

# Good Vibrations (Part 2)

## The Basic Principles of Unwanted Vibrations

When we play back audio, we only want to hear sound waves created from the electro-mechanical vibrations produced by the loudspeaker. They are the result and intention of the artists. They are the original signals. These are good vibrations. But what happens when there are bad vibrations? In Part 2 of this article, we explore ways to solve these issues using various products that AV RoomService, Ltd., provides when helping clients with their acoustic problems.

Photo 1: RoomDamp2 is applied to the back of the second layer of sheathing to act as a constrained-layer damping compound.

By  
**Norman Varney**  
(AV RoomService, Ltd.)

In the noise control industry, the best place to start is usually at the source of the noise. In our example, we start with the loudspeaker. The biggest contributors to unwanted noise and vibration are the walls, the ceiling, and the floor.

I have been serious about accurate music playback since I was a kid. I have been in the business for decades. I am someone whose hobby is also his living. It is because of my love of music.

My company, AV RoomService, Ltd. offers acoustic design and testing services, as well as several original acoustic products, two of which target the problems discussed in this article.

### RoomDamp2

We'll start out with RoomDamp2 constrained-layer damping compound. This product was developed for both noise control and sound quality attributes. As we have discussed, partitions are quite easily set into motion from both structural vibrations as well as the airborne sound waves impinging on them. Partitions

with too much mass (e.g., concrete) keep the low frequencies contained resulting in poor sound quality. Partitions with too little mass do not reinforce the low frequencies, which also results in poor sound quality. The partitions must be carefully designed in order to balance the two, while also being airtight for noise control. This requires resilient designs so that the shell is sealed, yet can move and act as a low-frequency absorber.

RoomDamp2 is a viscoelastic paste that remains pliable and never hardens. It has the viscosity of toothpaste and is available in five-gallon buckets. It is applied with a paint roller and is sandwiched between layers of sheathing of OSB, drywall, plywood, etc. (see **Photo 1**).

We have already discussed the fact that the room boundaries contribute a large amount of unwanted vibrations back into the listening environment. RoomDamp2 mitigates sound transmission and improves sound quality. It does this by reducing the movement of the sheathing. When sound energy



strikes the surface of a partition assembly, energy is transferred into the surface sheet material in the form of bending waves. Untreated, structural waves propagate sound energy throughout the floor, the ceiling, or the wall assemblies to other rooms. RoomDamp2 utilizes constraint layer damping technology to force bending waves to induce shear-deformation within a thin applied layer of RoomDamp2. It is these cyclic deformations occurring throughout RoomDamp2 that accelerate energy loss through damping in the form of heat dissipation.

## Noise Control

RoomDamp2 absorbs structural vibrations to significantly reduce noise transmission between rooms. This is measured in acoustic labs as transmission loss (TL) from 100 Hz to 5,000 Hz, and rated with the sound transmission class (STC) single number designator. Partition assemblies applied with RoomDamp2 reduce noise levels up to an additional 40% compared to untreated wall assemblies. This applies to noise entering and exiting the room. Not only are rooms quieter for living or sleeping, but the full dynamic range of the listening environment is captured.

## Sound Quality

RoomDamp2 reduces partition resonances and room reverberation times resulting in a fast, dynamic, articulate sounding room. Untreated room partitions resonate and store sound energy, which is then re-radiated back into the listening space later in time. They also reflect lower frequency sound energy back into the room. For any critical listening environment, these delayed and reemerged sound energies distort the original sound signal making the room sound slow, muddy, and droning.

RoomDamp2 reduces re-radiated sound energy by dissipating and absorbing wave deformations that impinge upon and within the partition. Rooms sound fast and articulate because the partitions are no longer ringing after the original signal event has stopped. Rooms have more low-level resolution because the partitions are no longer masking new original signal events (direct sound waves).

