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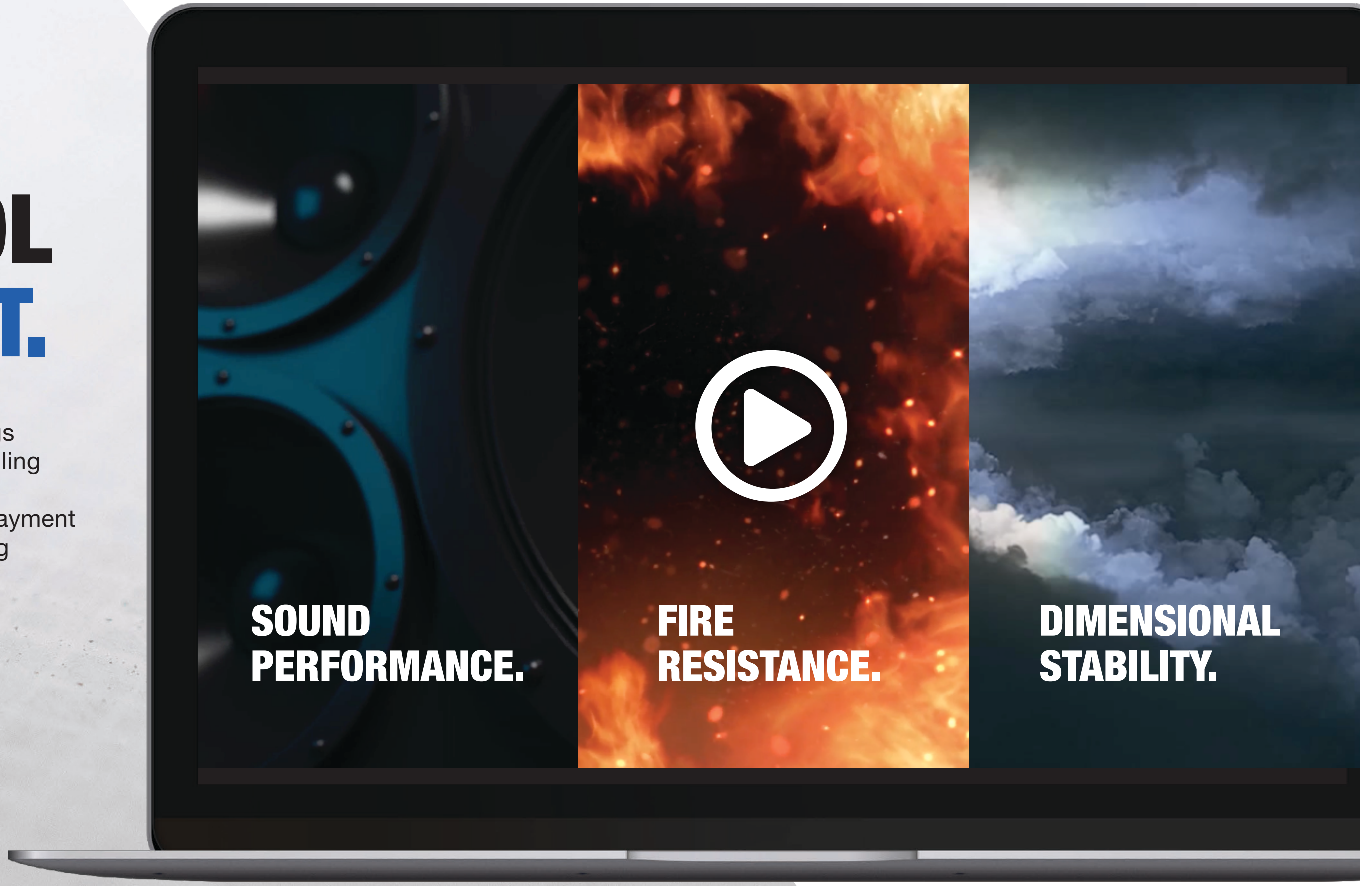

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Contents

When Numbers Lie

Interpreting IIC ratings for flooring underlayment performance

by Michael Martin and John Brunko

Images courtesy Formulated Materials

HEAVY STEPPERS, CLUMSY RESIDENTS, LARGE PETS, AND EXCESSIVE VOLUME FROM TELEVISION SETS AND STEREOS AT A SUITE ABOVE COULD MAKE LIFE MISERABLE IN A MULTILEVEL TOWNHOME OR APARTMENT. FOR OWNERS IN THE MULTIFAMILY AND THE HOSPITALITY INDUSTRY, THESE ISSUES CAN ALSO NEGATIVELY IMPACT PROFITABILITY, RESULTING IN A HIGHER TURNOVER OR A REDUCTION IN REPEAT BUSINESS. ALTHOUGH IT MAY SEEM LIKE A SMALL PART OF THE PROJECT, CORRECTLY UNDERSTANDING IMPACT INSULATION CLASS/SOUND TRANSMISSION CLASS (IIC/STC) RATINGS AS WELL AS CHOOSING ACOUSTICAL UNDERLAYMENTS CAN HAVE AN IMMENSE EFFECT ON THE LIFETIME PROFITABILITY OF A PROJECT AND VALUE OF REPEAT CLIENTS AND CUSTOMERS.

While the construction industry has seen many advancements and improvements in recent years, the numbers and accepted design practices do not always produce the expected results in real-world applications. Lab-performed tests provide a snapshot of acoustical performance. However, they do not account for the impact of load applied to the floor when a tenant moves in. At the end of the day, the acoustical performance of an assembly is determined when tenants put their heads on pillows.

A brief history of acoustical control mats

Throughout the 1950s and ’60s, new fire codes were introduced and existing ones updated to increase public safety. Gypsum was an excellent choice to increase fire-ratings for flooring assemblies due to its low-cost, lightweight, and reliable performance as a fire-rated material. Gypsum underlayments also had the added benefit of reducing sound between existing floors, and savvy marketers soon began touting these unique selling points. For customers looking for increased performance (especially under areas that would receive hard-surfaces for the finished floor), manufacturers began to produce a range of products to install before the gypsum underlayment. Sheet goods and rolled products in a variety of material types were developed as architects and owners saw the advantages of quieter units.

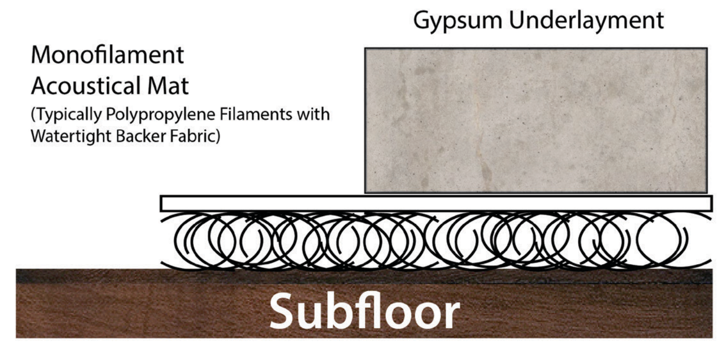
Typically, there have been two approaches to sound reduction: dampening (absorption) and decoupling. Absorption occurs when an underlayment ‘soaks up’ incoming acoustical energy. The material dampens the vibrations as they pass through, thus resulting in less energy output. Materials like rubber, neoprene, and foam panels do an excellent job of reducing sound in this manner.

Decoupling is accomplished by isolating surfaces entirely, resulting in two separate layers for the vibrations created by sound to pass directly through. An assembly built this way forces acoustical energy to pass through two isolated layers of noise reduction with deadening properties. Energy is lost through transference, thereby increasing the performance of the system as a whole.

The 1980s saw the introduction of mass-spring technology mats (Figure 1). These mats proliferated in popularity due to its ease of installation, low cost, and impressive test performance. They attempt to isolate the gypsum underlayment from the subfloor entirely by using an entangled mesh of synthetic fibers, allowing the floor to float and the fibers to absorb any transferred acoustical energy from the floor above.

Recent years have seen the addition of a new generation of rigid mats with the ability to decouple the surfaces with a thinner profile while providing higher compressive strength (Figure 2, on page 6). Required pour depths for gypsum underlayments over inexpensive monofilaments can be as thick as 38 mm (1 ½ in.) to meet the minimum requirements for sound attenuation in many regions of the United States (*i.e.* 50 STC and 50 IIC). Conversely, rigid mats can be 20 mm (¾ in.) deep, requiring less material for the underlayment pour while delivering ratings in the range of 60 STC and 55 IIC. When considering the added cost of materials and longer downtime on the building site to allow for proper curing of the thicker gypsum underlayment pours, these mats are competitive in terms of cost per square foot and performance when compared to monofilament technologies.

