

SAVIAC PAPER U-069 by Charles G. "Skip" Kahane
Kellett Ent.

Subject: VIBRATION & REMEDIATION OF ROOF TOP HEAT PUMPS utilizing customized
KELLETT LP-13 Shake Absorber Pad Isolators

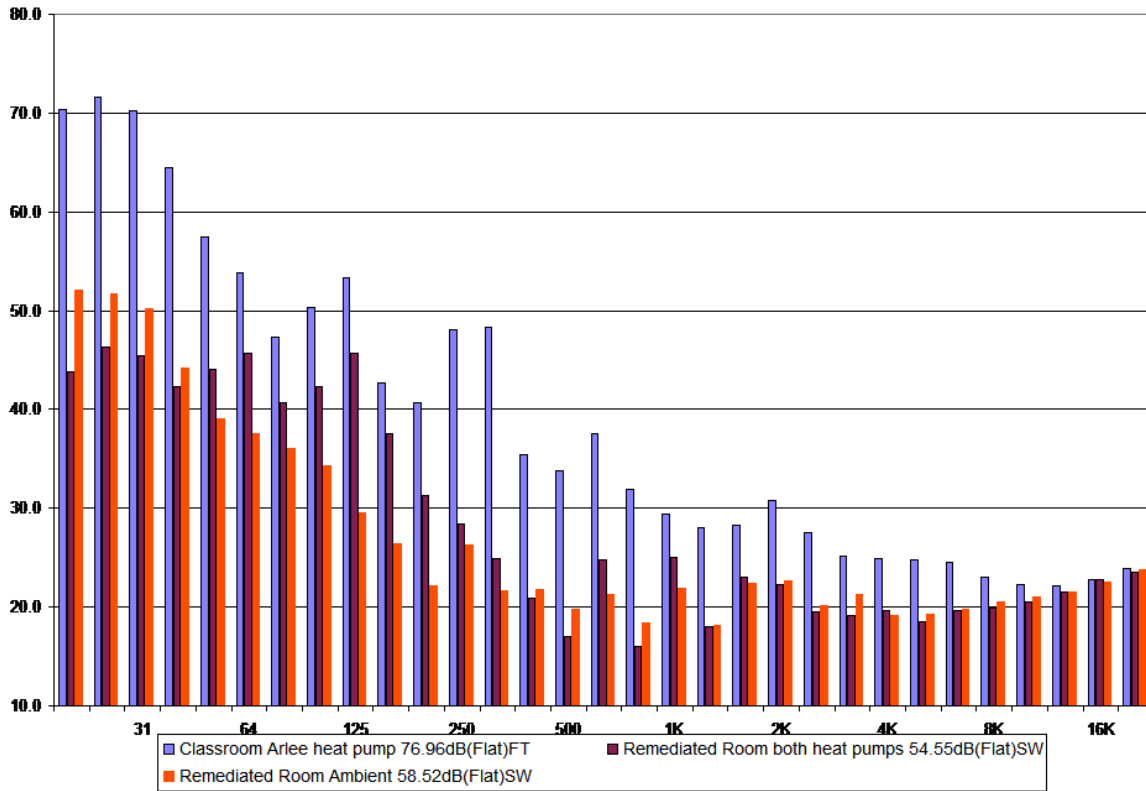
As owner of an engineering based business in Missoula, Montana for 20 years, one of the services we perform throughout the Pacific Northwest is Mechanical Noise & Vibration Control

My previous paper (presented @ last year's SAVIAC in Orlando) documented the Vibration Isolation performance achieved utilizing Kellett's unique Vibration Isolation Material. In the XLS from Site Dosimetry, I was able to achieve significant reduction in Vibration transfer using a Vibration Isolation Curb manufactured using Kellett's unique Flat Bed Laminate Composite. The reductions were so significant that the NEW CLASSROOM in the NEW SCHOOL BUILDING was pronounced useable. Imagine my dismay when 5 months & 3 weeks later, the Architect called me to tell me that the STRUCTURE-BORNE & AIRBORNE NOISE had returned, LOUDER THAN BEFORE! During this same period of around Six months, I had occasion to work with ROB SKILLICORN of COMFORT SYSTEMS USA in Missoula, Montana on another Roof Top HVAC System Application. This design was originally very similar to the 'value added engineering' design that had presented so many problems in Arlee (the subject of my paper last year), and Rob did not want to replicate the same VIBRATION. After a physical inspection of the ROOF TRUSSES he elected to suspend the 7,000 pounds of machinery on a STEEL RACK SYSTEM ABOVE the Roof, rather than ON the Roof. Again, the directive from Lewis & Clark School was clear: "If there is any excessive NOISE from Vibration, you've failed." Rob called me to ask if I felt the Kellett LP-13 Vibration Isolator could be utilized to insure that ALL Vibration from the 4 Units would be adequately deflected. I answered YES! We then turned over the machine data to Terry Mauldin @ Kellett, who performed the load calculations required to insure success. Rob's own Shop @ Temp Right COMFORT SYSTEMS USA (in Missoula, Montana) cut and fabricated the Kellett Flat Bed Laminate Composite in house, after receiving the correct material from Kellett. Every Mounting Point was isolated. In addition, the locations on the Building which were to bear the weight of the Rack Steel Flanges (to which the Racks were bolted) were isolated from the BUILDING using Kellett material correctly matched to the performance needs. Bolt Isolators were also fashioned from Kellett Material to effectively short circuit any transmission through the physical connections. The end result was: NO PERCEPTIBLE VIBRATION in the new Classrooms below, with 4 machines weighing over 7,000 pounds effectively VIBRATION ISOLATED above the roof.

