Vibration Attenuation Effectiveness of Foam Sandwich Enclosure

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Various foam materials and cargo bags are used to attenuate vibration transmitted to orbital replacement units to assure that International Space Station's (ISS's) orbital replacement units can successfully sustain launch environments when they are directly attached to the spacecraft structure, as is often done for the Progress, Soyuz, and other visiting vehicle launches. One such attenuation scheme is the foam sandwich "clamshell" box (figure 1), comprising stiff-soft-stiff foam materials. This box was designed specifically to carry the Recycle Filter Tank Assembly (RFTA) orbital replacement units to the ISS.

Fig. 1. *Recycle Filter Tank Assembly trainer in foam sandwich "clamshell" box, sandwich wall comprising stiff-soft-stiff foam materials, and clamshell strapped to test plate on shaker table.*

NASA performed a number of random vibration tests on the RFTA trainer and the RFTA flight unit #5 to verify the vibration attenuation effectiveness of the clamshell enclosure design. The trainer and the flight unit were both tested to the ISS workmanship vibration environment while hard-mounted to the shaker table. The trainer was also tested to both the ISS workmanship environment and the Space Shuttle Program 50835 Common Interface Requirements Document environment while isolated inside the clamshell enclosure strapped to the shaker table. This environment envelopes the internal volume stowage vibration environments of all the currently defined visiting vehicles.

For comparison, NASA obtained measured data predictions of isolated trainer response by multiplying the hard-mounted trainer response spectra by the attenuation functions developed from foam sample vibration test data. A similar analytical approach was used to predict the isolated response of the flight unit. While it would have been desirable, for research purposes, to have tested the flight unit in the foam sandwich clamshell, this was not deemed necessary for flight certification purposes due to the reasonable agreements obtained between isolated measurements and predictions for the trainer.

Conclusions

Recycle Filter Tank Assembly Tests

- The conclusions listed below were drawn from the random vibration tests.
- Measured response levels of the hard-mounted flight unit are lower than those of the hard-mounted trainer.
- Clamshell isolated RFTA responses are considerably attenuated over the hard-mounted responses for flexible body modes above 40 Hz (figure 2).
- Amplification at low frequencies is caused by resonance of the RFTA rigid body mass on the foam spring system, and hence is not a problem.
- Attenuation functions for the foam sandwich clamshell, as developed from measured foam sample attenuation data, provide good estimates of the measured clamshell attenuation functions.
- Multiplying hard-mounted trainer test data by the predicted attenuation functions yields reasonable predictions for the foam clamshell attenuated trainer response (figure 2).
- Multiplying hard-mounted flight unit test data by the predicted attenuation functions yields reasonable estimates of foam clamshell attenuated flight unit response (figure 3).

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continued

Comparison with Progress Vehicle Requirements

Results of random vibration tests conducted on the RFTA were compared against Progress vehicle requirements. Findings are:

- The foam-sandwich clamshell box and strap isolation system will attenuate the Progress vehicle random vibration excitation by a factor of 100 at the RFTA's 95 Hz first resonance frequency and by much greater factors at higher frequencies.
- Hence, the RFTA is verified to meet the Progress vehicle random vibration requirements. Further vibration testing of the RFTA and its foam-sandwich isolation box and strap system is not needed.

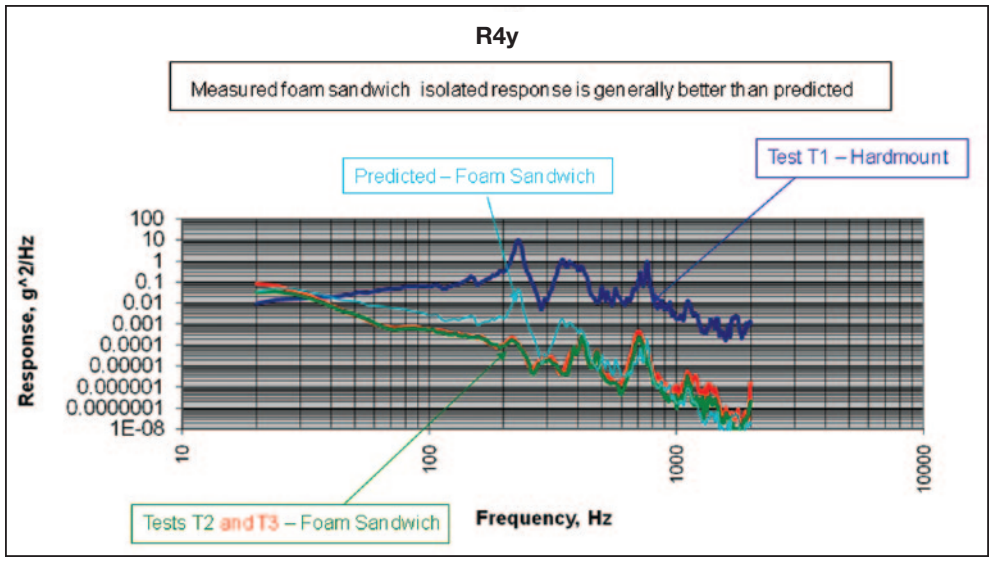

Fig. 2. *Comparison of measured hard-mounted response, measured clamshell isolated responses, and predicted clamshell isolated response (from measured foam sample attenuation data). Note: label R4Y denotes the Y direction response accelerometer at measurement location 4.*

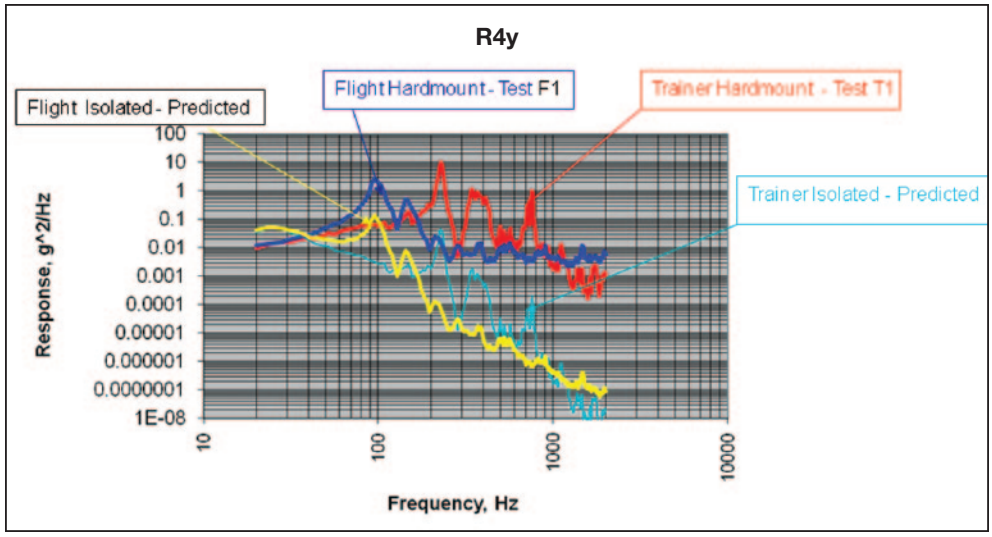

Fig. 3. *Comparison of Recycle Filter Tank Assembly trainer and flight unit responses as measured in hard-mounted configuration and predicted for foam clamshell configuration using measured foam isolation data. Note: label R4Y denotes the Y direction response accelerometer at measurement location 4.*