Figure 1



Mass-spring technology mats try to isolate the gypsum underlayment from the subfloor by using an entangled mesh of synthetic fibers, thereby allowing the floor to float and the fibers to absorb any transferred acoustical energy from the floor above.

Smoke, mirrors, and STC/IIC ratings

STC is a sound rating that attempts to measure the effectiveness of an assembly in addressing ambient or airborne sound. The test measures airborne sound transmission loss between 125 and 4000 Hz IIC. Sounds defined in this range include voices, music, televisions, pet noises, and others common to habitation. When assessing STC in the lab, sounds are generated using a tone generator, and the sound pressure levels (SPLs) are measured in the testing room and the room below. The resulting loss across each of the 16 bands is evaluated and then applied to a sliding scale that essentially averages the results.

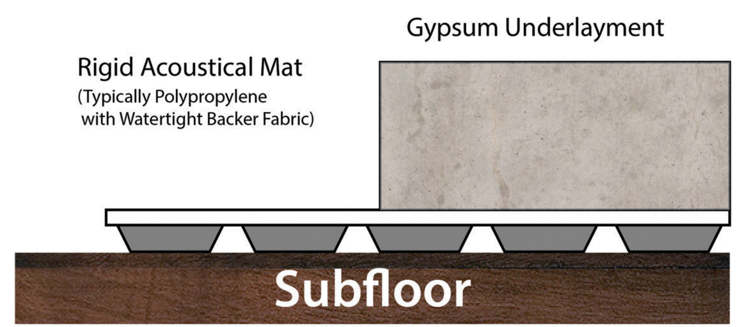
IIC is a measurement of an assembly's ability to mitigate impacts through physical contact, such as footfalls or dropped furniture. IIC tests can be accomplished using a tapping machine that provides a series of calibrated impacts to the specified assembly. The SPL of these impacts is measured in the room with the machine and in the space below using calibrated meters. STC ratings are obtained by measuring the difference in SPL over 16 frequencies between the test room and the unit below.

Each of these tests attempts to cover a broad range of the most relevant data available for each sound class. While the tests provide useful date when considering the capabilities of a sound attenuating mat, they have some limitations. Since the human ear can detect frequencies outside of the range of these tests, they are unable to present a complete picture encompassing real-world performance.

While many people assume the resulting ratings for each of these refer to an actual drop in decibels, it is more complicated than that, and this article acknowledges its risk of oversimplifying the issues. For both STC and IIC test results, a higher rating often shows improved performance. However, since the rating is essentially an average over the 16 frequency points tested, a look at the actual test data may reveal significant deficiencies in a particular frequency range. In fact, a product can perform exceptionally well in one range, poorly in another, and still end up with a better IIC rating than a competing material that may have performed better in a frequency range more relevant to the project's requirements.

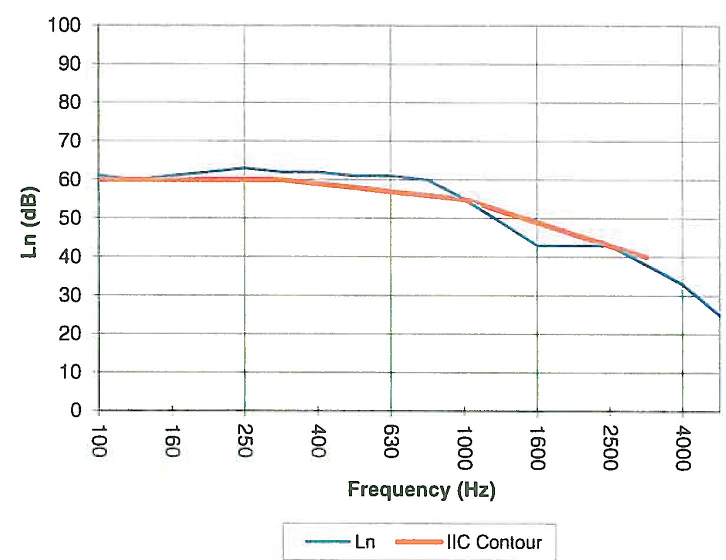
The products in Figures 1 and 2 have both achieved an IIC rating of 52. While performance may seem similar at first glance, Figure 3 reveals the assembly using a rigid mat is performing consistently better at almost

Figure 2



Rigid mats have the ability to decouple the surfaces with a thinner profile while providing higher compressive strength.

Figure 3



Impact Insulation Class (IIC) test result from a monofilament acoustical underlayment for a product delivering an IIC rating of 52. Note the lower reduction of frequencies below 315 Hz.

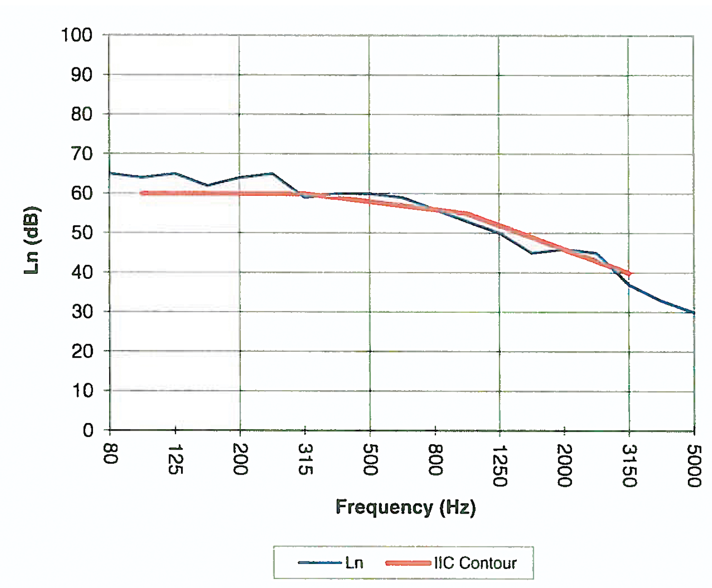
every frequency tested. The frequencies below 250 Hz are even more telling as these frequencies are testing almost 5 dB of pressure lower than the sound mat tested in Figure 4. This result clearly illustrates what the authors believe to be the primary shortcoming of current IIC test standards. In their paper "A dual-rating method for evaluating impact noise isolation of floor-ceiling assemblies," John Loverde and Wayland Dong discuss the need to create an IIC testing model to address two separate frequency ranges, a solution that would allow for clearer pictures of actual test results. The authors of this article agree with this assessment as it would do much to clarify the expected performance of products for specifiers.

What is not shown in either graph, but can also significantly impact the results, are the full details of the assembly utilized to test each sound mat. Companies are quick to share the subfloor, truss assembly, channel, and gypsum board employed during testing but may not be sharing other methods used to increase the ratings. These can also include the use of non-standard insulation between the subfloor and ceiling, a high-performance pad under soft floorcoverings, or a vinyl plank floor with an attached underlayment. While these system modifications improve the performance of acoustical treatments, one now needs to specify identical products on a project in the hope of achieving the manufacturers' published ratings.

As a best practice, all of these factors are usually considered when comparing products. It is advisable to sort through the misleading ratings by gaining access to the actual sound test data from the manufacturers showing the IIC contour line on the transmission loss graph. The performance in relation to the IIC contour line reveals the consistency of the product over the most common frequencies as well as any deficiencies. Interestingly, standards in IIC testing change frequently, and tests performed before 1999 may not produce identical results if conducted today, so it is always a good practice to confirm the dates as well. Accurate data is derived from testing performed to ASTM E 90-09, *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements*, for STC and E 492-09, *Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-ceiling Assemblies Using the Tapping Machine*, for IIC.

When combined, these two ratings provide a snapshot of the acoustical performance of the tested assembly in a controlled environment. While these tests provide a standardized method to evaluate performance, the results alone do not tell the whole story. Understanding how to read the test data reveals the whole picture, allowing one to make an informed decision with a clearer picture of real-world performance.

Figure 4



IIC test result from a rigid acoustical underlayment. Although the resulting curve delivers the same IIC rating of 52 as the product in Figure 3, overall performance is significantly better across many of the frequencies tested.

