EGUIDE

SOUND EFFECTS – THE SCIENCE OF SOUND IN THE BUILT ENVIRONMENT

Milliken™

The human brain is uniquely attuned to sensory input. We receive all types of sensory data and our cognitive processes take over. We're presented with a mixture of physiological and psychological feedback, nearly all of it occurring in the background. Whatever we're consciously doing from moment to moment takes precedence, unless some bit of data elbows its way to the front — maybe a car horn, a flash of light, an acrid scent. Only then will our attention shift.

Our main subject here deals with responses to — and the management of — sound. In this context, background input of the type noted above becomes a crucial focus. That we are not actively aware of an effect being the result of sensory input is a far different proposition than whether or not there is an effect.

When it comes to background noise, there are actually quite a few.

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SOUND EFFECTS

Let's briefly run through some of the documented effects that are a result of noise.

To begin with, loud ambient sound has been shown to raise heart rates and quicken breathing. Given this effect, it should come as no surprise that a study by Cornell University[1] indicated that workers in open-office environments exhibited increased levels of stress hormones, which made it more likely for them to become less motivated and creative. In fact, there are data showing that productivity can go down by as much as 66%[2] — obviously a *very* significant number.

For educational environments, acoustics are also crucial. Common ambient noise levels in many schools can decrease intelligibility by half (!)[3] — and that's *also* a significant number. Under such circumstances, students have to work harder simply to understand what's being said. The result is more fatigue, which affects a student's ability to think critically — and not surprisingly, the very same fatigue issues are going to affect their teachers, too. For office environments with similar ambient noise levels, the effects are analogous.

Open-plan office designs (and sit-to-stand arrangements) are intended to encourage moving around, and to promote collaboration between co-workers. Both can enhance health and wellness, but both ***also*** tend to increase ambient noise levels. Even in situations where occupants subvert carefully thought-out design objectives — by putting on headphones, or just keeping to themselves —it's in the inherent nature of open-plan office spaces to be louder than traditional ones.

Let's set aside the deeper complexities of human interaction for the moment. In any space where clear workplace communication is a priority — and that should be ***everywhere*** — one big obstacle is when people have a hard time hearing each other talk. Bad acoustics — ambient noise — is a significant contributor to the problem. At the most basic level, it's that simple.

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FOUR SOUND POINTS

When we talk about an "acoustically effective" space, the subject is a far more complex one than just to figure out a way to make a given space generically "quieter." We'll narrow our focus here and begin to examine the ways that floor covering choices might factor into a comprehensive acoustic strategy.

Here are four very specific areas of focus:

1. Noise Absorption
2. Noise Generation
3. Through-Floor Sound
4. Activity-Based Needs

Let's now take a deeper look into these areas.

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1) Noise Absorption

This one is pretty straightforward. The question here is: How well does a particular material absorb sound? When you walk into a space and it sounds "echoey," the reason has to do with reverberation times. The longer the reverberation time, the more echo you'll hear — and the louder a space tends to sound. With regard to building materials, a general rule is that softer surfaces are better at cutting down reverberation than harder surfaces. Carpet absorbs more sound than hard flooring, for example — and cushioned carpet absorbs more sound than hardback. Good sound absorption materials broadly applied over large surface areas tends to yield the best ambient noise level results.

So let's talk about measurements: The first term to be aware of is RT60. Simply put, RT60 is a measurement of how long it takes a sound to decay 60dB in a large room. The lower the RT60 value, the shorter the decay time, and the less echo you'll hear. The result is a quieter space. Office spaces should ideally have RT60 values of about .5 seconds. For comparison, the RT60 for a gymnasium where no sound-mitigation has been applied, could be as high as 5 seconds (or possibly higher).

Next we'll look at ***NRC.*** *This is a value you'll often see when looking at specifications for products where acoustic performance is relevant. NRC stands for Noise Reduction Coefficient. NRC values are derived as follows (and we're keeping it very simple, here): A test chamber is measured to determine its RT60. A relatively small piece of the product to be measured is then installed in that same chamber, and then a new RT60 measurement is made. The difference between the two values is used to calculate the NRC. Noise Reduction Coefficient values will always fall between 0 and 1 — an NRC value of 0 means no sound is absorbed, while an NRC of 1 essentially means all sound is absorbed. Broadly speaking, higher numbers indicate products better able to absorb noise.*

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Why do we use the word "essentially"? If you happen to be interested in the geeky details, here's why: To be precise — an NRC of 1 means that for a product covering an area of size X, the amount of sound absorbed by that product will be equivalent to the amount of sound "absorbed" by an opening in the test room of exactly the same X-sized area. No sound at all would be reflected back by an X-sized part of the wall covered by product, just as an X-sized opening in the wall would reflect no sound back.