Because this took place in the period where the ARLEE ROOF TOP VIBRATION REMEDIATION (originally the result of 'value added engineering') failed after what we thought was a success, when the request came from Jay Kirby (project Architect for the Arlee Schools) to revisit this project AGAIN in an attempt to find a working solution, I jumped @ the chance. With the success of the Roof Top Rack Mount System @ Lewis & Clark School, I felt we now had a plan! I gathered together the design work info on the Lewis & Clark Roof Top Rack Isolation & met with Jay. A short time later he called me to review his designs for the Rack System to be built to suspend the two Johnson J12BP single package heat pumps ABOVE the Roof of the affected classroom, effectively bypassing the now permanently deflected truss system. After quite a bit of investigation by several people, it was revealed that the Roof Trusses (a result of 'value added engineering') were underspecified for the weight of the two Johnson Units in close proximity. The 'value added engineering' had also been the cause of the original deletion of any Curb Isolation for the Johnson Units, which was later provided using a KELLETT CURB as detailed in last years' presentation. Once the Trusses deflected sufficiently, the loading points moved to several other locations in the interstitial space of the structure, effectively establishing multiple structural paths for the Vibration. Both the Architect & myself felt that it would be good to have TOM BEAUDETTE @ BCE Consulting Engineers review the structural details for the new rack installation, since some of the supports would be inside the building. Tom double checked all the attachment points scheduled for Isolation as well. All bolt holes for mounting the machinery were to be equipped with Kellett's proprietary BOLT ISOLATOR kit to eliminate any possibility of failure in this final remediation.

On September 15th the Arlee School Board approved the funding of the Remediation. Steel Fabrication began, based upon Principal Architect Jay Kirby's Roof Rack Design, incorporating correctly engineered KELLETT VIBRATION ISOLATION PADS. The design was thoroughly reviewed by Beaudette Consulting Engineers to be certain it met all structural requirements, prior to cutting the steel components. On Wednesday, September 21st I visited the Site of the Project to gather SITE DOSIMETRY of the Vibration & Air Borne Noise resultant from normal operation, prior to shutting down the units during the rack construction process. I wanted to determine how this truss deflection had affected the previous reductions over time. (Overhead image) I also wanted to determine if the NOISE LEVELS in the classroom below had increased over time. This would proffer a new baseline for measuring Vibration & Noise reductions after the new Rack Mounting System design was installed to the building and all systems were again operating.