## RoomDamp2 Development

We worked with a couple of different chemists to create various new formulas and compare them to existing products. Our objectives were to offer a product that:

- Is superior to the competition in noise control
- Costs less than the competition
- Is easier to apply than the competition

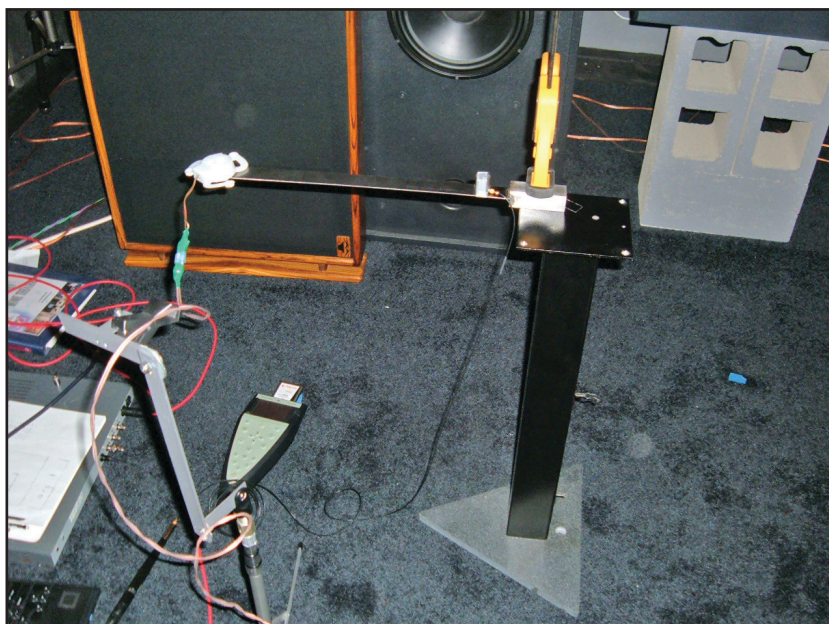


Photo 2: The Oberst bar apparatus with the exciter, an accelerometer, and measurement instruments was used for stage one testing of damping properties of various damping formulas.

- Has less stench than the competition
- Has less waste than the competition
- Cleans up easily
- Is essentially hazardless
- Is made in the USA

As formulas were developed, the testing process went in stages. First, we used an oberst bar apparatus, which measures the dynamic modulus of elasticity, and measures the internal damping factor from 20 Hz to 20 kHz (see **Photo 2**).

If the formula passed this test (see **Figure 1** for the results), we then tested it on a constrained-layer sheathing mock-up. We suspended the mock up with bungee cords, agitated the device under test (DUT) with a piezo exciter, and collected the data with an accelerometer. We positioned the accelerometer

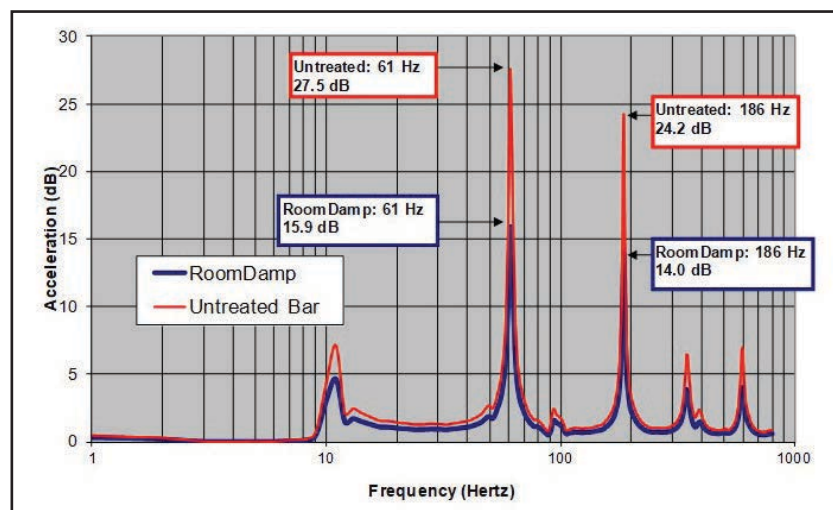


Figure 1: Here are the Oberst bar apparatus test results of an earlier formula of RoomDamp v1. RoomDamp v1 is shown in blue, untreated in red.