One Last Point Regarding NRC Values: *There is an important distinction between the NRC testing methodologies used for floor coverings and ceiling tiles. Floor coverings are tested directly on a hard surface. Ceiling tiles, in contrast, are tested with a large air cavity behind them. While these methodologies do generically approximate their placement in real-world room settings, the result (from a statistical standpoint) is that NRC values are always higher for ceiling tiles than for floor coverings. In a completed building, the overall acoustic benefit attributable to floor coverings vs. ceiling tiles is far less precise than a comparison between NRC .8 and NRC .2 would seem to imply. How spaces behave acoustically is the result of a complex mix of factors — and that's something to keep in mind when you choose a product that affects sound design. As the cliché goes — for a true apples-to-apples comparison, it's best to compare apples with other apples. The most accurate comparisons will be between one ceiling tile NRC value with another ceiling tile, and one floor covering NRC value with another floor covering.*

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2) Noise Generation

In a building-materials context, we aren't talking about how loud something is on its own — we're interested more in its ***potentia***l for generating noise. Foot traffic across a floor is a noise-generating process — think particularly about how loud a dress shoe can be on a hard surface. The relevant question is: How much noise will be created by foot traffic on different products? Polished concrete or wood floors will generate more noise than floors covered by carpeted surfaces. It's important to remember here, that among office surfaces, the floor is by far the largest producer of impact sounds — from footfalls, objects dropped or furniture moved. Sure, doors do open and close, and sometimes a box or bag might accidentally bang into a wall — but the floor is the only ***surface*** likely to generate near-constant noise. We use the word "surface" here specifically to distinguish sounds produced by contact with the floor from other sources of ambient noise, such as talking, or HVAC systems.

A welcome development is that ASTM International recently released a new standard test to quantify noise generation on flooring. The new test will use a similar methodology to that of the test that determines IIC values (which we'll get to below). It will measure sound levels directly inside the room where the noise is produced. IIC values, in contrast, come from measurements of sound levels on the other side of a barrier (like a floor, or wall) from the generated sound. So — now that we've teased you with IIC, let's move to the next point:

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3) Through-Floor Sound

This is related to Noise Generation, but here we're strictly concerned with how much of the sound gets through the floor into the space below. For commercial spaces we're particularly concerned with impact noise generated by foot traffic, rolling traffic, or dropped objects — but sounds like music or speech can sometimes be relevant, too. Ceiling tile and the configuration of plenum spaces both have a big impact here — but flooring is an important factor to be considered. People on a lower floor will hear a significant difference in through-floor sound transmission from the floor above, depending on whether that floor is covered with a hard surface, hardback carpet, or cushioned carpet. These choices should be carefully considered as part of a holistic acoustic strategy.

IIC (Impact Isolation Class measures the ability of a floor assembly to absorb impact sound. IICs are always whole numbers. The higher the number, the higher the amount of impact sound being absorbed. As a benchmark, the ASTM reference IIC for 6" of bare concrete is 28. Ceiling and floor treatments are generally additive — so, for example, adding Milliken LVT with premium underlayment will increase IIC by about 10. Hardback carpet used instead of LVT on bare concrete will add another 10 — cushion-backed carpet will get you about 10 more.

To help clarify what you're looking at, in layman's terms it would be generally fair to consider an IIC increase of 10 as equivalent to a 10dB decrease, more or less, in sound level. The two values aren't precisely the same, but for a ballpark estimate they'll work just fine. It's also important to keep in mind is that the dB scale is logarithmic. +10dB will be measured as over three times the sound pressure, +20dB will be 10 times higher. The crux of the matter is — lowering sound levels by 10dB is a big decrease (68%). Every 10dBs matters. Looking back at our series of examples above, if you modify a space by putting cushioned carpet onto a bare concrete floor — this translates up to 30 dB decrease.