The importance of transparent assemblies

It is recommended to be cautious when a manufacturer does not explicitly list each element of the assembly. As mentioned, there may be additional insulating elements in the test assembly influencing the published IIC/STC ratings. If a manufacturer offers a generalized sound data sheet, but does not list every component of the assembly, they may be hiding additional insulation or uncommonly used construction methodologies. While the lack of mechanical fasteners in the testing assembly may produce fantastic results, real-world construction practices (especially those in the multifamily and hospitality industry) include nails and screws. Performance achieved by installing the same product will most likely produce a different result. When comparing products, it is essential to compare the details of the assembly used during testing. Was the cavity filled with insulation? Are the resilient channels spaced similarly? Was an additional underlayment or membrane used on top of the gypsum? As a best practice, specifiers should always request full testing details from a manufacturer.

When reading the acoustical testing results of any product, it is beneficial to note not only the assembly used, but also the finished flooring type. Many hard-surface floors now also have an underlayment pre-attached to the planks or tiles. These pre-attached underlayments can affect the tested ratings of a floor, making an underlayment to appear as if it offers a clear advantage after installation. This advantage only exists if the same flooring is specified in the project. Understanding the thickness and composition of the floorcovering is also critical. All 'luxury vinyl tiles' (LVTs) are not alike—although most projects use 2 to 3 mm (79 to 118 mils) glue-down LVT, several manufacturers still test with 5 mm (197 mils) or even thicker products because they boost performance.

Real-world performance of acoustical mats

Lab and real-world performances are, of course, two separate conditions entirely. The authors feel a few issues need to be addressed when

Properly installed sound mat covered with a layer of gypsum underlayment provides long-term benefits for property owners and residents.

selecting and installing sound isolation on multifamily projects. The first factor would be the effects of load on monofilament technologies over time.

Monofilament underlayments offer mechanical resistance, which is a good thing as their sound rating is dependent on the ability to maintain the 'spring.' If the compression on the floor increases beyond the specification, then the amount of deflection increases, thereby reducing the acoustical properties of the mat. Every mat compresses as weight increases, and this happens over time. This mechanism is known as 'creep,' and is common among closed-cell, low-density foams, thick fabrics, and sparsely applied monofilament mats improperly engineered to withstand loads as small as 4.8 kPa (100 psf). Creep occurs over a period of months, although it is most rapid within the first few days of a floor being loaded. As the sound mat compresses, its density and the degree of acoustical isolation are slowly compromised.

Initial compression also takes the load of the underlayment into account. The most common mats require an underlayment pour depth of 25 mm (1 in.), resulting in a load of approximately 6 kg (13 lb). While this is well below the loads measured in the manufacturer's specifications, this assessment does not include the finished weight of loaded kitchen cabinets, heavy appliances, and furniture. However, that is not the most significant concern.

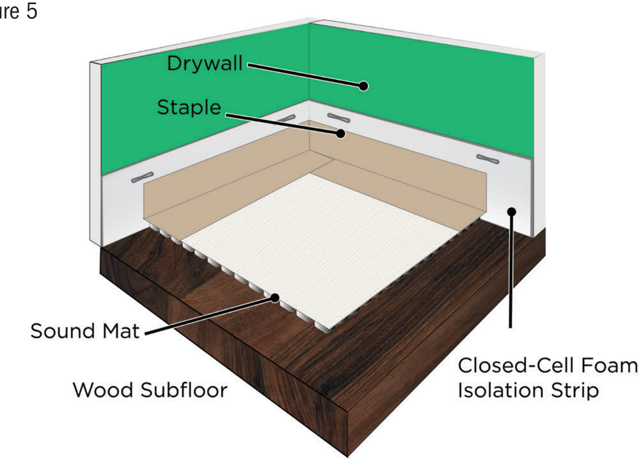
When this mass-spring vibration technology was developed and released into the market, tile was the standard choice for finished hard-floor surfaces in multifamily and hospitality sectors. By its design, rigid tile has the added benefit of dispersing any loaded weight over its surface area, thereby increasing the area of the underlayment under compression and reducing the effective load at any given point.

Recently, the market moved to LVT and luxury vinyl plank (LVP), as these materials offer significant advantages in terms of cost, ease of installation, and selection when compared to traditional hard-surface finishes like tile and wood. These materials are flexible and do nothing to disperse point loads to a broader footprint. If the specified mat has only been tested with a rigid vinyl tile or plank, the building professional and property owner may be displeased with the acoustical performance of the actual installation.

The longevity of gypsum underlayment may also become an issue as tenants move in and out of the multifamily developments. While correctly installed, cured gypsum has high compressive strength, it may compress in a localized area if the acoustical mat below it cannot properly handle the point load of a heavy object, and thereby resulting in cracking, as the material is inadequately supported. Large wood-framed buildings inevitably settle and move, even during the construction process, and cracks in the gypsum are almost always occurring to some degree. The question is, are these cracks moving beneath a compressible sound mat? The authors believe they do. The competitive nature of the construction industry has pushed pours over 10-mm (3/8-in.) thick sound mats from what used to be 38 mm 10 years ago to as little as 25 mm in recent years. It is crucial the gypsum topping is of adequate thickness when specifying compressible sound mats.

Prior to specifying, it is important to carefully review manufacturer specifications and data sheets so that all pertinent information is considered. One may be surprised to find the acoustical products used for years have made necessary changes or innovations to accommodate the same from floorcovering manufacturers.

Figure 5



A properly designed acoustical underlayment system has uninterrupted perimeter isolation to ensure no flanking paths exist.

Addressing flanking paths

Flanking paths can be created by any rigid, sound-absorbing surface. Walls on an upper floor can transmit sound through the subfloor and into supporting walls below. When the underlayment comes into contact with a rigid surface of the structure due to poor system design or installation error, this may exacerbate the issue. This failure could be as simple as the tape between the perimeter isolation and the mat 'lifting' to allow the underlayment to reach the wall and the subfloor. A properly designed acoustical underlayment system provides a method to prohibit contact between the underlayment and rigid surfaces in the room. Currently, most manufacturers offer perimeter isolation in the form of a closed-cell foam strip, typically 75 to 100 mm (3 to 4 in.). This strip is applied on vertical surfaces adjacent to the substrate receiving the acoustical treatment.

While the application in Figure 5 (page 9) is universally accepted as an industry standard, the actual installation of this material is often not according to the manufacturer's specifications. These strips are commonly stapled to the walls during installation to ensure they do not release during the underlayment pour. If these mechanical fasteners are placed below the depth of the underlayment pour, they become a transmission point for vibration into the wall. Individually the effect is most likely minimal. Collectively, it can minimize the effectiveness of the system as a whole. In one lab test the authors witnessed, the test results were improved by 8 dB after correcting a flanking path on the assembly. This error occurred after careful installation in a controlled environment. This 8 dB is consistent with estimates made by V. Hongisto, a researcher from Aalto University, Finland, while developing prediction models for performance of acoustical systems in real-world applications.[1]

Tape is generally applied to provide a seal between the acoustical mat and the perimeter strip. Currently, the most commonly used tape is crepe, which tends to release quickly when exposed to moisture. Gypsum underlayments are poured wet, requiring the tape to maintain a strong bond to the surface of both the acoustical mat and the perimeter isolation strip to ensure underlayment does not pass through the bond and reach the subfloor or the wall. If the gypsum underlayment can create a flanking path to either of these rigid surfaces, the design professional or contractor has reduced the effectiveness of the system (Figure 6).

Figure 6

Perimeter isolation must be installed properly to be effective. Care should be taken to ensure flanking paths are not created.

The rise of rigid technologies

Recently, rigid mats have become popular due to their lower-profile, thinner pour requirements, and reduced deflection. These mats rely on rigid studs closed with a membrane attached to its surface (Figure 2, page 6). Rigid innovation addresses the concerns associated with monofilament products by eliminating the deflection/compression that is tested and proven to reduce sound transmission. The advancements of rigid products have already reached deflection/compression resistance of 1580 kPa (33,000 psf) while creating only 1 mm (39 mils) of deflection.

When using a rigid mat, one is not relying on the finished floor surface to disperse the load weight over a given area. The STC and IIC results for these mats are often comparable or preferable to mass-spring vibration technology, and their compressive resistance makes them an ideal fit for modern vinyl flooring systems. The rigid support for the poured underlayment and complete decoupling from the subfloor increase the lifespan of the floor.

Field versus lab tests

The use of field tests to qualify and specify products has become popular recently for a few reasons. It is well-documented field tests are generally lower than lab due to the existence of flanking paths and a variety of real-world factors. Lab tests are designed to eliminate the flanking paths to the highest degree possible. Additionally, items such as air vents, light fixtures, truss spans, and the quality of the ceiling installation all play a role in reducing the ratings. For this reason, the *International Building Code* (*IBC*) requires a minimum SCT/IIC rating of 50 dB for testing performed in a lab, but reduces this rating hurdle to 45 dB for field results. The rationale for using field results is it is proof the assembly is actually capable of achieving the desired result. Specifiers should use caution when relying on field test reports to specify products. The assembly in question may have tested well on a particular project, but room volumes, light fixture types and locations, and truss span and stiff will all play a factor in the results achieved on a project. Lab tests, on the other hand, are pure because they eliminate most of these variables and are valid for comparative purposes.