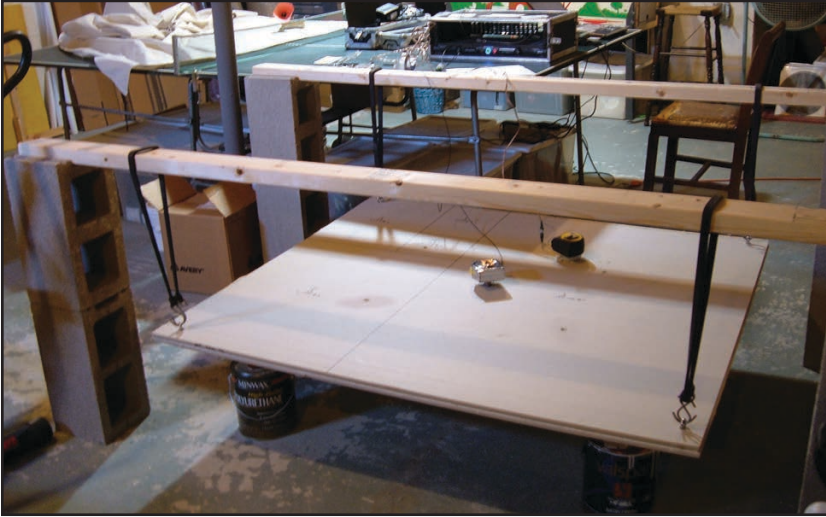


Photo 3: This is a sheathing mock up of constrained-layer damping compound testing. Two layers of sheetrock suspended with bungee cords allow for relatively free movement.

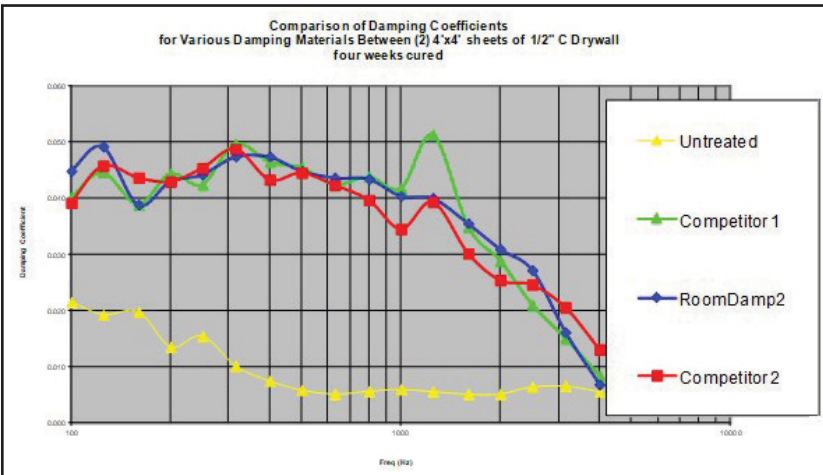


Figure 2: Here is an example of collected data from sheathing mock up tests as seen in Photo 3. We conducted eight formulas. This example compares the best formula to the best two competitors, against no treatment.



Photo 4: The author oversees one of the ASTM E-90 TL tests in the source side reverberation chamber. These are actual wall constructions filling an 8' wide by 12' tall chamber opening between the source and receive reverberation chambers.

around points of a golden ratio drawn on the DUT to control mode interference and averaged the data collected (see **Photo 3**).

If the formula passed this test (see **Figure 2** for the results), we knew we had something worth re-testing at an accredited lab where we would perform an ASTM E-90 Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements. The standard is designed for evaluating the transmission of airborne sound through the test specimen between two reverberation chambers. This involved conducting many tests with several common building wall types and against those of our best competitor.

We tested in a couple of accredited labs with larger reverberation chambers and requested data be collected below the standard frequency limit. The confidence levels were calculated for each of the centered one-third octave bands (see **Photo 4**). We achieved all of our objectives with RoomDamp2 and the E-90 TL results can be seen in **Figure 3**.