Another value you may encounter is ΔIIC. The symbol Δ (that's "delta" for those of you who don't stare at lab results all day) usually means the difference between two numbers, which is also the case here. ΔIICs are determined by measuring the IIC for a space and then looking at the difference in IIC once the product in question has been put in place. If you're interested in precision, always use ΔIIC to compare one product to another.

Be aware that IIC is used strictly to measure how much impact noise gets through the floor. To find out how much ambient room noise (like talking) gets through, you'll want to look at STC (Sound Transmission Class). It quantifies a material or product's ability to mitigate the amount of sound (not generated by impact noise) that travels through floors, or ceilings, or walls. Like IIC, STC values are also whole numbers. Typical building codes usually require STCs of 45 or 50.

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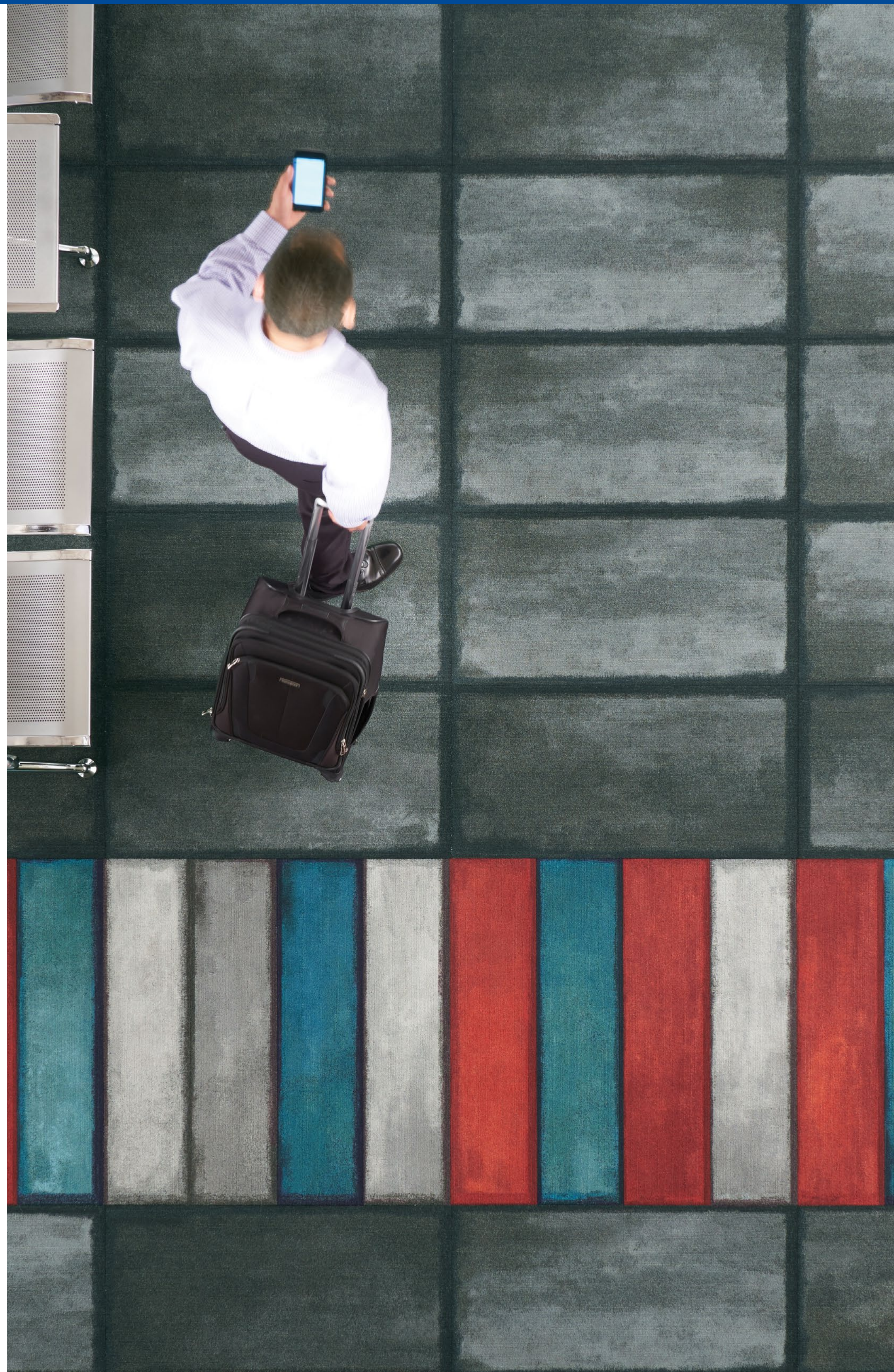

