How Flooring Affects **Acoustic Performance**

EF Contract®

Noise is typically defined as unpleasant and unwanted sound. High noise levels worsen patient and staff outcomes in hospitals, hinder teaching and learning in schools, and negatively impact productivity in offices. With flooring, one of the most abundant finishes in the built environment, the opportunity to positively influence the acoustical performance of a space is great.

Acoustical Properties of Flooring

Different commercial floor coverings such as rubber, resilient/vinyl, carpet and textile composite flooring control sound differently. Harder materials such as rubber and resilient/vinyl absorb little or no sound and have greater potential to transmit sound, contributing to a noisier environment. Softer materials such as carpet and textile composite flooring absorb significantly more sound and transmit less sound, contributing to a quieter environment.

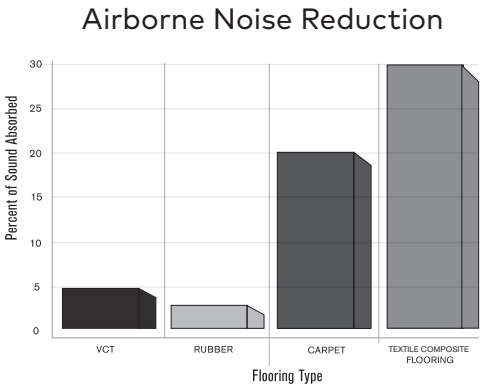
Laboratories typically use two tests to measure the acoustic properties of interior surfaces and finishes—airborne noise reduction and structure-borne noise reduction.

Airborne Noise Reduction

The typical frequency range for normal human hearing is 100-10,000 Hz. The human voice falls within the low-frequency end of the spectrum, at around 100 Hz. Building noises such as those emanating from elevators, HVAC systems and mechanical systems fall near the 1,000 Hz range. Loud noises such as alarms and bells are in the high-frequency end, up to 10,000 Hz.

The airborne noise reduction test, ASTM C423-02a,[1] measures a surface's ability to absorb these and other airborne sounds which contribute to ambient (background) noise. A floor covering sample is typically tested in an anechoic reverberation room. The test measures the product's absorption of sound at 15 different frequencies ranging from 100 Hz to 10,000 Hz. All of these frequencies fall within the range of what a normal human ear can hear.

A floor covering's measure of effectiveness in absorbing airborne sound is expressed as a Noise Reduction Coefficient (NRC). The greater the absorption, the higher the NRC number. A surface that completely eliminates sound has an NRC of 1.0. Hard surfaces such as rubber and vinyl typically have NRCs of about 0.0-0.015, meaning they absorb little to no airborne sound. Commercial carpets used in hospitals, schools and offices have NRCs typically ranging between .15 and .2, meaning they absorb about 15-20 percent of airborne sound. A textile composite flooring's NRC is about .30, meaning 30 percent sound absorption.

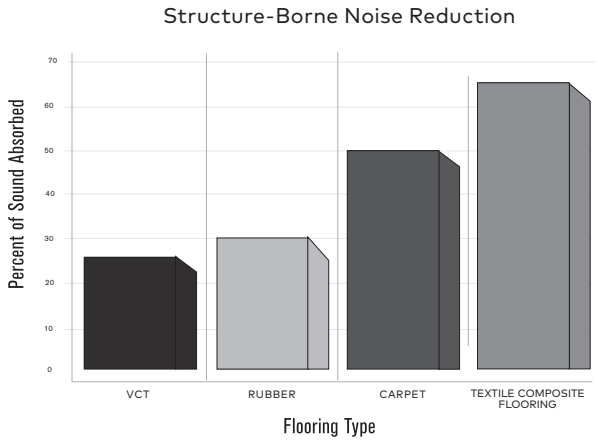


Structure-borne Noise Reduction

The structure-borne noise reduction test most used for flooring, ASTM E492-09,[2] studies the material's ability to reduce impact sound transmission into the space below. Footsteps and objects dropping on the floor are examples of impact noises.

The structure-borne noise reduction test is performed using a tapping machine in which five hammers strike the floor 10 times per second. Sound pressure in 16 frequency bands is measured in a reverberation room below the floor being tested. The measure is expressed as a whole number, Impact Insulation Class (IIC). The higher the numerical rating, the greater the sound insulation.