## EVP Development

The next product we developed addresses the noise source, along with equipment that is sensitive to the influence of vibrations. Our objectives were to make it:

- Applicable to all equipment regardless of price class
- Affordable to most consumers
- Have a natural resonant frequency below 20 Hz
- Available in densities and sizes to accommodate a wide range of loads
- Made in the USA

A vibration isolator is a resilient support, which decouples an object from forced vibration. Natural frequency and damping are the properties that determine the system's transmissibility.

The purpose of vibration isolation for audio equipment is to control unwanted vibrations and resonances from causing adverse effects to both electrical audio signals and sound waves—both airborne and structureborne.

The natural frequency is a function of the stiffness of the isolation system in conjunction with the mass (load) being supported. The purpose of tuned damping is to dissipate the unintended energy as quickly as possible. Transmissibility is the ratio of the output vibration divided by the input vibration. It is the amount of vibration passing through the system. The isolation efficiency of an Equipment Vibration Protector (EVP) is conservatively >80% from about 5 Hz on up. This means that better than 80% of the vibratory force is not transmitted to the support structure or



the equipment.

The EVP core is a matrix of precisely compressed layers of high-density molded glass fibers, which allows controlled air movement through the fibers (see **Photo 5**). This action provides viscous damping, reducing physical motion, while widening the frequency

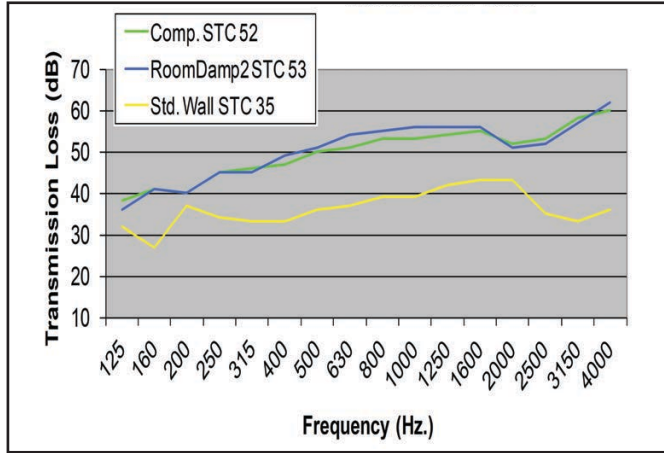


Figure 3: Here are the ASTM E-90 transmission loss test results of a 2' x 4' wood construction with a double layer of 5/8" drywall on the receive side, and a pre-laminated layer of RoomDamp2 on the source side. R-13 fiber glass insulation fill.



Photo 5: Equipment Vibration Protectors (EVPs) are available in 2" and 4" squares by approximately 1" tall, with felt and rubber finishes, and in three standard densities to handle equipment loads from 3 lbs to more than 300 lbs.

### About the Author

Norman Varney is the owner of AV RoomService, an acoustic design company that also offers a few acoustical products. Having been in the noise control and sound quality industries for decades, he has earned awards for acoustical products and room designs while working for AV RoomService, Kinetics Noise Control, Owens Corning Science & Technology Center, and MIT. Norman has presented white papers to the industry and written articles on acoustics for numerous publications over the years, as well as participated in seminars and panel discussions. He is an active member of ASTM (Committee E-33 on Building and Environmental Acoustics), the Acoustic Society of America, the Institute of Noise Control Engineering, the Audio Engineering Society, the National Association of Music Merchants, CEDIA, and others.

