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SAVIAC Paper: Remediation of Mechanical Vibration to Roof Curbs Using Kellett Material

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SAVIAC Symposium
Orlando, FL
October 27, 2010

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As owner of an engineering based business in Missoula, Montana for 20 years, one of the services we perform throughout the Pacific Northwest is Mechanical Noise & Vibration Control.

We have worked on the operating environments of many systems and integrated types of machinery. Over and under planers for Plum Creek Lumber mills in Columbia Falls may have been one of our biggest challenges in the remedial sense. Yet one of the most common complaints fielded by our offices is that of mechanical vibration and airborne noise from a multitude of roof top units (known in industry parlance as RTUs) and therefore is remedial in nature, having received the call about the noise and vibration *only after* the installation was completed and the units were installed.

In today's economy, indicators are that so-called value added engineering may be (in part) responsible for some of these noise and vibration complaints from Contractors, owners and builders. The drive to keep costs down may eliminate the use of conventional wisdom based mechanical spring isolation curbs, allowing these often weighty RTUs and Single and Dual Package Heat Pumps to rest directly on the roof deck or on a solid roof curb, facilitating structure borne transmission of the powerful low frequency vibrations often associated with these electro-mechanically coupled machines.

In the fall of 2009, I received a call from Jay Kirby & Associates, an architectural company in Missoula, Montana. Jay called to ask me if there was any way to remediate the noise and vibration from two high efficiency single package heat pumps, located close together on the roof of the recently completed classroom addition to the Arlee, Montana Schools. I have been involved with other acoustic work for the school system, and arranged a visit for the purposes of viewing the installation and taking some site dosimetry of the noise and vibration perceived throughout the new classrooms directly below the unit. This vibration and the air borne component associated with it were described as making the classroom 'un-useable'. After speaking with the Superintendent, John Miller, and receiving his permission to speak with the installers of the two high efficiency single package heat pumps, I began to search through the contract documents prior to my meeting with Rob Skillicorn of Comfort Systems USA, the installers of record. I've known Rob and many others at the company for over 15 years, so interfacing with them went effortlessly. During the investigation and disclosure process, it was made clear to me that value added engineering had been implemented to cut costs in the building program. This directive to the HVAC contractor meant that mechanical spring isolation curbs were deleted from the bid. Yet the building was newly constructed and completed. The cost for hiring a crane to lift the units after breaking all the newly installed connections was prohibitive, and the cost for manufactured spring isolation curbs was deemed high as well. The task assigned to me

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was to find a way to remedially reduce the vibration and noise to the roof and truss system, resulting in a quieter, more concentrative classroom for teachers and students.

I've specified mechanical spring isolation curbs on most of my hotel and commercial work in this area of building acoustics and noise and vibration control. While this falls under the category of conventional wisdom, in most installations such curbs are extremely successful at minimizing vibration transfer through the roof assembly, when properly engineered, well constructed and correctly installed. Given the fiscal and engineering limitations of this project, I began searching for another means of dealing with the physics of the vibration transfer from units to existing curbs. In my discussions with Rob at Temp Right Comfort Systems USA, I found that these units were designed with pallet jack cutouts (structural) that would allow them to be lifted up a short distance of 2 to 3". This would eliminate the need for the costly crane, lifting arms and rigging. The question then arose of how to deal with the vibration that was causing this new classroom to be deemed un-useable.

In May of 2009 I read an engineering test report of the Kellett Enterprises' LP-13 Shake Absorber® Pad. I began to realize that this material might very well provide the perfect solution to this problem if it could be configured in the manufacturing process, to comply with my various acoustic and engineering requirements. The unique nature of the pad material's construction was such that it could also satisfy the needs of the system installers, for correct operation of the units. It was first necessary to determine that the units could be lifted easily with small hydraulic pallet jacks. Rob confirmed that they could do this easily even though the J12BP units are 12 and 1/2 ton rated. Space on the roof top site was limited, but small hydraulic pallet jacks would do the job, at a fraction of the cost for hiring a Crane.