Because a different Installer was providing the Steel Fabrication, relocation & re-ducting of the two J12BP Single package High Efficiency Heat pumps weighing 1197 pounds each (combined weight of 2,394 lbs.), I began communication with them to be certain they would correctly install the Kellett Vibration Isolation Pads & Bolt Isolators at the specified locations. Missing any Isolation point could easily short-circuit this remediation. The project Architect communicated these issues directly to the General Contractor. On October 25th, after the steel rack system was in place, the Architect called me from Site to confirm the weight of the two j12BP Units (each & combined) to verify once more that the Kellett Vibration Isolation Pads were correctly matched in durometer & PSI loading capability by Terry Mauldin, of Kellett. The Kellett Pads were placed in the assembly locations per my specs (confirmed by Beaudette Consulting Engineers) utilizing Kellett Bolt Isolator kits to short circuit any hard connections of the machines to the Rack Assembly. Correctly sized Kellett Vibration Isolation Pads had already been installed into the Rack Assembly, as well as pads installed between the piers and the vertical steel. The machinery was mounted to the Rack Assembly, lifting the 2,394 pounds off of the roof, and suspending it above the roof, on a completely Vibration isolated Rack. Specially constructed flexible boots were built to bridge the gap between the units & ducting. These were then insulated with R 10 Blue Board insulation (rated for Exterior use in Montana) and covered with epdm material that was held in place by non-hardening silicone caulk, thereby avoiding a hard connection between the J12BP Unit casement & curb and the Duct below, while ensuring a sealed insulated air path. As soon as the two Units were operational, I visited the site @ the request of the Architect to Record the Airborne Noise Levels in the Classroom below, for comparison with the previous Dosimetry. Everyone involved hoped to hear & SEE a significant enough REDUCTION in the previous Noise levels to consider the problem solved. The results (overlaid with the previous Noise Levels from original Site Dosimetry) are supplied here. Had we indeed solved the problem? After all, this WAS the final opportunity we would have to normalize the acoustics in this new classroom. I am happy to report that all is as it should be. The pencils don't visibly vibrate on the desks, and the ceiling & light fixtures no longer shake. Similar to the 'pilot project' (suspending 4 machines weighing 7,000 pounds) above Lewis & Clark School's new classroom addition) failure was not an option. By racking this equipment ABOVE the Building & ISOLATING every bearing point with Kellett Vibration Isolation Pads & Bolt Isolator Kits (for affixing the machinery) we had removed any structural path to the building which might translate into both Airborne & Structure-borne Noise &/or Vibration in the new classroom below. The Steel support Posts in the School Hallway were isolated Top & Bottom with correctly size Kellett Vibration Isolation bearing pads, and showed no trace of the Vibration previously detectable from 2,394 pounds of electro-mechanically coupled machinery. The final comparison of the BEFORE & AFTER printouts from the measurement of Air borne Noise resultant from the Vibration transferred through the roof speaks volumes.



064 Hz Reduced from 53 dB to 42 dB.

125 Hz Reduced from 52 dB to 33 dB.

250 Hz Reduced from 48 dB to 28 dB.

500 Hz Reduced from 30 dB to 20 dB.

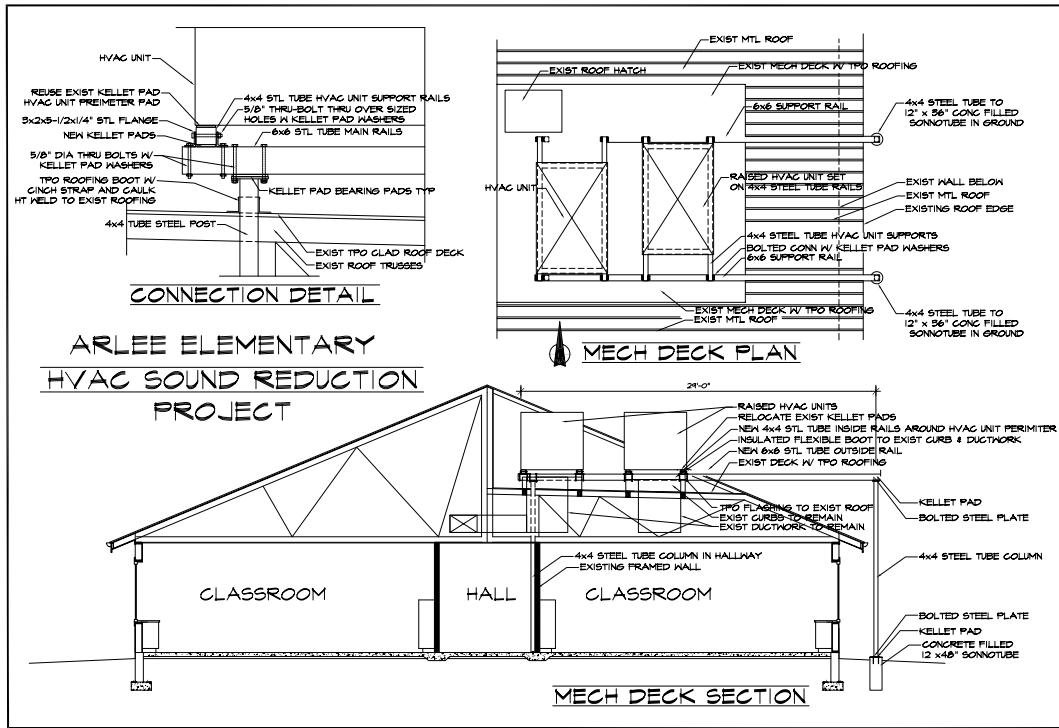
1 K Hz Reduced from 30 dB to 20 dB.

2 K Hz Reduced from 33 dB to 23 dB.



KELLETT Vibration Isolation Pads installed at multiple locations in Rack.

MECHANICAL DECK SECTION: Jay Kirby, Architect



**ARLEE ELEMENTARY
HVAC SOUND REDUCTION
PROJECT**

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