The details really do matter. While there is no magic bullet to attain the IIC and STC ratings required for a project by local codes or clients, careful attention to the specific details pertaining to any product claims are important and worth questioning. **CS**

Note

[1] For more information, consult "Case Study of Flanking Transmission through Double Structures" by V. Hongisto.

ADDITIONAL **INFORMATION**

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Abstract

Acoustical monofilament underlayment technologies were introduced to the market more than 20 years ago with the intent of providing enhanced acoustical performance for the tile flooring commonly used at the time. The mass-spring vibration technology performed well as the load being applied to the floor was spread out over the surface area of the tile. Recently, the multifamily and hospitality markets have moved toward luxury vinyl tile (LVT), as it offers significant advantages in terms of cost, ease of installation, and selection. This presents problems for existing monofilament technologies, such as cracking and reduced acoustical performance. It is important to understand real-world performance of underlayments is often impacted by floorcovering. Therefore, care should be taken to select underlayments with the ability to meet the unique demands of the job to ensure long-term performance.

MasterFormat No.

03 54 13–Gypsum Cement Underlayment
06 16 26–Underlayment
09 65 00–Resilient Flooring

UniFormat No.

C1060–Raised Floor Construction

Key Words

Divisions 03, 06, 09
Acoustical sound mats
Flooring
Gypsum underlayment
Impact insulation class
Luxury vinyl tile
Monofilament mats
Rigid mats
Sound absorption
Sound transmission class

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REQUEST A SAMPLE

Managing Noise in **Healthcare Spaces** with **Fusion-bonded Resilient Flooring**

by Mark Huxta and Sharon Paley

Images courtesy Ecore

ACCORDING TO THE RESEARCH PAPER, "SHADES OF FLORENCE NIGHTINGALE: POTENTIAL IMPACT OF NOISE STRESS ON WOUND HEALING," "NOISE HAS LONG BEEN RECOGNIZED AS AN ENVIRONMENTAL STRESSOR THAT CAUSES PHYSIOLOGICAL, PSYCHOLOGICAL, AND BEHAVIORAL CHANGES IN HEALTHY SUBJECTS. ENVIRONMENTAL NOISE AND ITS POTENTIAL EFFECTS ON HEALING AND RECOVERY ARE OF SPECIAL CONCERN TO NURSES IN HOSPITAL SETTINGS, WHERE INCREASED LEVELS OF NOISE AND THE EFFECT OF NOISE ON PATIENT SLEEP AND COGNITIVE FUNCTION HAVE BEEN WELL DOCUMENTED IN THE LITERATURE."[1]

Perhaps one of the most significant examples left behind by the founder of modern nursing, Florence Nightingale, was her commitment to patient care. She understood the importance of producing a state of mind and body conducive to healing. When it comes to designing the built environment in a way that promotes healing, the old adage of "out of sight, out of mind" rings true, as acoustics are too often neglected. Yet, according to the 2018 Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) scores, noise remains one of the poorest scoring categories.[2]

The World Health Organization (WHO) guidelines call for continuous background noise in hospital patient rooms to remain at or below 35 dB(A) during the day and 30 dB(A) at night, with nighttime peaks no higher than 40 dB(A).[3] The dBA metric is the most commonly used one for noise control guidelines and regulations. It stands for A-weighted sound pressure levels. A-weighting is used to represent the human ear's sensitivity to various sounds. A 2005 study examining U.S. hospital noise levels over the previous 45 years found no facility complied with these guidelines. In fact, hospital background noise levels have been increasing since the 1960s, up from 57 dB(A) in 1960 to 72 dB(A) in 2007 during the daytime, and 42 dB(A) in 1960 to 60 dB(A) during the night.[4]

To better improve the healing environment for patients and providers, healthcare design professionals are now seeking materials with specific acoustic benefits. While noise is a subjective term and can be traced to a variety of sources (*e.g.* hallway conversations, footsteps, rolling carts, and alarms), hospitals and healthcare facilities are working to implement sound control and mitigate sound transmission, as both play a key role in creating a healing space.

Impact of noise on patients and staff

A comfortable acoustic environment is vital to supporting the safety, health, healing, and well-being of patients and providers. Patients' physiological health can be negatively affected by poor acoustics, inhibiting the healing process and increasing their chances for readmission. High noise levels can lead to patient annoyance, sleep disruption, elevated blood pressure, and decreased healing rates.[5] In terms of mental and emotional health, acoustics can impact how comfortable and secure a patient and their family members feel in the healthcare setting. Noise is of particular concern in behavioral health facilities where there is a strong emphasis on creating a calm, quiet environment for patients. Loud noises that startle patients or disrupt sleep can have long-term effects, while poor sound isolation can present a lack of privacy and also cause discomfort.[6]

Fusion-bonded resilient flooring consists of a vinyl surface bonded to a vulcanized rubber performance backing to offer the hygienic benefits of hard surfaces with the acoustic and ergonomic traits usually associated with carpets and other textile flooring.

Similarly, patient care teams also feel the impact of poor acoustics. When completing tasks in a space with a high level of noise, providers may have to exert more energy to listen or be heard, which can cause fatigue and burnout.[7] Speech intelligibility is imperative in a healthcare environment, and extraneous sounds can impede providers' abilities to understand and quickly respond to a variety of auditory signals, such as conversations, alarms, and other equipment, which directly affect patient care and human error.

Further, the *Health Insurance Portability and Accountability Act* (*HIPAA*) requires individual patient information that is communicated orally, written, or digitally must remain private.[8] When the healthcare environment is finished with sound-reflecting materials or designed without acoustics in mind, discussions among patients and providers can easily carry into other areas and be overheard by an unintended listener. Poor acoustic design increases the risk of noncompliance with federal privacy regulations.

Different design strategies and technologies can be used to quiet the healing environment and minimize the transmission of sound from adjacent spaces. Acoustical ceiling tiles and wall panels aim to protect patients and providers from extraneous noise by absorbing sounds from a variety of sources rather than just reflecting them back into the environment. Another often overlooked component is flooring surface technology that offers noise reduction without sacrificing cleanliness or ergonomic comfort.

Beyond carpet and tile

In the healthcare environment, hygienic and easy-to-clean flooring is a top priority, prompting most designers to select hard surface materials for durability and cleanliness. Constant foot traffic and the movement of equipment along these surfaces, however, create loud noises that increase sound levels throughout the facility and impact patient satisfaction. Opting for a carpet or other fibrous material that reduces floor impact sound, on the other hand, can raise concerns of cleanliness as well as increase risks of tripping and catching when rolling carts.

Recent breakthrough technology has resulted in a third option—fusion-bonded resilient flooring—that marries the hygienic benefits of a hard surface with the acoustic and ergonomic attributes associated with carpets or other textile surfaces. The flooring option consists of a vinyl surface fusion-bonded to a vulcanized composition rubber performance backing. These innovative materials reduce floor impact sound while providing supportive cushioning underfoot to drive safety and comfort. The fusion-bonded flooring also offers a wide variety of design and color possibilities, such as wood-like surfaces or modern finishes, without sacrificing the performance benefits of rubber flooring. Adding a new dimension in healthcare finishes, these resilient flooring options are helping to create more comfortable and effective healing environments for patients and providers.

Healthcare designers and specifiers are seeking flooring materials with specific acoustic benefits to improve the healing environment for patients and providers.

In-room impact noise

In healthcare environments where the staff is constantly in motion, flooring impact sound from rolling carts, footsteps, and dropped items can be a major source of noise. These sounds are often sudden and unpredictable, making them harder to tune out than more consistent ambient sounds like those from the heating and cooling system. A 2019 study showed peak occurrence rates (the amount of time a peak sound level was above a certain threshold) are correlated with HCAHPS scores for quietness.[9] Flooring impact sound can be a source of peak sound levels in healthcare environments. It can be reduced by selecting the right surfacing.

Noise has been a known issue in the healthcare environment for years, and many organizations have developed standards and guidelines to help address this problem. For instance, guidelines from the Facilities Guidelines Institute (FGI) set forth maximum design criteria for noise in interior spaces. However, these standards are often for building systems and based on unoccupied rooms. Therefore, they do not consider noises, such as footsteps, generated by building occupants.