I then called Terry Mauldin at Kellett. I had been using various shore durometer pads by Kellett for removing vibration in many critical applications such as Concert Halls, Recording Studios and high end custom residential applications; so I was familiar with the product. I gathered the manufacturer's engineered data on the unit dimensions, weight and other information needed by Terry to insure that the specifically constructed pad material would be capable of isolating a high degree of the vibration transferred to the curb. After sending the data to Terry and conferring with both Terry and Rob several times, it was determined that a 50 durometer pad of 3/8" thickness could be manufactured to custom fit the curb and duct assemblies. This would require only a 2" lift to install. The electrics would have to be switched off during the installation process, but few (if any) other mechanical accommodations would be necessary to retro fit the engineered Kellett material beneath the two units. After a cost benefit analysis to determine the feasibility of the remedial work, we were instructed to proceed.

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According to Rob at Comfort System USA, Terry Mauldin at Kellett did a great job at providing support with the installation of the LP-13 Shake Absorber® pads. Rob sent Terry the submittal information of the packaged rooftop units and the existing roof curb. Terry provided a quote for the LP-13 Shake Absorber® pads that would correct the vibration and sound transfer problem. If the solution was an isolation curb, the cost would have been 4 times more expensive.

The installation consisted of elevating the units with timbers and bottle jacks, installing the pad on the existing curb, and lowering the units. Installing the pads on the curbs consisted of using a spray-on adhesive and applying the pads to the top edge of the curb. The installation took less than 2 hours per unit. Rob stated that, "As a design and building contractor, we would prefer to use a Kellett LP-13 Shake Absorber® rather than isolation curb. I believe that this provides a better value for our customer."

After the Installation was complete I visited the site to record some basic dosimetry. I utilized our IVEY IE33 Hand Held Sound Analysis Computer to record the noise at the identical location's used (directly under each unit, inside the interstitial space) when I recorded the noise complaint sample upon my initial visit to the site with Project Architect Jay Kirby several weeks prior. I photographed the screen shots of the noise levels before remediation. I did the same with the screen shots of recorded noise after the remediation. I normally save this data on my meter, but the memory was full, so I took digital photos of the readings with my phone at both visits to allow me to examine the results back in the office. Arriving back at my office later that day, I began to examine the before and after 1/3 octave data. What I saw confirmed immediately what was perceived on all on site; that the noise and vibration exhibited by the pair of roof top units was literally cut in half!

I began to examine the 1/3 octave data more closely, to determine exactly which frequencies had been reduced, and by how much. The findings were more than significant!

At 1K (1000Hz) the before reading was 44 dB. The after reading at1K (1000Hz) was 26 dB! This was a quantifiable net loss in the airborne noise directly resulting from vibration transfer through the solid roof curbs. This frequency was the most predominant frequency (bandwidth) perceived in the classroom directly below these 2 units, as tested on my before visit to the site. All the complaints about this noise seemed to center on the noise interfering with speech intelligibility in the classroom, and the teacher was ready to move out.

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After remediation with the LP-13 Shake Absorber® Pads, a net loss was produced of 18 dB of noise and vibration to the roof curbs at this frequency (1000 Hz). The classroom has been deemed "cured" and is now used.

My investigation did not stop there. I examined the net loss in other specific frequencies. 250 Hz read 52 dB before remediation. After remediation with Kellett's LP-13 Shake Absorber® pads, custom produced for this application, 250 Hz read 42 dB. Again, a quantifiable net loss of 10 dB. Anyone familiar with the 10 dB rule understands that this cuts the perceived sound in half.

It has been my experience that low frequencies are difficult to vibration isolate, even with the conventional (but time tested) wisdom of mechanical spring Isolation roof curbs.

