

RECOMMENDED NC VALUES FOR ROOMS

NC Range	Space Usage
<20	Concert halls, broadcast studios, churches, large auditoriums
20 - 30	Theaters, large meeting rooms, courtrooms, executive offices
25 - 35	Bedrooms in hotels, apartments, hospitals, and residences
30 - 35	Classrooms, libraries
35 - 40	Retail shops, restaurants
40 - 45	Drafting rooms, general office areas
45 - 50	Kitchens, laundries

SPEECH AND FREQUENCY

Speech intelligibility depends on the frequency of the speech. The best understood speech ranges from 1000 Hz to 3000 Hz.

HOW SOUND TRAVELS

Sound mainly moves as vibrations in the air, bouncing around between surfaces in a room. However, sound can also create vibrations in walls, floors, ductwork and piping, allowing it to pass from one space to another and to be heard far from its source.

DIRECT VS. REFLECTED SOUND

Direct Sound - Isolating the receiver from the source with a barrier or enclosure is the only way to dampen direct sound. Barriers can be single panels or, for more serious, direct sound problems, double panels.

Reflected Sound - Placing a sound absorptive material such as fiber glass over reflecting surfaces can reduce reflected sound. Sound absorbing materials are most effective in rooms with "hard" reflective surfaces and in which the noise source is positioned far from the receiver. Sound-absorbing materials are also effective within wall cavities, in source rooms, and on sound barriers.

REVERBERATION TIME

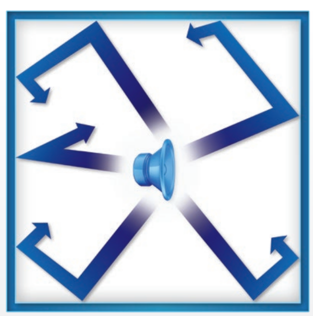
A room's reverberation time is the time it takes for an echo to decay in a space once the sound source is turned off. Generally, the goal is to reduce reverberation time; however, the ideal reverberation time varies by room function. For example, to maximize speech intelligibility, a reverberation time near zero is best for sound studios and classrooms. At the other extreme, a long reverberation time may be desirable in concert halls because reverberation adds richness and complexity to musical sounds.

SOUND TRANSMISSION CLASS

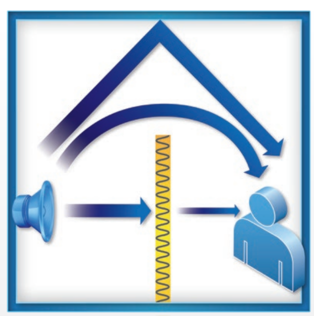
Sound Transmission Class (STC) rates the effectiveness of walls, floors, and barriers designed to reduce noise transmission between spaces. STC rates decibel reduction as sound passes through a wall or floor as shown in the table above. Higher STC ratings indicate better sound barrier performance.

EXAMPLES OF STC RATINGS

STC	Speech Heard Through Walls or Floors
30	Loud speech fairly well understood
35	Loud speech audible; not intelligible
45	Some loud speech barely audible
50	Loud speech not audible



Interior of an Enclosure



From Work Space to Work Space

NOISE REDUCTION COEFFICIENT

Noise Reduction Coefficient (NRC) rates the effectiveness of acoustical materials such as fiber glass to absorb sound in a space. Adding more absorptive materials reduces the reverberation time in a room and can also lower the overall noise level, if the sound source is not close by. Higher NRC ratings for materials indicate better sound absorption across a wider frequency range. Thicker materials tend to have higher NRC ratings.

EXAMPLES OF NRC RATINGS

Material	NRC (typical)
Gypsum board walls/ceilings	0.05
Commercial carpet	0.25
1", 3 lb./ft³ fiber glass board	0.65
2", 3 lb./ft³ fiber glass board	0.95

SOUND CONTROL

Once we understand how sound is transmitted through a room or space, we can determine the most effective ways to control it.

At the Source - We can modify the source of noise to control it. This may involve balancing parts, lubricating equipment, reducing motor speeds, changing to equipment based on quieter technologies, or adjusting work or operating schedules.