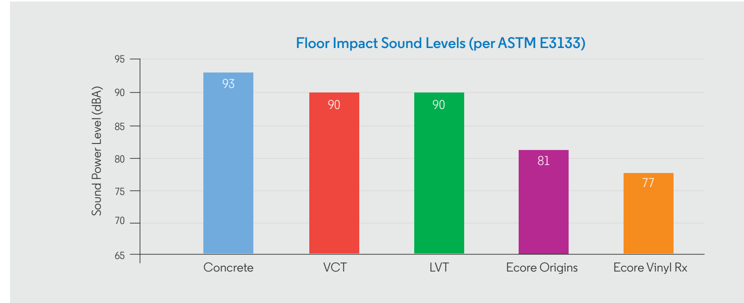
Introduced in 2018, ASTM E3133, *Standard Test Method for Laboratory Measurement of Floor Impact Sound Radiation Using the Tapping Machine*, helps address this gap and provides the healthcare designer with a key acoustic metric for the healing environment. Testing to ASTM E3133 allows architects and designers to make an apples-to-apples comparison of the performance of various materials.

To compare the effect of different materials on flooring impact sound, Intertek was tasked with measuring the performance of five surfaces according to the new standard. They included concrete, vinyl composition tile (VCT), luxury vinyl tile (LVT), vulcanized composition rubber with cork, and vinyl surfaces fusion-bonded to a vulcanized composition rubber backing.

Intertek's testing shows concrete recorded the highest floor impact sound level of 93 dB, followed by generic VCT and LVT at 90 dB. In contrast, vulcanized composition rubber with cork tested at 81 dB, nine dB lower than VCT and LVT, almost 50 percent quieter. Finally, vinyl fusion-bonded to a vulcanized composition rubber backing had the lowest impact sound level at 77 dB—13 dB below VCT and LVT. A 13-dB decrease in noise level is equivalent to two-and-a-half times of relative quietness in terms of perceived loudness.

Testing also found the floor impact sound levels for vulcanized composition rubber with cork as well as vinyl fusion-bonded to vulcanized composition rubber were below the floor impact sound levels for a bare concrete floor at all frequencies. Floor impact sound levels for these two surface types were also below the VCT and LVT levels at almost all frequencies. At high frequencies, VCT is as much as 24 dB (more than four times) louder than vinyl surfaces with a vulcanized composition rubber backing.

Testing showed vulcanized composition rubber with cork and vinyl with a vulcanized composition rubber backing significantly reduced the 'click' (high frequency portion) of footsteps that is prominent with high-heels and hard-soled shoes on hard floor surfaces.



The graph details the effect of different materials on flooring impact sound, as per ASTM E3133, *Standard Test Method for Laboratory Measurement of Floor Impact Sound Radiation Using the Tapping Machine.*

Impact sound transmission

Testing of in-room flooring impact sound is fairly new, but the testing and analysis of impact sound transmission from a room above to a space below has been common for decades. Common industry standards used to determine the severity of impact noise transferred from a source room to a space below are impact insulation class (IIC) and delta impact insulation class (ΔIIC) ratings. These standards play a key role in determining the effectiveness of flooring and flooring underlayments when addressing impact sound transmission from footsteps, rolling carts, and dropped items.

IIC ratings depend on the design and construction of an entire floor/ceiling assembly, but they can be improved significantly with the right selection of flooring and/or acoustical underlayments. Higher IIC ratings mean lower noise levels in the room below.

Where IIC ratings measure the performance of an entire floor/ceiling assembly, ΔIIC ratings just measure the impact insulation performance of floorcoverings and underlayments when tested on a standard 152-mm (6-in.) concrete slab. A ΔIIC rating is essentially the difference in IIC ratings between the bare 152-mm concrete slab, and the 152-mm concrete slab with the flooring and underlayment. For example, if a bare 152-mm concrete slab has a rating of IIC 29 and the addition of flooring and underlayment result in an IIC 52, the ΔIIC rating would be 23. Since ΔIIC ratings are based on a standard 152-mm concrete slab, they provide a better apples-to-apples comparison of the impact insulation provided by flooring and underlayment. However, when comparing underlayments, it is important to note the finish floor tested on top of the underlayment also affects the ΔIIC rating, so it is advisable to only compare underlayment tests using similar finish flooring materials.

Conclusion

Studies reveal loud sound levels can have a negative impact on patient wellness, provider efficiency, and the overall quality of care. To reduce sound levels and improve patient experience and outcomes, many healthcare facilities are now looking to update their site designs and building materials, including flooring selection. When evaluating the healthcare flooring options, it is important to consider the need to reduce noise levels while maintaining high standards of cleanliness to provide safety and comfort to patients and providers. Studies show resilient flooring surfaces backed with recycled rubber underlayment solve acoustical issues without creating a hygiene risk. These single, fusion-bonded materials contribute to a quieter environment more conducive to healing while supporting providers in their delivery of quality care. **CS**

Notes

[1] The paper was written by D.O. McCarthy, M.E. Ouimet, and J.M. Daun for the *Holistic Nurse Practice* in 1991.
[2] Visit www.ashe.org/management_monographs/mg2015kenney.shtml.
[3] For more information, consult the World Health Organization's (WHO's) guidelines for community noise.
[4] Refer to "Noise levels in Johns Hopkins Hospital" by Ilene J. Busch-Vishniaca, James E. West, Colin Barnhill, Tyrone Hunter, Douglas Orellana, and Ram Chivukula.
[5] Read "Influence of intensive coronary care acoustics on the quality of care and physiological state of patients" by I. Hagerman, G. Rasmanis, V. Blomkvist, R. Ulrich, C.A. Eriksen, and T. Theorell.
[6] Visit www.psqh.com/marapr05/noise.html.
[7] Visit www.healthdesign.org/sites/default/files/Sound%20Control.pdf.
[8] Visit www.hhs.gov/sites/default/files/privacysummary.pdf.
[9] Read "Evaluating hospital soundscapes to improve patient experience" by J.M Bliefnick, and E.E. Ryherd.

ADDITIONAL **INFORMATION**

Authors

Mark Huxta is the director of healthcare sales for Ecore. An industry veteran with more than 40 years in the flooring industry, Huxta offers extensive experience and knowledge to his clients with a focus on issues affecting patients, residents, and providers. He was a founding board member of the Delaware Valley Green Building Council and is a member of the HealthPoint Advisory Board. Huxta can be reached at mark.huxta@ecoreintl.com.

Sharon Paley is an acoustic engineer with Ecore. She graduated with a master's degree in mechanical engineering from Boston University and is a full member of both the Acoustical Society of America (ASA) and the Institute of Noise Control Engineering (INCE). Paley can be reached via e-mail at sharon.paley@ecoreintl.com.

Key Takeaways

Noise has a negative impact on patient wellness, provider efficiency, and overall quality of care in healthcare facilities. When evaluating flooring options for healthcare centers, it is important to consider the need to reduce noise levels while maintaining high standards of cleanliness to provide safety and comfort to patients and providers. Studies show resilient flooring surfaces backed with recycled rubber underlayment solve acoustical issues without creating a hygiene risk.

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SOUND CHOICES ARE SMART CHOICES

EXACOR™ MgO panels efficiently deliver acoustic performance for multifamily structures

Multifamily design-builds present a myriad of variables to consider. Architects have the impossible task of ensuring every assembly on the job site meets specification. How can a designer plan for a host of potentially disruptive social environments long after the construction dust has settled?

It's undeniable that architects have the profound ability to improve the quality of life for residents when they approach their drafting stations. One condition in particular that ranks high for those who live in multifamily units is sound control. Here, smart decisions at the beginning can help resolve a mountain of headaches for construction crews, occupants and building owners down the road.

In a recent continuing education session, building science instructor Christine Williamson suggested magnesium oxide (MgO) boards offer a practical, efficient way to help meet acoustic thresholds in lightweight, multifamily structures.[1] EXACOR™ delivers high-quality MgO panels that rival gypsum underlayment without sacrificing performance.

EXACOR modernizes design-builds with MgO panels for subflooring and underlayment assemblies. With the strength of MgO and an integrated mesh core, EXACOR offers a smooth base for floor coverings that are both dimensionally stable and can help meet acoustic and fire-resistant assembly requirements. And since EXACOR installs like wood, existing framing crews can easily add it to their workflow, eliminating the need to coordinate an additional trade on the job site and wait on cure times with gypsum underlayment.