Imagine my astonishment when I examined 125 Hz. The before reading was 65 dB. The reading taken after remediation was 44 dB. Even at this low frequency, a net loss of 21 dB was recorded. It would seem that performance was increasing in the lower frequencies!

Upon examining 63 Hz the before reading was 72 dB. The after reading was 52 dB at 63 Hz. This information gathered from the site before and after remediation confirmed the opinions of all involved in the project. This material has remarkable vibration isolation properties, which can be fine tuned to almost any kind of machinery that produces vibration, and the airborne noise associated with it. The material does indeed appear to act in isolating vibration and reducing airborne noise, utilizing specific physical properties of the material in combination, to produce this "dual action" material.

While I did not expect the material to eclipse the performance of the traditional spring isolation roof curb in this application because the nature of the task was remedial, it did, in fact, achieve better performance than the traditional spring isolation roof curb that had been eliminated via "value added engineering" or "cost cutting" early in the project. The costs were determined to be 25% of remedially installing a spring isolation roof curb. Based upon the acoustic performance, with the Kellett pad dealing with multiple frequencies and low frequencies well, not just single frequencies; I am convinced that this material (non metallic and unique in composite manufacture) has a much wider range of applications to which it can readily be designed and manufactured to isolate vibration and the noise resulting from it. I've utilized this material to isolate vibration in sensitive digital electronic equipment, large heat pumps, roof top exhaust fans, large air compressors and much more. My clients include hotels, commercial builders, multi-unit residential builders, theaters and performance venues and many

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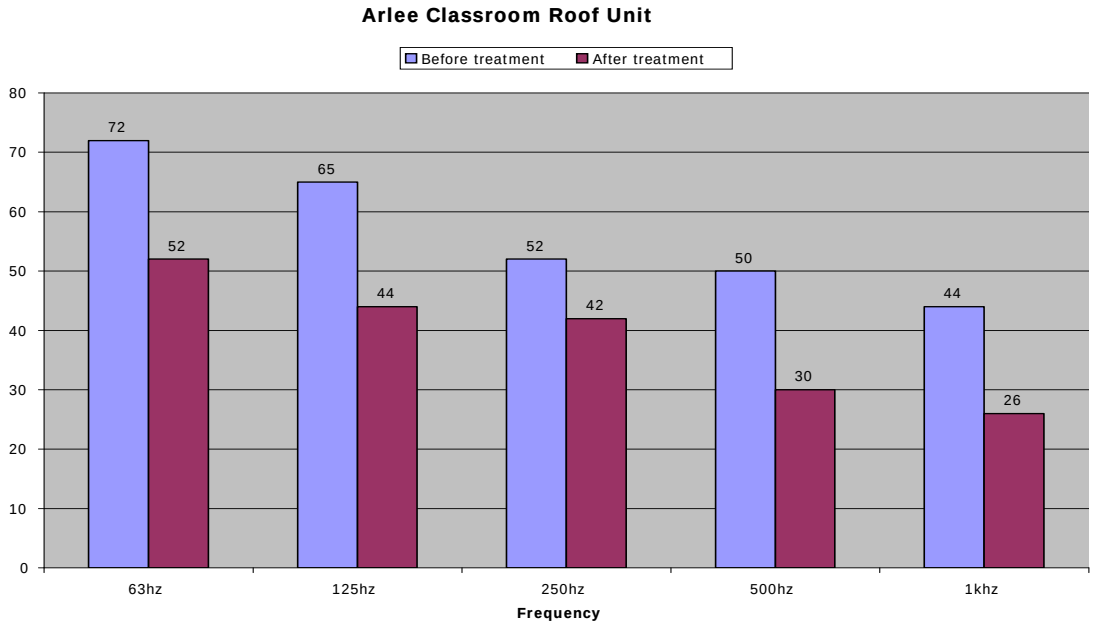
industrial manufacturers. All have one thing in common…. I've specified Kellett products in specifically engineered, custom designed applications for all of them.



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