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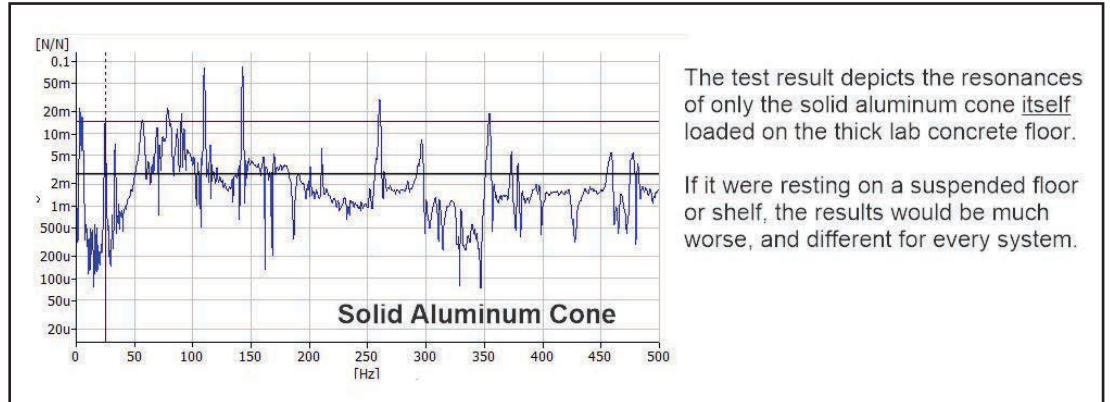
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Figure 4: Note that the size, shape, density, and load (not to mention resting platform properties) will act as a filter attenuating some frequencies, while amplifying others.



bandwidth of attenuation. As sound energy moves fibers against fibers, the friction transfers sound energy to heat energy. The annealed fiberglass is produced by a multiple flame attenuation process, which generates fibers having modulus of elasticity of 10.5 million PSI (738,223 kg/cm<sup>2</sup>) and nominal fiber diameters of less than 0.00027" (6.8 microns).

The matrix of the glass leaf springs is bonded at all fiber intersections with a low VOC water-resistant binder during the molding process under controlled heat and pressure. The material is then stabilized by multiple pre-compression cycles to many times the maximum published load capacity for the specific density of the media.

The cold-rolled steel plates on the top and bottom of the pad function to evenly deflect the weight across the whole surface for even weight distribution. They also allow existing cone or spikes to be used without damaging or compromising the performance of the pad.

Our own RoomDamp2 constrained-layer damping compound is used to bond the steel plates to the fiberglass core. This damping further improves the EVP absorption properties by lowering the Q-factor, which broadens the bandwidth, reduces ringing, etc. RoomDamp2 is a viscoelastic paste that remains pliable and never hardens. The paint applied to the fiberglass pad is a very special formula that allows flexing. This elasticity means the pad can be compressed without the paint cracking or flaking. The formula contains low VOCs and is UV protected. The flexible paint does cause slow shape-return after pad compression. Unlike other elastomeric materials, EVPs are resistant to water, mold, sunlight, humidity, age, and extreme temperatures.

### EVP Use

EVPs are vibration isolation feet for high-fidelity playback and recording equipment, as well as guitar, bass and keyboard cabinets, microphone stands, etc. EVPs allow equipment to perform optimally,

quiet the room, and prevent vibrations from being transmitted to adjoining spaces. Structural vibrations and resonances are no longer heard, leaving only the pure original loudspeaker signals.

EVPs decouple vibration transmission. They do so by transforming the mechanical energy into thermal energy. Most of the competition offer one-size-fits-all devices, and/or couplers, as in rigid spikes, blocks and cones.

In regard to resilient isolators as in rubber, cork, sorbothane, etc., it should be well understood that in order to perform properly (mitigate vibrations in the audible range) the device must have a natural resonant frequency below 20 Hz. under the load designed. Most do not and most have no test data published to back their claims. Understand also that if the device is loaded with too much or too little weight, it cannot perform as designed.

In regards to couplers (hard spikes, cones and blocks), there are a couple of misconceptions:

"Because there is so little surface contact area, very little vibration can be transferred." Though true when applied to resilient materials, it is not true with solid materials. It actually acts as a very efficient conduit for vibration transfer. In some situations, the heavier the load, the better the transmission. Note that the size, shape, density, and load (not to mention resting platform properties) will act as a filter attenuating some frequencies, while amplifying others (see **Figure 4**). The audible results can be for better or worse, never predictable or neutral.