Sound too good to be true? The proof is in the performance. Get your hands on EXACOR and feel the strength for yourself.

REQUEST A FREE SAMPLE

AIRBORNE SOUNDS V. IMPACT NOISES

To minimize sound disturbances, it's helpful to first understand how sound energy transmits.

Addressing concerns about sound attenuation requires a blend of science and application. It's important to distinguish between airborne sound and impact noise, as the problem-solving approach is specific for each.

Airborne sounds constitute talking, music or appliances, while impact noises refer to footfall, dropped items and furniture movement.

"In multifamily design, we're primarily concerned with sound isolation," Williamson explained. "Airborne sound energy travels through the air to the wall assembly and floor-ceiling assembly, where it radiates through the panel to the other side. Impact noise sound energy sets the structure into vibration and structure-borne sound is radiated to both sides of a floor-ceiling assembly."

IMPACT NOISES

When it comes to impact noises, design can play a stronger role in providing greater sound isolation.

"For impact noises, improving performance usually requires design changes to the floor-ceiling assembly," Williamson said. "This can involve a complete redesign or substituting existing materials with higher performing alternatives, usually flooring finishes and underlayments."

These design change considerations could include damping at the point of impact, but that may not always be suitable for all multifamily designs, as there are other constraints to deal with. Damping within the floor-ceiling assembly can improve sound performance -- either in proprietary flooring finish systems or through a dropped ceiling using resilient channels. Creating denser joists or truss spacing is a good tactic to provide stiffness and mass through floors, but may not always be realistic.

Another way of adding both stiffness and mass is by installing an underlayment over the subfloor. This is why gypsum concrete is commonly included in multifamily construction -- it can increase acoustic performance. But gypsum underlayment isn't the only option.

EXACOR™ offers an efficient way to create better performing acoustical assemblies, by adding stiffness and mass to the floor/ceiling assembly. In particular, it offers an effective solution where space constraints restrict the ability to implement other sound dampening features, as is often the case in multifamily construction.

AIRBORNE SOUNDS

Helping mitigate airborne sounds isn't so much a design issue as much as it's an installation issue. When wall and floor-ceiling assemblies are properly air sealed, the transmission of airborne sounds is better contained within each unit. This is the goal of most architectural designs, but these installation details can get lost or be done to a sub-standard level on a massive multifamily job site.

Job sites are juggling tight timelines and budgets, where rigorous inspection of every installation can present a daunting task for even the most well-intentioned general contractors.

BEYOND SOUND BENEFITS

Outside of its dimensionally stable, sound control benefits, EXACOR™ panels provide a smooth base for floor coverings, so construction can continue without waiting for cure times, like with gypsum underlayment. This also benefits those who continue construction in cold weather months, and for those who need materials that can withstand exposure to moisture, since gypsum concrete requires specific conditions to cure properly. With EXACOR, all of those potential delays are eliminated.

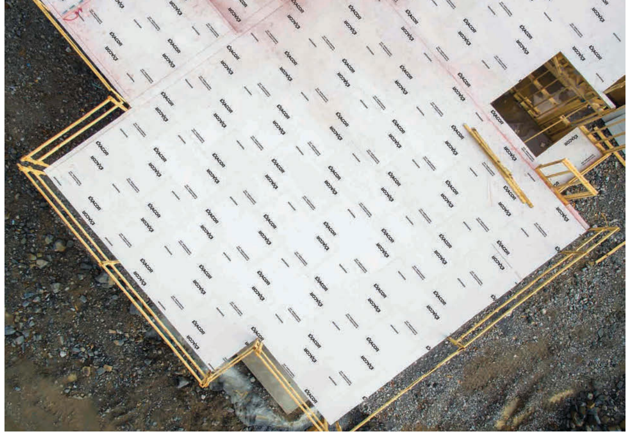
Why is time savings important? Aside from the obvious benefits, streamlined systems create efficiency on the build site. When assemblies are easier, more quality work can take place. EXACOR's ease of installation helps keep construction on schedule, while delivering solid performance.

"A single building mistake or installation error in new construction can lead to compounding problems," Williamson said.

> **A single wise decision, well executed, can lead to disproportionate benefits in building performance.**
>
> **CHRISTINE WILLIAMSOM**
> Building Science Instructor

Learn more about EXACOR, including specifications for assemblies.

ABANDON GYPSUM



BUILDING A STRONG CASE FOR A SOUND CHOICE

Rationale and research are crucial. But so is real-world application. How does EXACOR™ perform on an actual build site?

Murfreesboro, Tennessee-based TDK Construction documented their experience in a case study. The owner-developer recently installed EXACOR in its 127-unit, luxury apartment complex. “With construction projects like ours — a three-story building — you want to make sure you alleviate all the sound from above, and that is always one of the architect’s biggest challenges,” TDK Supervisor Todd Hardy said. “With the gypsum underlayment assembly we’ve used in the past, we had to add a sound mat between the gypsum and the finished flooring. This was eliminated with the EXACOR™ underlayment assembly.[2]”

> **Using MgO panels saved TDK approximately $30,000 and knocked almost two months off the construction schedule,**

allowing potential renters of the luxury apartment to start moving in sooner than originally projected.

“We’ll use this for everything going forward. At TDK Construction, everything we build, we own. Our owner and developer are all about getting it done, and they were super happy with the results,” Hardy said.

See what else TDK Construction had to say about EXACOR.

VIEW THE EXACOR CASE STUDY

1. *Williamson, Christine. “Acoustic Control in Multifamily Construction.” Home Building Crossroads, Feb. 2021, www.huberwood.com/events/home-building-crossroads/archive/acoustic-control-in-multi-family-construction.*
2. *This job was designed in accordance with UL L528. Assembly specifications and requirements vary.*
3. *EXACOR panels may be used in specific published fire-resistant-rated assemblies as tested in accordance with ASTM E119 / ANSI UL 263. Follow published fire-resistance rated assembly requirements and consult local building codes and designer of record for fire-resistant design requirements.*

MANUFACTURER SNAPSHOT

Founded in 1883, EXACOR™’s parent company the J.M. Huber Corporation has grown to be one of the largest family-owned companies in the U.S.

Huber Engineered Woods, a division of the J.M. Huber Corporation, is guided by its calling to meet the building industry’s evolving challenges. Huber Engineered Woods has launched successful, industry-leading brands like AdvanTech® Subfloor Assemblies and ZIP System® Building Enclosures. Their latest innovation, EXACOR MgO Panels, are backed by a 10-year limited warranty. Limitations and restrictions may apply, visit huberwood.com for more details.

Specifying Ceiling Panels with a High NRC

by Gary Madaras, PhD

Photo © Robert Pepple, Images courtesy Rockfon

STANDARDS NOW REQUIRE HIGH-PERFORMANCE SOUND ABSORPTION OVERHEAD INSIDE MANY BUILDING TYPES. UNDERSTANDING THE ACOUSTIC REQUIREMENTS WITHIN THE BUILDING STANDARDS AND TRANSLATING THOSE CORRECTLY INTO A PROJECT'S WRITTEN SPECIFICATION IS ONLY THE FIRST STEP. ONE SHOULD ALSO UNDERSTAND OTHER POTENTIAL IMPACTS ON THE BUILDING DESIGN TO ENSURE THE OCCUPIED BUILDING SOUNDS GOOD OVERALL WHEN COMPLETED.

Section 11.5.4. of the new American National Standards Institute/Green Building Initiative (ANSI/GBI 01-2019), *Green Globes Assessment Protocol for Commercial Buildings*, contains sound absorption requirements for various rooms in office buildings, schools, and healthcare facilities. There are two compliance paths: one being minimum ceiling noise reduction coefficient (NRC) and the other is maximum reverberation time (RT). Patient care areas in healthcare facilities and resident care areas in senior living facilities are required to have ceilings with a minimum NRC of 0.90, or if a portion of the absorption is provided on the walls and floor, a maximum RT of 0.50 seconds. In this example, writing the project specification is straightforward. The specified ceiling panel should have an NRC of no less than 0.90. This ensures compliance with this section of the standard.

There can be, however, other potential impacts on the building design and compliance with other sections of the standard. Section 11.5.1.2 requires the minimum sound transmission class (STC) rating of the floor/ceiling assembly to be 50. The design and specification of the floor slab, floor finishes, underlayments, and high NRC ceiling system must comply with the STC-50 requirement. Meeting the absorption requirement in 11.5.4 does not stand alone. It is related to meeting the floor-to-floor, airborne, noise isolation requirement as well, and one should not compromise the other. As project specifications are amended to comply with the high NRC requirements, there are other building design impacts that should be considered.