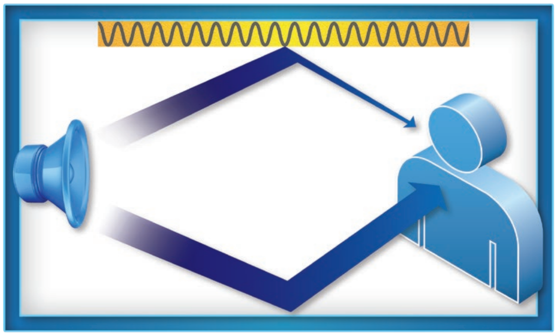
Modifying the Path - Often it is more effective to separate the source from the receiver, eliminate reflective sound paths, seal leaks, or block or absorb the noise with fiber glass or similar material.

Hearing Protection - If noise control measures are insufficient, as is often the case in industrial applications, personnel must wear appropriate hearing protection.

Masking Noise - Open-plan offices may opt to mask unwanted noise. Noise with the correct level and frequency content reduces the intelligibility of speech from surrounding workstations.

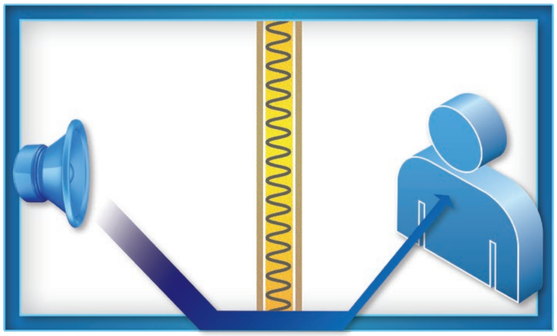
Active Noise Control - This sophisticated technique emits a signal that cancels unwanted noise. Active noise control attenuates low frequency fan noise in HVAC ductwork, and improves noise reduction in luxury vehicles and aircraft cabins.

Reflected Path



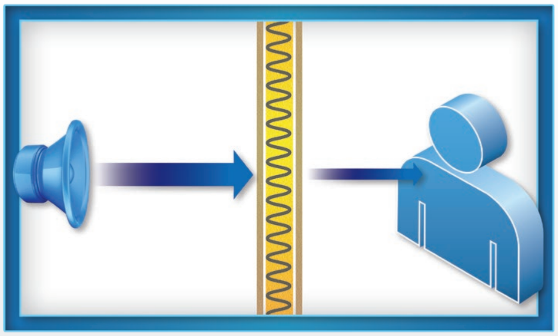
Fiber glass insulation significantly reduces the amount of reflected energy.

Structural Path



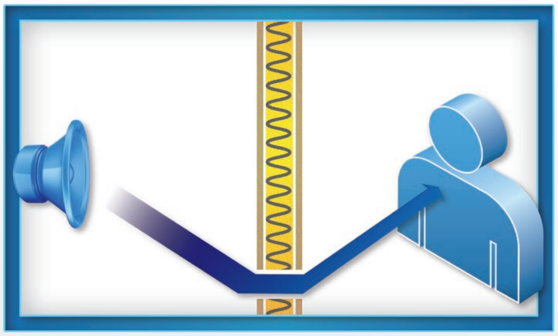
Structural paths can flank the partition thereby reducing the effectiveness of the noise control system.

Direct Airbourne Path



Fiber glass can improve the sound insulation of double leaf constructions.

Leaks



Penetrations to a partition can severely reduce the effectiveness of the noise control system. Penetrations as well as all joints should be sealed air-tight.

FIBER GLASS & HEARING SENSITIVITY

Fiber glass best absorbs sound with frequencies of 1000 cycles and above. Since the ear is most sensitive to this range of frequencies, fiber glass is especially effective in noise control.

SOUND CONTROL MATERIALS

Fiber Glass, foams, lead, fabrics, and other materials are used to control sound. The density and thickness of the material and system design determine the overall effectiveness of the system.

SOUND ABSORPTION VS. MASS

A panel's weight is important to sound control if the panel is solid and impervious to airflow. However, sound absorption, such as that provided by fiber glass, is a critical factor if a panel has two or more layers separated by an air space.

ROLE OF FIBER GLASS

Fiber glass is an excellent sound absorber and a key element in sound barrier systems. Fiber glass insulations are among the most widely used acoustical materials in applications such as aircraft fuselages, ship and submarine bulkheads, automotive under-hood components, air-handling systems, appliances, furnaces, architectural panels, and wall and ceiling panels. Johns Manville has developed a wide range of insulations for acoustical control in many kinds of equipment and situations. These fiber glass products can be engineered for specific noise problems in different applications by varying product density, thickness, and fiber diameter.

