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EVALUATION OF MATERIALS FOR SOUND TRANSMISSION LOSS

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1. INTRODUCTION

Automotive acoustical insulation material is typically tested using either ASTM E 90 or SAE J1400. Both standards use acoustic excitation sources to measure sound transmission loss (STL) of a material or composite. If structurally transmitted vibrations are the primary excitation of the panel to be treated it may be instead advisable to use a different method. Structural excitation of the test sample can yield information on damping provided by the insulator as well as insulation properties.

2. EFFECTS OF SOURCE SIDE AND RECEIVER SIDE TREATMENTS

Figure 1 shows results of STL testing according to SAE J1400 for various insulator configurations. The dimensions and densities of materials used are typical of what is commonly used in automotive noise control. The sheet metal test sample was treated on the source side, receiver side or both. As expected, the addition of a source side insulator increases sound transmission loss significantly [1]. None of the decoupler/barrier combinations tested perform significantly better than plain sheet metal below 250 Hz. Structurally transmitted vibrations from the engine, however, tend to be concentrated more in this lower frequency region.

Figure 2 shows the corresponding acceleration spectra of the source side and receiver side surfaces. One remarkable characteristic of this figure is the fact that the acceleration of the source side of the metal/ foam/barrier configuration is higher than that of the metal alone condition above 250 Hz, yet lower below 250 Hz. The following abbreviations are used in the legend in figure 2: "M" - metal panel; "M/B" - metal panel plus PVC barrier layer; "M/F/B" - metal panel plus foam/PVC insulator;

"B/F/M/F/B" - metal panel with insulators on both source and receiver sides.

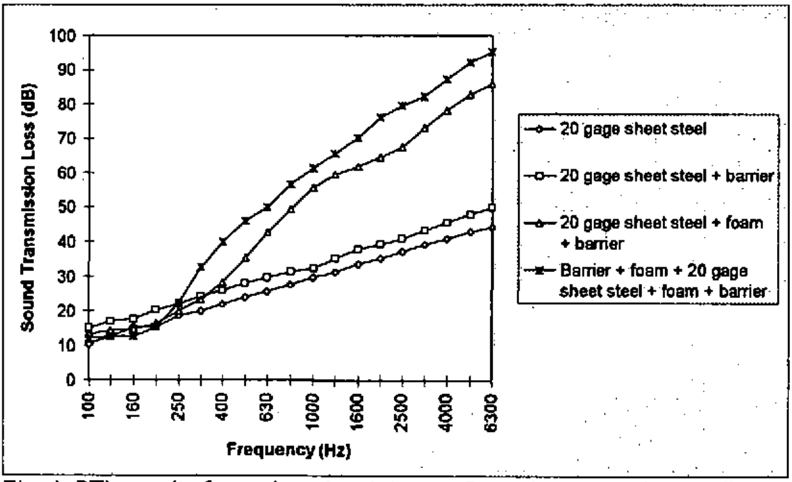

Fig. 1. STL results for various insulator configurations tested according to SAE J1400

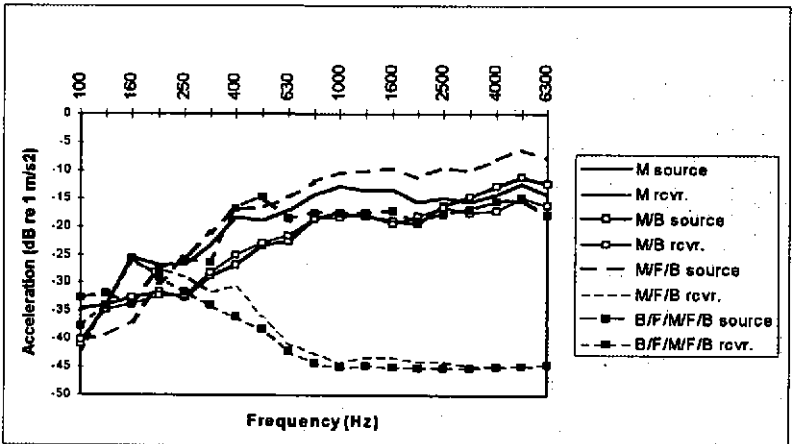

Fig. 2. Source and receiver side test panel acceleration levels during SAE J1400 test

The "B/F/M/F/B" (barrier/foam/metal/foam/barrier) construction could reasonably be chosen as the best performer overall. However, the fact that barrier alone on sheet metal outperforms any decoupler/barrier insulator below 250 Hz could be even more important if the engine noise is primarily low frequency and/or structurally transmitted via the engine mounts.