Review of acoustic ceiling panel

Modular acoustic ceilings comprise of a metal suspension grid—ceiling panels made from a porous and fibrous material, such as stone wool, fiberglass, or mineral fiber—and various building systems elements, such as light fixtures, air terminals, sprinklers, and speakers.

The ceiling panels are made of lightweight materials that are typically less than 5 kg/m^2 (1 psf) and are fibrous and porous to permit the airborne sound energy to enter the panels and dissipate due to conversion to heat energy. This process decreases noise and reverberation, making speech more intelligible in enclosed rooms like classrooms and creating privacy, comfort, and freedom from distractions in large open spaces. In most everyday spaces, such as schools, healthcare facilities, offices, and restaurants, the higher the amount of sound absorption, the better.

A ceiling panel's ability to absorb sound is indicated by NRC, an acoustics metric that averages the measured absorption coefficients at the 250, 500, 1000, and 2000 hertz (Hz) octave bands. NRC can be categorized as high-performance when is it 0.90 or higher. Many of the standards, guidelines, and rating systems require a minimum ceiling absorption of NRC 0.90. If the absorption is not provided by a contiguous acoustic ceiling, the alternatives should offer an equivalent amount of sound absorption.

Building standards and guidelines require good acoustics and are evolving with more stringent requirements. Many now require the use of high noise reduction coefficient (NRC) ceiling panels.

Photo © Joe Ciarlante

Sound absorption in the standards, guidelines, and rating systems

ANSI/GBI 01-2019 requires minimum ceiling absorption of NRC 0.90 in open offices, patient and eldercare areas, medication safety zones in healthcare facilities, and exam and treatment rooms in medical office buildings. The General Services Administration (GSA) PBS-P100, *Facilities Standards for The Public Buildings Service*, requires ceilings over open offices areas to be NRC 0.90 or higher for 100 percent of the space.[1] According to *Sound Matters: How to achieve acoustic comfort in the contemporary office*, a related GSA document, published in December 2011:

Open workspaces require acoustical treatment on a significant portion of the surfaces in the space to absorb noise from people and equipment. The more absorptive the material added to the open space and the higher the acoustical performance rating of the material, the more acoustically comfortable the environment will be. Two surfaces are key contributors to absorption: high quality acoustic ceiling material is typically the most significant contributor to sound absorption. Similarly, walls may be treated with acoustic material, either applied to a surface or integral with the wall finish.

The WELL Building Standard requires the ceiling over an open office space is NRC 0.90 or higher for the entire surface area exclusive of light fixtures and air devices.[2] Complying with this criterion improves the functioning of the cardiovascular, endocrine, and nervous systems of the building's occupants.

Section 5.3 of ANSI/Acoustical Society of America (ASA) S12.60, *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools*, requires core learning spaces to be designed in a way their RTs can be readily adapted to achieve RTs not greater than 0.30 seconds. To achieve this level of performance, the ceiling of an average-sized classroom needs to be a minimum of NRC 0.90, possibly even higher, and some wall or floor absorption is required as well.

Why NRC 0.90?

While it is known good acoustic design requires high-performing sound absorption of NRC 0.90 or higher, the question of 'why' might still linger in the minds of some architects and specifiers. An abbreviated answer to this question is because exhaustive and conclusive research has shown the benefits of it.

Modular acoustic ceilings comprise a metal suspension grid, ceiling panels, and various building system elements, such as light fixtures, air terminals, sprinklers, and speakers. Even when the ceiling panels offer high sound absorption, these components may result in unwanted sound transfer.

In the early 2000s, the National Research Council Canada (NRCC) methodically isolated and tested a set of a dozen physical features of open offices relative to speech privacy.[3] Those features included ceiling absorption and height, screen wall absorption and height, light fixtures, workstation size, furnishings, etc. Some studies used mockups of actual cubicles in open spaces. Other studies used sophisticated acoustical analysis software based on the image sources technique. These studies used the acoustic metric sound absorption average (SAA), which is very similar to NRC.

Of the design features studied, it was found ceiling absorption, screen wall height, and workstation plan size have the largest effects on speech privacy. The most significant noise paths are those that reflect sound from the ceiling and diffract sound over the separating screen wall. However, only a limited range of these parameters will lead to acceptable speech privacy.

The ceiling is a critical element. There are no obstacles to prevent sound from reaching the ceiling and being reflected down to other areas. The absorptive properties of the ceiling can have a large effect, but speech privacy values are only substantially reduced for highly absorbing ceiling tiles. For a wide range of medium- and low-absorption ceiling tiles (NRC 0.50 to 0.80), acceptable speech privacy is unachievable and not influenced much by the ceiling absorption because too much sound is still reflected off these low-performing panels (Figure 1).

The main conclusion about ceiling absorption, after years of intense investigation, is a minimum ceiling absorption for achieving acceptable speech privacy is an NRC/SAA of 0.90. In practice, it would be better to have an even more absorptive ceiling than this to compensate for any limitations or absence of the other important design parameters.

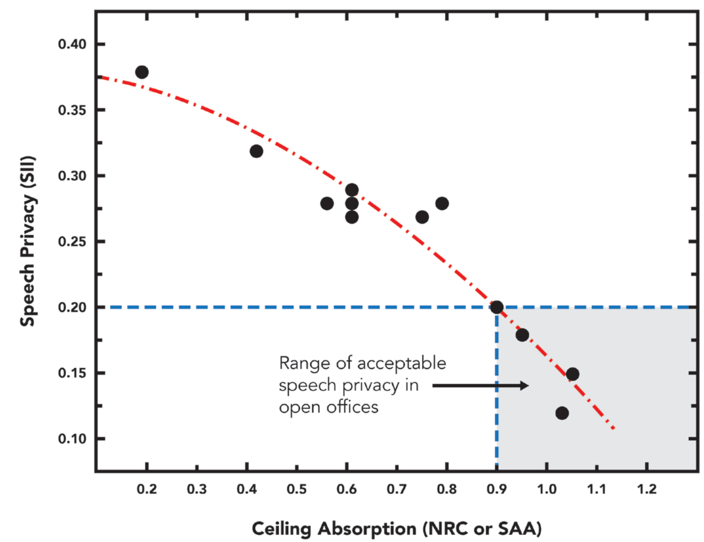
Seeing the NRC 0.90 difference

The foundational studies conducted by NRCC 20 years ago have been corroborated more recently by research conducted by an acoustic ceiling manufacturer and presented at InterNoise 2018, an exposition on noise control engineering.[4]

A sound intensity probe was used to scan an acoustic ceiling system with panels of different absorption performance levels of NRC 0.60 to 0.95 while loud, broadband noise was played in the space under it. A high-definition camera and analysis software tracked the location of the probe and the sound intensity levels it measured. These location-specific sound intensity data were then processed into color sound maps, which were overlaid onto the digital image of the ceiling (Figure 2, page 25).

Yellow and red colors in Figure 2 indicate loud noise reflecting off the acoustic ceiling while blue indicates noise being absorbed by the acoustic ceiling. Red areas are mostly caused by noise reflecting off the hard, painted metal—plaque-style—air diffuser, and light fixtures. Note the open return air grille on the right side of the images (blue) acts as an effective sound absorber because the noise passes through the opening

Figure 1



In this figure, speech privacy (vertical axis) improves with lower speech intelligibility index (SII) values. Once ceiling sound absorption average (SAA)/NRC is 0.90 and higher, acceptable speech privacy can be achieved in open offices (gray box in lower right). Each incremental increase in SAA/NRC above 0.90 results in an appreciable improvement to speech privacy.

into the plenum and is not reflected. The base question is, at what NRC rating does an acoustic ceiling stop behaving like a reflector (red and yellow) and behave more like an effective absorber (blue)? Based on the series of images in Figure 2, the answer is NRC 0.90.

The perception of what constitutes high-performance sound absorption has slipped over time. Some have come to believe NRCs as low as 0.70 to 0.75 are acceptable, but as the sound intensity scans in Figure 2 show, at that level of performance, the ceiling is still acting more as a noise reflector than absorber. Fortunately, building standards, guidelines, and rating systems are now reinforcing what science has shown for decades.

Improved well-being

In 2003, a multiorganizational study conducted by academic institutions in the United States and Sweden inside a Swedish hospital investigated the effect high-performance, sound-absorptive ceiling panels had on the quality of care and physiological state of patients in an intensive coronary care unit (ICCU).[5] The study was conducted in an actual hospital ICCU under clinical conditions and involved 94 coronary patients.