"The small contact point acts as a vibration sink or ground." This too is false. We already know that the vibrations will be efficiently transmitted to the resting platform, which will then likely continue to be transmitted throughout the connected structure. Vibrations can also be transmitted to the source, which in fact, this can also alter the sound.

This is a good place to talk more about sound energy characteristics in dense materials. Of course, every material has a density and that density affects

sound energy in two particular ways of interest to our listening environment:

- The speed of sound travel increases with density. In air, it travels about 1,130 feet per second or 343 m/s. In rubber sound travels approximately 60 m/s, in glass 4,650 m/s, in steel 5,960 m/s. Hence, you can hear the train coming with your ear on the rail well before any other indicator.
- The distance of sound travel increases with density. Hence, whales can communicate with each other hundreds of miles apart in salt water.

### Noise Control

By reducing sound transmission to adjacent spaces, other occupants are not annoyed because vibrations are not transferred into the building structure. EVPs have been lab tested and found to conservatively eliminate vibrations to and from equipment from about 5 Hz and up, by >80%. This is done by converting the mechanical energy into thermal energy. The result is audible from both a sound quality and a noise control point of view.

Standard EVPs are 2" or 4" squares by about 1" tall (approximately 51 or 102 square x 30 mm tall). Standard EVPs are black with felt or rubber top and bottom.

### Sound Quality

Clarity, dynamics, timbre, and soundstage are improved because resonances and vibrations are nearly eliminated. Floors, walls, ceilings, and furnishings cause unwanted resonances and vibrations, which can be re-radiated into the room. Vibrations can even cause sonic degradation in electronic components, their connections, errors of laser reading and turntable playback, resulting in data corruption, phase distortions, noise, etc.

Microphony occurs when electrical components receive mechanical energy and convert it into electrical energy, thus distorting the signal. Tubes and phono cartridges are especially susceptible. Crystal oscillators in digital products can be effected by vibrations by changing their frequency slightly, causing timing errors. Turntables are certainly the most sensitive to vibrations, amplifying them over the speakers, sometimes even to the point of feedback. They are also most sensitive to footfalls being picked up and amplified, or causing mistracking.

The first and best place to decouple vibrations is at the source, the loudspeakers. This will prevent structural vibrations, not of course airborne. RoomDamp2 will affect both.

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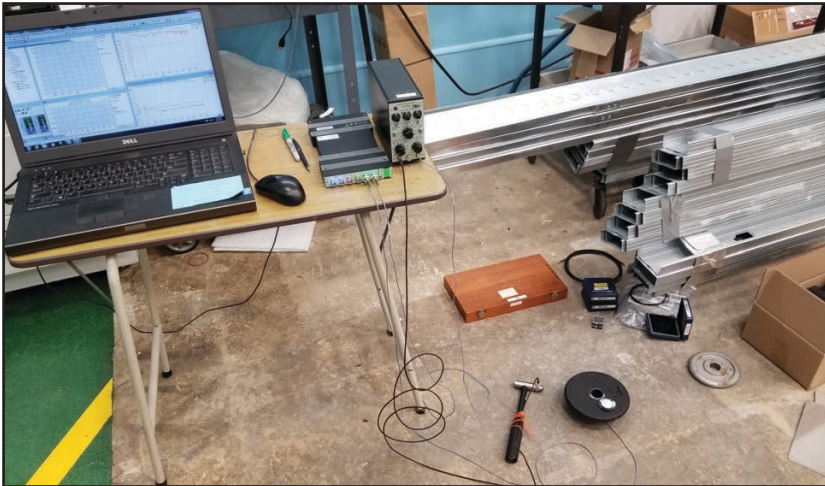


Photo 6: Here are lab test instruments for impulse hammer vibration transmissibility tests of EVPs.

