HOW &WHY SOUND PROPAGATES THOUGH A STRUCTURE OR BUILDING

Airborne Sound: Sound that is traveling freely through the air will spread (propagate) outwards to fill the room or space that it is created in. ANY penetrations, voids, ducting, gaps or holes in the room's envelope (walls, floor, ceiling, door) will allow the sound to escape. Making a room 'virtually airtight' (really no such thing) will eliminate much of the problems of sound migration.

Where air must travel freely, e.g. HVAC supply & return air – the path that the air will take must be planned in advance and acoustically treated. By installing faced absorbent material inside both; the supply and return-air ducts, the sounds that will be propagating within these ducts will be attenuated by "some amount".

There are two truisms (sayings) to remember when considering airborne sound:
1. Sound travels via the air – if air can move – sound can move also.
2. Imagine a room with 10-ft thick concrete walls, floor, and ceiling; if a ¼-inch gap is left open below the door; 60% of the sound in the room, will be able to escape.

Without successfully addressing these small penetrations, voids, ducting, gaps or holes in the room's envelope, much of the other costs that will be / have been incurred to achieve acoustic isolation will be a complete waste of money and effort. Acoustic isolation is achieved with great attention paid to small details. If you don't address sound migration in the air FIRST… then don't bother with the rest of the treatments.

In addition, both supply and return-air ducts must also be protected from "break-in" sound/noise from the surrounding area. E.g. If your main supply-air trunk duct is installed in the ceiling above a common hallway with a lot of activity, chances are that sounds made in the hallway will "break-into" the main trunk. If the sounds can get into the duct, it will migrate to the end of the branch ducts – therefore to the individual rooms.

Airborne Sound into Structure: Sound travels spherically out from the source through the air until it reaches a boundary or partition. When the sound strikes the partitions in a room (walls, floor & ceiling) "some portion" of the sound's energy will be transferred into the partitions and will cause them to vibrate. Another portion of the sound's energy will be reflected off of the partition at some incident angle and therefore back into the room where it will then strike the next partition, and so on…
At each of these reflected intersections between sound wave and partition (there are thousands) "some portion" of the initial or remaining sound energy will be transferred into the structure – until such time as the initial sound and reflected sound have

The last remaining portion of the sound energy will continue to reflect off of the partitions until the air molecules (air of the room) absorb this last fraction of the energy. How long this process takes and how much energy is transferred into the structure is a function of many factors and ingredients – a few examples are listed below.

How loud was the initial sound?
Is the room completely air sealed?
What are the partitions made of?
Partitions hard attached to structure?
What are the interior acoustic treatments?
How long in time did the initial sound last?
How stiff are the boundaries / partitions?
What is the frequency content of the initial sound?

THE LAST EXAMPLE OF FREQUENCY CONTENT CANNOT BE EMPHASIZED ENOUGH!

High-frequency sounds have very little intrinsic energy. Additionally the size (wavelength) of high-frequency sounds are so small – in the order of fractions of an inch in length – they are more easily captured or absorbed by materials or by the partition they strike. However in contrast, low-frequency sounds have enormous intrinsic energy levels. Furthermore, the size or wavelength of these frequencies is measured in feet or tens-of-feet. They are not easily captured nor absorbed by materials or the partitions they strike.

Principally there are only two treatments that low-frequency sound can be affected / influenced by, de-coupled mass or distance. Distance is never really an option for use as a low-frequency controller – it would just take too much space. This then only leaves de-coupled mass as a controller for these frequencies. If the mass of a partition wall, floor or ceiling assembly is not sufficiently high, low-frequency sounds will not be absorbed by it. The low-frequency sound (or portion of a sound) will typically just pass through it and/or flank it (pass around) via other structural components.

Impact or Vibrational Sound into Structure: Sound which is created via mechanical (physical) movement in contrast to air movement. It too can travel spherically from the source, but more often will travel within the path of least physical resistance. Once an impact or vibrational sound has entered a building component or the structure, it is extremely difficult (if not impossible) to control or eliminate.

These sounds travel from the source via the physical components of a building and will re-surface somewhere else in the building. It is not always the case that the impact or vibrational noise will be heard directly across from or adjacent to the source of the impact or vibration. The path of least resistance within the structure might make the energy follow an unpredictable course, allowing the impact or vibrational noise to reappear somewhere unexpected.

Sound and vibrations travel faster (easier) through solids than through the air. The speed of sound through air is 1,125 ft. / sec., whereas through wood it is 13,000 ft. / sec. and through steel it is 20,000 ft. / sec.

Impact and vibrational sound by nature is mostly low-frequency sound. The rigidity and mass of the structure that these sounds are travelling through, acts as an "acoustic filter" to the passage of mid to high-frequency sounds. The mid and high frequency sounds simply do not have the power intensity to travel through the solid materials. Therefore the sound that is transferred will be almost entirely lower frequency.

Consider the sounds heard through a floor/ceiling in 99% of multi-story buildings.

1. Adult walking heel impacts – bare foot or in shoes.
2. Kids playing and jumping around.
3. Low-mid to low frequencies from media playback systems: TV's, stereos, etc.
4. Items that are dropped onto the floor above.
5. Vibrations caused by motors, compressors and transformers, etc.

To address the propagation of low-frequency sound or noise through a structure, the component parts of the structure MUST BE; (1) high mass, (2) de-coupled – and/or – (3) damped. All three is best…!

High Mass components (walls, floors, ceilings, doors) will require a large amount of external stimulus to excite them. Therefore the higher the mass of a floor for example, the more energy will be required to set the floor into vibration. High mass building components offer the best barrier to all frequencies of sound, if the mass is blocking the transfer of lower frequencies, then it goes without saying that the mid and high frequencies will also be blocked.

De-coupling the parts of a building that could pass vibrations to or through each other is another method of vibration control. E.g.: by placing a thin (5-10mm) rubber pad below the bottom plate of a stud wall and isolation brackets at the top of the stud wall, the studs and the GWB they will eventually carry, will be isolated from the floor and the ceiling. When a sound wave now strikes the finished GWB wall, the vibrations that will be caused in the wall will not migrate (flank) into the floor and ceiling. Damping goes hand in hand with both high mass and de-coupling.

No matter how high the mass of a building component, once a sound wave strikes it, it will vibrate by "some amount". For example; with two layers of 5/8th GWB on a wall, when a sound strikes the wall both layers are set into vibration, but if a layer of viscoelastic damping compound (Green Glue) is installed between the 2-layers, the outer layer will vibrate with the sound but the damping compound will stop those vibrations from passing through to the inner 2nd layer of GWB.
Genie Clips, Green Glue, springs, rubber and underlayments are all examples of decoupling / damping materials.

Peter Harper
ACOUSTIGUARD-WILREP LTD.