ICC ratings vary, depending on materials and construction. IICs for VCT typically range from 15 to 20. The results for rubber range from 15 to 30. Carpet IICs range from 35 to 50. The IIC for textile composite flooring is 64.



HEALTHCARE ENVIRONMENTS: Noise Impacts Patient Care, Reimbursements

Evidence shows that high noise levels in hospitals worsen patient and staff outcomes, including sleep quality and physiological stress. High noise levels also impact speech recognition which is critical to delivering good medical care. For example, Methodist Hospital in Indianapolis, Indiana, improved its medication error index in a coronary critical care unit after decentralizing nursing and installing carpet in hallways[7].

The World Health Organization recommends that noise levels in patient rooms not exceed 30 decibels (dB)[8]. Studies have reported noise levels in excess of 95 dB in patient care areas. For example, in one Atlanta hospital's ICU, daytime noise levels reached 96 dB at shift changes. This is in the range of noise levels at an NFL game, rock concert and the New York City subway[9].

The Centers for Medicare and Medicaid Services (CMS) holds hospitals accountable for high noise levels. CMS will not reimburse hospitals for serious hospital-acquired conditions identified as "never events"—adverse events and complications deemed "reasonably preventable" through the use of evidence-based guidelines[10].

Medication errors, injuries caused by patients falls and hospital-acquired (nosocomial) infections are all considered never events. A study of 112 medication errors and near misses in a UK psychiatric hospital found that 15 percent of the errors had the potential to cause moderate or severe harm to patients. One of the most common factors cited by nurses as contributing to medication errors was a busy, noisy environment[11].

Patients taking sedatives to combat sleep disruptions, increased heart rate and other effects of hospital noise could be at higher risk of falling[12] which could lead to injuries. Additionally, high noise levels in hospitals can potentially contribute to reduced speed of patient wound healing;[13] unhealed wounds are potential sites for nosocomial infections.

CMS also links reimbursements for patient stays to a hospital's scores on the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey. This survey asks recently discharged patients about their hospital experience. Results are posted online at www.hospitalcompare.hhs.gov. On average, the results show that patients are most dissatisfied with the "quietness of the hospital environment".[14] The lower the satisfaction score, the smaller the reimbursement.

Speech Intelligibility

Speech intelligibility, or speech recognition, is the degree to which speech can be understood. The Acoustical Society of America recommends 95 percent speech recognition for effective learning in schools. Meaning, listeners with normal hearing can understand 95 percent of the words read from a list. This level of speech recognition is equally important for delivering good medical care and conducting business.

Excessive noise impedes speech recognition. As speaking volume approaches that of background noise, speech recognition declines dramatically. When speaking volume equals background noise, a person achieves just 40 percent speech recognition. A person must speak 12 decibels (dB) louder than the ambient noise to achieve 95 percent speech recognition.[3] Every 10 dB increase seems twice as loud to the human ear.

Materials with higher NRC ratings are much more effective in absorbing ambient noise and improving speech recognition.

LEARNING ENVIRONMENTS: Noise Influences Student Performance

Up to 60 percent of classroom activities involve speech.[15] High noise and reverberation levels hinder speech intelligibility, causing reduced understanding and reduced learning. Many U.S. classrooms have a speech intelligibility rating of 75 percent or less.[16]

Inappropriate levels of background noise and reverberation can also hinder reading and spelling ability, affect behavior and attention, and affect concentration and academic performance.

Children for whom English is a Second Language and those with learning, attention or reading deficits are more affected by poor acoustics. Additionally, teachers may need to raise their voices in loud or reverberant classrooms, causing greater teacher stress and fatigue.[17]

A growing body of research links acoustics to student learning and achievement.[18] In one study, 97.9 percent of school principals indicated that acoustics had a somewhat to very strong influence on student achievement. [19]

In a national survey of public school teachers, 81 percent of respondents believed that a quiet environment with good acoustics had a very strong impact on student performance. Another study found that students in classrooms with carpet scored higher on tests in math, language and other subjects than students in classrooms with hard floor coverings.[20]

FACILITY MANAGERS ATTENDING A RECENT APPA FACILITIES DRIVE-IN WORKSHOP HOSTED BY TEXAS CHRISTIAN UNIVERSITY WERE POLLED ON A VARIETY OF BUILDING PERFORMANCE ISSUES. NOISE WAS CITED AS A PREDOMINANT CONCERN WITH 90% OF COLLEGE AND UNIVERSITY FACILITY MANAGERS NOTE THAT NOISE IS A PROBLEM IN THE BUILDINGS AND SPACES THAT THEY MANAGE WITH CLASSROOMS, ADMINISTRATIVE AREAS AND DINING HALLS HAVING THE HIGHEST NOISE CONCERNS.