Also, structurally transmitted energy which is radiated by a panel will not be affected by the sound transmission loss of an insulator on the opposite side of the panel. This insulator may, however, provide some damping to the panel. This can be quantified but cannot be interpreted as being equivalent to acoustic insulator or barrier performance.

3. VIBRATION TESTING OF INSULATORS AND BARRIERS

A device designed to structurally excite sheet metal panels was used to evaluate insulator performance in attenuating radiated sound and in providing additional damping to the sheet metal test panel. This device connects a mechanical shaker rigidly to a frame clamped to the perimeter of the test panel. Figure 3 shows transfer functions of radiated sound to panel input acceleration.

The single most interesting aspect of figure 3 is that the barrier/metal condition shows measurable reductions in this transfer function even though the barrier layer was mounted on the side of the test panel opposite the microphone. Damping must then be playing a role and should be measured. To avoid problems associated with analyzer filter response times, an alternative to the traditional decay time method of loss factor computation was used.

Power Injection Method

The damping loss factors of different insulator combinations were determined on the structural test fixture using the power injection method, or PIM [2]. The loss factor is defined as the frequency-weighted ratio of vibrational power dissipated in the structure to vibrational strain energy of the structure. This ratio can be estimated from measurements of point and transfer mobilities, from which the loss factor is computed.

Figure 4 shows measured frequency-dependent loss factors for several insulator configurations. Note that not only the barrier layer in contact with the sheet metal but also the foam/barrier insulator provide measurable increases in damping to the test panel, indicating that some of the noise reduction of a standard decoupler/heavy layer insulator is due to the damping it adds to the panel.

4. ACKNOWLEDGMENTS

The author is extremely grateful to Gary Kritcher and Mark ZumMallen of Masland Industries for their invaluable assistance in providing STL data and in construction of the structural testing fixture, respectively.

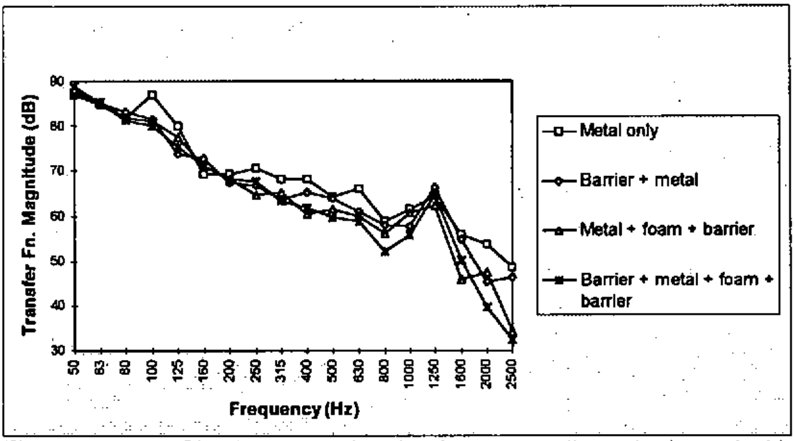

Fig. 3. Radiated SPL/frame acceleration for structurally excited panel with various insulator configurations

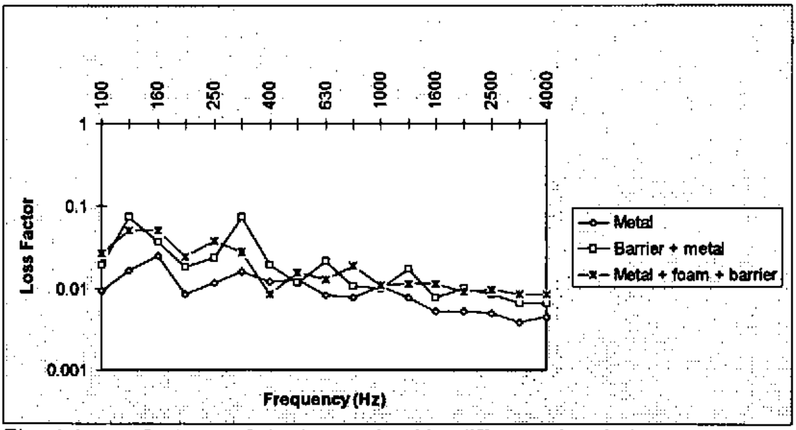

Fig. 4. Loss factors of test panel with different insulation treatments computed according to power injection method

5. REFERENCES

[1] F. Fahy, Sound and Structural Vibration (Academic Press, London, 1985).
[2] J. Plunt, 'The Power Injection Method for Vibration Damping Determination of Body Panels with Applied Damping Treatments and Trim', SAE, 911085 (1991).