Acoustic Issue	Rating Designation	Explanation of the Test: What Does it Measure?	APPLIES TO — Whole Room *or* Specific Product?
Noise Absorption	RT60	RT60: Reverberation Time Measures how long it takes a sound to decay 60dB in a large room *The lower the RT60 value, the shorter the decay time, resulting in less echo — and therefore, a quieter space. For an office space, an ideal RT60 value will be about .5*	ROOM
	NRC	NRC: Noise Reduction Coefficient Measures a product's effectiveness at noise absorption. *NRC is calculated by comparing two test chamber RT60 measurements: First empty, then after being fitted with a product to be tested. NRC will fall between 0 and 1 — higher is better. NRC 0 means no sound is absorbed, NRC 1 means (put simply) that all sound is absorbed.*	PRODUCT
Through-Floor Transmission *(Impact Sound)*	IIC	IIC: Impact Isolation Class Measures how well a floor assembly (sub-floor plus a product) absorbs impact sound (such as footfalls), from below the floor. *IICs are always whole numbers. Higher numbers mean less impact sound will be audible from below. As a benchmark, the ASTM reference IIC for 6" of bare concrete is 28.*	FLOOR ASSEMBLY WITH PRODUCT
	ΔIIC	ΔIIC: "Delta IIC" Shows how much a specific product will improve IIC. *ΔIIC is determined by measuring the difference in IIC for a space with and without the use of the product to be tested. ΔIIC, rather than IIC, is the best way to compare one product with another.*	PRODUCT
Through-Floor Transmission *(Ambient Sound)*	STC	STC: Sound Transmission Class Measures how well a floor assembly absorbs ambient sound (like voices), from below the floor. *Like IIC, STC will also be a whole numbers. Higher numbers are better. Typical building codes usually require STCs of 45 or 50.*	FLOOR ASSEMBLY WITH PRODUCT

4) Activity-Based Needs

Not a complex idea — yet one that can be easily overlooked. No one disputes that a conference room should be sized and shaped differently than a hallway, or an open-plan office. It's important that the same approach be applied to sound design. What are the needs of the space? Is it intended for collaboration or for quiet study? What types of activities are most likely to occur there? The acoustic best-practices for each of these spaces are as varied and important as are the structural or spatial demands. One generalization that usually makes sense is to physically separate areas for concentration (or quiet work) from areas where there will be plenty of talking — noisy work.

HOLISTIC SOUND DESIGN

As we noted at the beginning of this paper, high ambient sound levels have physiological as well as psychological effects. We also know that these effects have an impact on individual performance in the workplace, or in school. From there we can extrapolate to larger, enterprise-wide effects on productivity and quality of work. These broad-based effects have tangible bottom-line repercussions. For businesses, there's a financial effect. Educational scenarios will also take at least *some* financial hit — but the real concern has to be the way a student's knowledge and understanding might be diminished, however fractionally.

Meanwhile, we've also explored how acoustic design can be broken down into components, each of which comprise just part of an overall sound-design strategy. Put all of it together and this is the goal: Find a more holistic approach to create productive and comfortable aural environments in the spaces we build, for the people who use them.

Discover how (and why) Milliken cushion-backed carpet is your best flooring option when it comes to controlling unwanted sound.

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WHAT ABOUT THE FLOOR?

Acoustic strategies for new buildings, or renovation projects — when they come up — often revolve around ceiling and wall treatments. The floor, while not completely neglected, tends to take a back seat. A big reason for this is that sound control is usually thought of as an intrinsic benefit with ceiling tiles, or baffles, or the like. Many times, architects and designers make purchasing decisions about products such as these with acoustic performance specifically in mind. The same can often be true for wall coverings — acoustic performance is once again a desired (and expected) effect. With floor coverings, sound-related performance ***might*** be part of the decision-making process (certainly in educational environments), but it tends to be further down on the list.

1 Evans, G. W., & Johnson, D. (2000). Stress and open-office noise. Journal of Applied Psychology, 85(5), 779-783.
2 The 4 ways sound affects us, Julian Treasure, Talk at TEDGlobal 2009, July 2009.
3 Why architects need to use their ears, Julian Treasure, Talk at TEDGlobal 2012, June 2012.