APPA Drive-In Workshop Poll, April 2014

Reverberation Time

Reverberations are continuing effects of a sound. Like echoes, they occur when sound waves strike a surface and are reflected back into the space. Reverberation time is a measurement based on physical volume, areas of different surface materials and the absorption coefficient of those materials. Reverberation time influences a floor covering's NRC.

Shorter reverberation times aid speech recognition. For example, the recommended reverberation times for offices and classrooms are 0.7 seconds[4] and 0.4-0.6 seconds[5] respectively.

Excessive reverberation interferes with speech intelligibility. To reduce reverberation time, sound absorption must be increased or noise volume decreased.

Test results show that soft-surface mutes reverberation. In one study, reverberation times of a hand clap and human speech were measured in a room with a hard, concrete floor. Measurements were taken again after carpet was installed in the space. The measured reverberation time was 3.3 seconds for the empty room and 1.6 seconds with the carpet[6].

OFFICE ENVIRONMENTS: Noise Hinders Productivity

Noise is a leading source of employee dissatisfaction in offices. Research conducted by the Center for the Built Environment (CBE) at the University of California, Berkeley, reveals that office workers are generally poorly satisfied with acoustics, particularly in open plan environments. Additionally, acoustics is typically the lowest ranked category in CBE's occupant survey.[21]

In one particular CBE survey, people talking on the phone and people overhearing private conversations were reasons for acoustical concerns for 86 percent of respondents. Additional acoustical concerns included: people talking in neighboring areas, 84 percent; excessive echoing of voices or other sounds, 60 percent; telephones ringing, 36 percent; outdoor traffic noise, 31 percent; and office equipment noise, 29 percent.[22]

Research by the General Services Administration (GSA) Center for Workplace Strategy, Public Buildings Service, also shows that work environments do a poor job of providing acoustical comfort. After seven federal offices were redesigned, employee surveys showed substantial improvements in all environmental factors except two—noise and voice privacy.[23]

Of 3,700 respondents to a GSA WorkPlace 20-20 program survey, 60 percent said "they could get more done if it were quieter", 56 percent said "the ability to insulate themselves from distractions was important" and 50 percent said "noise keeps them from being as productive as they could be".[24]

Conclusion

All types of flooring, hard and soft, have merit for the right place and right population. Acoustics is an important consideration when specifying flooring and should be evaluated based on the needs of a particular environment.

An environment with good acoustical control supports the activities and goals of that space, such as improved health outcomes and higher patient satisfaction in hospitals, effective teaching and learning in schools, and improved worker productivity in offices.

The two most important acoustical factors to consider when specifying flooring are the product's sound absorption and noise reduction capabilities. Independent laboratory tests show that carpet and textile composite flooring control noise more effectively than any other floor covering. Even so, no flooring material can provide all of the necessary acoustical management within a space. Depending on the goals for the space, acoustical ceiling tile, sound masking technology and other noise-reduction strategies may be necessary.

Notes

[1] "Standard Test Method for Sound Absorption and Sound Absorption Coefficinets by the Reverberation Room Method." ASTM International.

[2] "Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Ma
chine." ASTM International.

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[5] "Classroom Acoustics". Acoustical Society of America. Retrieved from http://asa.aip.org/classroom/book let.html; accessed March 31, 2014.

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[15] "Acoustics in Schools." Produced by the InformeDesign Research Desk at the University of Minnesota, under contract to the Ceilings and Interior Systems Construction Association. November 2009.

[16] "Classroom Acoustics". Acoustical Society of America. Retrieved from http://acousticalsociety.org/about_acoustics/acoustics_of_classrooms; accessed March 22, 2014.

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