HOW FIBER GLASS WORKS

Sound waves that strike fiber glass cause minute changes in the air pressure within the labyrinth of interconnected air spaces. Small back and forth movements of the contained air volume adjacent to relatively stationary fibers convert kinetic energy in the air mass into heat. The result is absorption of sound power. Generally, increased thickness, smaller fiber diameters, and higher bulk densities improve the sound absorption performance of a fiber glass absorber.

WHERE FIBER GLASS EXCELS

For speech intelligibility, the critical frequencies are 1000 to 2000 Hz—the range in which porous materials such as fiber glass are most effective. The thickness of fiber glass is all-important in achieving high sound absorption with density a secondary factor. When thickness is the limiting factor, multiple layers of fiber glass in various thicknesses and densities can be engineered for optimum acoustical performance.

JOHNS MANVILLE SOUND CONTROL PRODUCTS

Johns Manville has developed a wide range of insulations for acoustical control in many kinds of equipment and situations. These fiber glass products can be engineered for specific noise problems in different applications by varying product density, thickness, and fiber diameter.

Appliances: Johns Manville specialty insulations are designed to control sound in the frequency range produced by refrigerators, freezers, microwave ovens, and dishwashers. Other insulations also provide thermal control in appliances.

Office Walls and Ceilings: Freestanding panels, open space furniture systems, and acoustical panels feature Johns Manville acoustical insulation for superior sound attenuation.

HVAC Systems: Specialty insulations reduce noise generated by mechanical vibration and turbulent air movement in central forced-air furnaces, central air conditioners, room air conditioners, heat pumps, and mixing boxes.

Other Applications: Johns Manville specialty insulations are used for acoustical and thermal control in a wide range of products including flexible air ducts, aerospace, buses, commercial appliances, lighting fixtures, water heater kits, pipe wrap kits, and tank cars. The Johns Manville Technical Center near Denver, Colorado, has decades of experience with acoustical testing and product development. The laboratories, equipment, and experienced staff regularly conduct tests of many acoustical materials for a range of applications. This expertise is available on a contract basis to help other companies and organizations test and develop acoustical products and systems.

JOHNS MANVILLE TECHNICAL SUPPORT

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MEMBERSHIPS AND ASSOCIATIONS

- National Voluntary Laboratory Accreditation Program – Lab Code 100425-0
- ASTM - American Society for Testing & Measurement
- INCE - Institute of Noise Control Engineering
- ASA - Acoustical Society of America
- ISO - International Standardization Organization

STANDARD TEST METHODS AND MODELING CAPABILITIES

Sound Absorption

- ASTM C423 Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
- ASTM E1050 Impedance and Absorption of Acoustical Materials Using a Tube, Two Microphones and a Digital Frequency Analysis System
- ASTM C522 Air F1ow Resistance of Acoustic Materials
- ISO 354 Acoustics – Measurement of Sound Absorption in a Reverberation Room
- Sound Absorption Prediction Using Commercial and Proprietary Computer Models

Sound Transmission

- ASTM E477 Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers
- ASTM E90 Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
- Prediction of Sound Transmission Loss with Commercial Models Utilizing Transfer Matrix or Statistical Energy Analysis (SEA) Methods
- SAE J1400 Laboratory Measurement of the Airborne Sound Barrier Performance - Automotive Materials and Assemblies

Sound Power

- ANSI S12.31Radiated Sound Power Determination using the Reverberation Room Method
- ANSI S12.10 Measurement and Designation of Noise Emitted by Computer and Business Equipment
- ISO 3741 Determination of Sound Power Levels of Noise Source Precision Methods for Broad-bank Sources in Reverberation Rooms
- ISO 779 Measurement of Airborne Noise Emitted by Computers and Business Equipment

Sound Intensity Mapping

- ANSI S12.12 & ISO 9614 Sound Power Determination using the Sound Intensity Technique

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Most noise control problems are very complex and often require the services of a qualified acoustical consultant.

Contact the National Council of Acoustical Consultants (NCAC) at (201) 564-5859 or 66 Morris Avenue, Suite 1A, Springfield, NJ 07081-1409 for a membership list.

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For information on our other acoustic insulations and systems, write: Johns Manville Corporation, Performance Materials, Product Information Center, P.O. Box 5108, Denver, CO 80217-5108, or call 1-800-654-3103