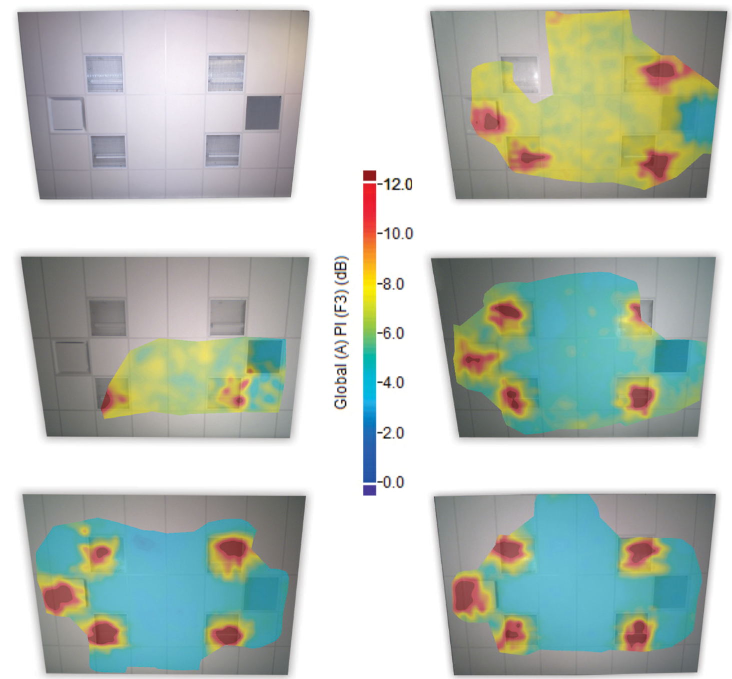
During the 20-week baseline condition, the ceiling was hard and sound-reflective. Patient physiology (heart rate and variability, blood pressure, pulse, etc.) and acoustic conditions (RT) were recorded. At the end of the baseline condition, the ceilings in the ICCU were changed to high-performing, Class A, acoustic ceiling panels. Class A in Europe is equivalent to NRC 0.90 in the United States.

Patient physiology and acoustic conditions were then monitored for another 22-week period. The study showed the effects of the high-performing, acoustic ceiling panels decreased patient heart pulse amplitude and their rehospitalization rate. In other words, the high-performance ceiling panels reduced stress in the patients' bodies and cardiovascular systems, while they were in the hospital, resulting in fewer of them being readmitted after three months due to complications or reoccurrence.

In 2010, researchers from the Department of Psychology at the University of Kaiserslautern in Germany studied the effect of RT and noise on speech perception and listening comprehension in child and adult students.[6] Acoustics conditions in a real classroom, before and after an acoustic renovation, were measured and then simulated in the laboratory of the university's Hearing Research Center.

The acoustically unfavorable condition, representing surfaces with low sound absorption performance, had an RT of 1.10 seconds. The acoustically favorable room, representing surfaces with high-performing sound absorption, had an RT of 0.47 seconds (as mentioned, ANSI/ASA S12.60 recommends classrooms be adaptable to an RT of 0.30 seconds). More than 350 first-graders and third-graders, and adults were tested under both acoustic conditions. The results showed with the high-performance sound absorption present, speech recognition improved significantly in all test subject groups. As an example, with the high-performance absorption in place, first graders sitting in the third row recognized 22 percent more words than when the acoustic

Figure 2



Ceiling panels with NRC ratings varying from 0.60 to 0.95 reflect different levels of noise (red and yellow) when they are below NRC 0.90, but absorb most noise (blue) at NRC 0.90 and above. The color scale represents wideband noise in decibels (dB).

conditions were unfavorable. Similarly, adults recognized 18 percent more words under the favorable acoustic conditions.

Ceiling alternatives

While the standards often state the absorption requirements as ceiling NRC, it does not necessarily mean every space must have a standard, contiguous, modular, acoustic ceiling. That approach does not always agree with the preferred architectural style or aesthetic of the room or building. Other sound absorptive systems are permitted if they provide at least the same amount of absorption as an acoustic ceiling of NRC 0.90.

An equal amount of absorption can be achieved with a variety of acoustic metal or wood ceilings—suspended, horizontally oriented, clouds, or islands—or vertically oriented baffles. The first step is to determine how much absorption a ceiling with NRC 0.90 would have provided.

A sabin is the unit of sound absorption. Sound-absorptive elements that hang free in space, such as acoustic islands and baffles, have their performance specified in sabins rather than NRC. There are both metric and imperial sabins—it is important to distinguish between the two when reviewing product information.

Metric

For every square meter of floorspace, NRC 0.90 ceiling provides 0.9 metric sabins of absorption. Another way to look at it is to multiply the total area of the floor in square meters by 0.9 metric sabins per square meter to get the total number of metric sabins required inside the room by any absorption system.

Example

A 100-m^2 (1076-sf) classroom should have 90 metric sabins of absorption over it (100 m^2 x NRC 0.90 = 90 metric sabins). If a baffle provides 1 metric sabin of absorption each, then 90 baffles would be needed over the classroom.

In modular ceiling systems, panels are made of lightweight materials such as stone wool, fiberglass, or mineral fiber that are fibrous and porous to permit the airborne sound energy to enter the panels and dissipate due to conversion to heat energy. This process decreases noise and reverberation, making speech more intelligible in enclosed rooms and creating privacy, comfort, and freedom from distractions in large open spaces.

Imperial

For every square foot of floorspace, an NRC 0.90 ceiling provides 0.9 imperial sabins of absorption. Therefore, multiply the area of the floor in square feet by 0.9 sabins per square foot to get the total number of imperial sabins required inside the room by any absorption system.

Example

A 1000-sf (93-m^2) classroom should have 900 imperial sabins of absorption over it (1000 sf x NRC 0.90 = 900 imperial sabins). If a baffle provides 10 imperial sabins of absorption each, then 90 baffles would be needed.

Conclusion

Building standards, guidelines, and rating systems are now requiring high-performance acoustic absorption overhead with a minimum NRC of 0.90. This requirement is based on both quantitative research and studies showing the positive impact on occupant well-being in offices, schools, and healthcare facilities. Specifiers should remember complying with the high NRC requirement may impact other acoustical requirements, such as minimum airborne sound isolation between vertically oriented rooms. Other sound-absorptive systems, such as acoustic islands and baffles, can be used in lieu of ceilings if they provide equivalent absorption. **CS**

Notes

[1] Referenced from Table 3.1 on page 101 of the 2018 version of the General Services Administration (GSA) PBS-P100, *Facilities Standards for The Public Buildings Service*. This rating is for when sound masking is not used in the space.

[2] Details can be found in the Comfort section 80 on page 130 of version 1 of the WELL Building Standard.

[3] Read the National Research Council Canada (NRCC) reports on "Acoustic Design Guide for Open Offices," "Measurements of Sound Propagation between Mock-up Workstations," "Acoustical Design of Conventional Open Plan Offices," "A Renewed Look at Open Office Acoustical Design," and "Acoustical Design for Open-plan Offices" for more information.

[4] Consult *Look, Do You See the Noise Leaking Through that Ceiling?* by Gary S. Madaras, for InterNoise exposition 2018.

[5] See *Influence of Intensive Coronary Care Acoustics on the Quality of Care and Physiological State of Patients* by Inger Hagerman et al from the International Journal of Cardiology in 2005.

[6] Read *Effects of Noise and Reverberation on Speech Perception and Listening Comprehension of Children and Adults in a Classroom-Like Setting* by Maria Klatte, Thomas Lachmann, and Markus Meis in Noise & Health, 2010.

ADDITIONAL **INFORMATION**

Author

Gary Madaras, PhD, is an acoustics specialist at Rockfon. He helps designers and specifiers learn the optimized acoustics design approach and apply it correctly to their projects. He is a member of the Acoustical Society of America (ASA), the Canadian Acoustical Association (CAA), and the Institute of Noise Control Engineering (INCE). He authors technical articles and speaks publicly on the topic of optimizing acoustic experiences. Madaras can be reached at gary.madaras@rockfon.com.

Key Takeaways

Building standards, guidelines, and rating systems now require high-performance acoustic absorption overhead with a minimum noise reduction coefficient (NRC) of 0.90. This is based on research showing the positive impact on occupant well-being in offices, schools, and healthcare facilities. However, specifiers should remember that complying with the high NRC requirement may impact other acoustical requirements. Other sound-absorptive systems, such as acoustic islands and baffles, can be used in lieu of ceilings if they provide equivalent absorption.

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Key Words

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