DIAGMAK – Vibration and Rotor Balancing Diagnostics

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REPORT

Report from dynamic measurements of the anti-vibration platform constructed by Pro Audio Bono

1. Methods of measurement

The goal of dynamic measurements of the anti-vibration platform constructed by Pro Audio Bono was to learn the dynamic abilities of the platform, describe the vibration characteristics of the platform as well as dynamic behavior in context of its application as support for audio-video equipment. The measurements were made in two stages.

Stage 1. Measuring the intrinsic vibration of the top shelf of the platform in three directions in the level and perpendicular, with different loads up to 103.0 lb, simulating the load with equipment. A method of forcing of the top shelf to vibrate in the level was used. This was achieved by moving the platform out of the resting position. For the perpendicular direction vibration was achieved using percussive force. Measurements were made utilizing the 400 Sensor Computer System and a piezoelectric sensor PCB/UM353 with a mass of 20.9 lb, mounted to the top shelf by a double adhesive tape.

Stage 2. Dynamic measurements with a test machine placed on the shelf of platform. The test machine was a grinder, with the two rotors out of balance, generating vibration (rotation speed 2960 rpm, mass of the machine 20.9 lb). During the experiment the magnitude of vibration – imbalance of rotors – was not changed. Without switching it off it was placed in various positions. The machine was equipped with three vibration sensors mounted to the enclosure of bearing. In addition the rotational speed was measured, to create run-out characteristics.

Furthermore a vibration profile of the support construction of the machine was made, in their characteristic points. Those measurements were made with constant revolutions of the machine – meaning the same level of excitation. Those measurements were made with the PCB/UM353 sensor.

2. Conclusions from measurements

To evaluate the dynamic support construction of the Pro Audio Bono anti-vibration platform the following assumptions were made:

- criterion 1 – in the audible frequency range audible (16 – 20000 Hz) there may be no intrinsic vibrations – self-resonances;
- criterion 2 – there is a good dynamic separation between the top shelf and plinth – and between the plinth and top shelf;
- criterion 3 – there is an isotropy of rigidness of vibration in the three directions of measurements: A, H, V, what results in practice in similar self-vibration values in all individual measurement directions.

2.1 From the 1st stage of dynamic measurements, we see low values of self-resonance (4 Hz) of the top shelf in level directions (horizontal). So criterion 1 is met. The differences in self-vibration for the two measurement directions (3.75 Hz and 4.00 Hz) – measurement without load, are acceptable. The rigidness of support in level are isotropic. Criterion 3 is met. The self-resonance in perpendicular direction (vertical) of the unloaded shelf is 14 Hz, much higher than the rigidness measured in the horizontal directions. The rigidness in vertical direction of the support is anisotropic with regard to the one measured in the horizontal directions. So criterion 3 in not met in this case. However we have to add, that the frequency of the vertical vibration of the top shelf is lower than the lower border of the audible frequency spectrum. So we can assume, that the vibration in that direction will not limit the very good anti-vibration capabilities of the Pro Audio Bono anti-vibration platform, when used while reproducing sound or vision.

Loading the platform with the test mass of 10 kg the top of resonance lies at 14 Hz, while the resonance range between 10 and 16 Hz (for a platform placed on top of a table). Placing it atop an anti-vibration rack there values are respectively: 17 Hz and 15-18 Hz. Those results are on the border of criterion 1. We have to add, that increasing the load moves the resonances lower, what has a positive effect on moving them away from the audible spectrum (16-20000 Hz).

For the measurement horizontal direction, when loaded with a mass of 103.0 lb, the resonance vibration lowered from 3.75 to 2.50 Hz.

2.2 During the measurements the rigidness of support of the test machine was changed, and influence of that fact was observed on dynamics. The level of dynamic excitations was the same in different parts of the measurement, this is the reason, that only changes in the rigidness of support are the cause for the changes in vibration. Vibration in vertical direction at constant rotation speed of 2960 rpm and rigid support are 0.73”/s (measurement 1) and for example 0.36”/s when placing the machine on the platform (measurement 2) and 0.24”/s when placing it on springs (measurement 5). **This means, that the means of supporting the machine has substantial influence on magnitude of vibration and appearance of critical frequencies – resonance frequencies.**
The resonances are mainly depending on the rigidness of the support for the machine. High vibration magnitude of the machine in vertical direction – 0.73”/s when placed on ceramic floor (measurement 1) are the result of resonances of the support and artificial increase of the vibration in that direction, the peak of resonating frequencies is at 2600 rpm, while the rotation speed of the rotors is at 2960 rpm, so it is well within the resonance. Using the PAB anti-vibration platform (measurement 2) decreased the rigidity of the support for the machine and resulted in lowering the resonance frequency from 2600 to 1150 rpm and shifting it away from the normal operating speed, hence lowering of the dynamics of the vibration. Placing the machine on the platform resulted in no resonances in the horizontal direction, what means, that it shifted below the lower border of measurement.
From measurements of the platform placed on anti-vibration feet in variant 1 and 2, it turns out that the resonances in direction V (1780 and 1660 rpm) are higher than for the platform alone. This result allows to deduce, that the rigidness of support on the anti-vibration feet is higher than on the platform, and hence it is the less preferred way of support. It is however worth noticing, that the resonances in vertical direction are about 40% lower, than those achieved on rigid support). The frequency difference between variant 1 and 2 is also significant.

2.3 To verify the proper dynamic separation of the top shelf and the plinth, profiles of vibration were made for them. The shelf of PAB anti-vibration platform were induced to vibrate using the test machine and then measurements were made in characteristic construction points of the platform. From the analysis it is visible, that vibration of the plinth in horizontal directions are low (around 0.02”/s) and do not differ much from the background vibration taken from the floor. So we can conclude, that the PAB platform has very good separation in the horizontal directions. For those directions all the vibration induced by the test machine is nullified in the supporting wires. However for the vertical direction, the vibration is transferred from the shelf to the plinth and vice versa. So we have to assume, that in the tested unit the vertical direction has worse separation. However taking into account, that in listening rooms and home cinema rooms (where the platform will be used most often) horizontal vibration is predominant, related mostly to vibration caused by speaker systems, higher vertical vibration (still on the verge of the sound spectrum) are harmless and lower the usability of the platform in an insignificant way.

3. Recommendations
Based on the vibration dynamics measurements of the Pro Audio Bono anti-vibration platform we can recommend their constructors to test new solutions and materials, that would lower the vertical self-resonances of this product and improve the separation capabilities. Measurements using the test machine show, that it would be best to use springs with appropriate rigidity. However practice – experience of the manufacturer shows, that in listening rooms, where vibration is related to the work of speakers, they would be always stimulated resulting in wow and flutter. In that case we could recommend to rework the platform to include more layers of different vibration damping materials like rubber, teflon, felt or small rubber balls. Those should be sufficient to reduce vibration by about a half (down to 6-7 Hz) so placing them well outside the audible frequency spectrum and improving the separation capabilities of the platform.