transmitted through the test sample (see **Photo 6**). The system ensures that the structural characteristics of the hammer are filtered out and do not influence the measurement data. The hammer strike is extremely light (about the force of a pencil tapping a desk). A strike that is too hard, too soft, or a double hit is detected and rejected by system parameters. Each test sample was load tested incrementally from below to above its estimated ideal load range. Each test result is an average from five clean tests. Tests indicating poor or questionable coherence results were not collected. Tests were for vertical single degree of freedom movement, and a bandwidth of 1 Hz to 500 Hz. The single degree of freedom set up provides the most basic control system, eliminating the possibility of unique and/or additional material influences. The 500 Hz upper limit was deemed high enough to prove continued isolation, yet low enough to show low-frequency detail, which is of primary interest. Test samples were randomly selected. A sample representing each density, size and finish type was tested through its applicable load range. The vibration energy transferred from the impact, through the isolation sample, is received and recorded by the accelerometer (see **Figure 5**).

### Vibration Transmissibility Tests

The force sensor in the impact hammer in conjunction with the movement sensor of the accelerometer serves to provide a frequency and amplitude measurement of the energy that is

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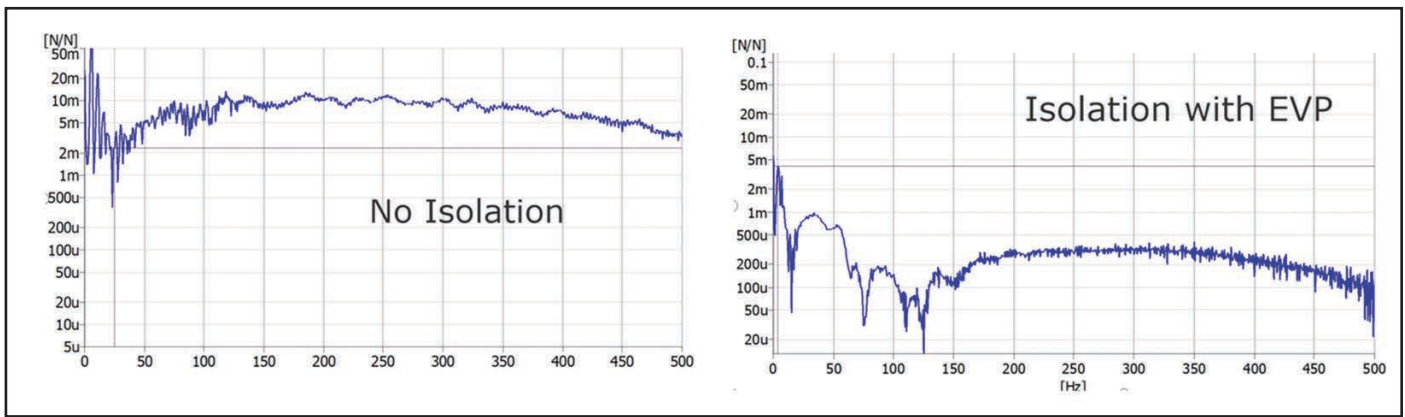



Figure 5: A sample representing each density, size, and finish type was tested through its applicable load range.

### Test Conclusions

It should be very apparent from the measurements that solid materials transfer significant energy to whatever they are in contact with. Different solid materials transfer different energies depending on their densities, size, shape, and in conjunction with the characteristics of the material(s) it is resting on. Some frequencies are attenuated, while others are amplified. This coupling is the reason why wood, metals, and even rubber can sound different, but never neutral. In addition, solid materials will deliver a unique response for every system configuration; coupling material, resting platform, equipment weight, etc. The EVPs offer

a predictable, repeatable, reliable solution to decouple and isolate audio equipment from transferring or receiving vibrations.

### In Summary

Loudspeaker cabinets vibrate and can transfer their vibrations into the structure. The structure can vibrate and radiate new vibrations into the room after the original, direct sound waves have stopped. The partitions will absorb, transmit, reflect and re-radiate sound energy. These unwanted vibrations interfere with the wanted vibrations. Learn more at [avroomservice.com/products](http://avroomservice.com/products). 

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