inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 4.7

AN EXPERIMENTAL STUDY OF VIBRATION DAMPING PROPERTIES OF RUBBER LAMINATE MATERIAL IN AN AUTOMOTIVE APPLICATION

A. Norberg

Trelleborg Rubore, Box 860, S-39128, Kalmar, Sweden

Tel.: +46 480 499427 / Fax: +46 480 499494 / Email: arvid.norberg@trelleborg.com

Keywords:
DAMPING, LAMINATE, NOISE, VIBRATION

ABSTRACT
An experimental study of vibration- and noise damping properties of a sheet metal oil pan made of a new rubber-laminate material is presented. Frequency response functions for mechanical excitation has been measured and loss factor was derived from modal parameters. Sound radiation for airborne sound excitation and mechanical excitation applied to oil pans, made of Duru-Lam and undamped steel respectively and mounted with realistic boundary conditions are presented and compared.

1 - INTRODUCTION
Steel-rubber-steel laminates, designed for noise and vibration reduction through vibration damping are developed and marketed by Trelleborg Rubore AB as Duru-Lam. This report presents the results of measurements made to verify the noise damping properties of an oil pan made of Duru-Lam.

Definition of quantities
Loss factor, η. The damping loss factor is defined [1] as

$$\eta = \frac{\Pi_{diss}}{2\pi f E_{stored}}$$

where

- Π_{diss} is the dissipated vibration power [W] by the component
- E_{stored} is the maximum stored vibration energy [J] in the component
- f is the frequency [Hz]

Radiated sound intensity level, L_I. The level of sound intensity I [W/m^2] radiated by a surface element of a sound source. The level is defined as

$$L_I = 10\log\left(\frac{I}{I_{ref}}\right)\ \text{dB},\ \text{where}\ I_{ref} = 10^{-12}\text{W/m}^2$$

Radiated sound power level, L_w. The level of sound power Π [W] radiated by a surface of a sound source. The sound power is obtained (for measurements reported here) as $\Pi = I \cdot S$ for each surface of interest, where S is the surface area.

$$L_w = 10\log\left(\frac{\Pi}{\Pi_{ref}}\right)\ \text{dB},\ \text{where}\ \Pi_{ref} = 10^{-12}\text{W}$$

The total radiated sound power of the source is obtained from the sum of the sound powers of the individual partial surfaces.

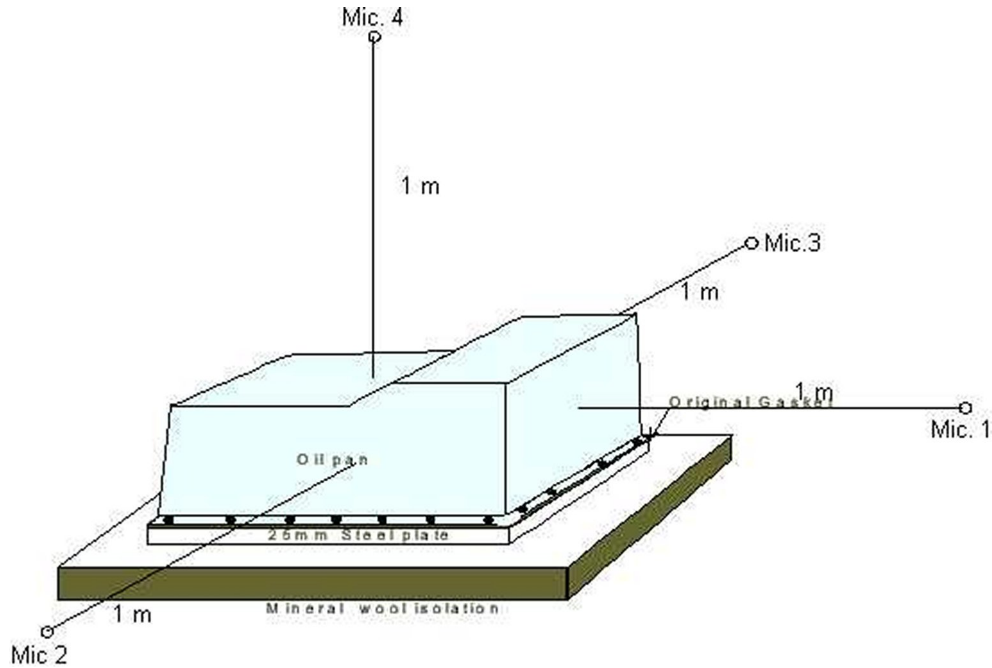

Figure 1: Sketch of the measurement arrangement for the mounted oil pan.

2 - MEASUREMENTS AND MEASUREMENT METHODS

A typical oil pan for a 1,6L 4-cyl diesel engine has been mounted, using its own gasket and mounting bolts, to a 25 mm steel plate, see Figure 1. This is estimated to represent a reasonably realistic laboratory boundary condition to simulate the influence on damping from mounting the oil pan to a stiff engine block. The pan and the steel plate are resiliently supported on a mineral wool slab. All measurements have been performed for a pan made of both Duru-Lam and undamped steel sheet.

Mechanical excitation. The inertance transfer functions have been measured between 10 response positions and both exciter positions. Radiated sound intensity has also been measured in $1/3^{rd}$-octave bands for the five principal surfaces of the oil pan and both excitation positions. Radiated sound power levels have been calculated from these intensity measurements. Loss factors for the two mounted oil-pans have been determined from the inertance functions, using modal analysis as well as PIM-calculations.

Acoustical excitation. The sound pressure levels at 3 microphone positions inside the oil pan and 4 positions outside the oil pan at 1 m distance have been measured. Data in $1/3^{rd}$-octave bands for one loudspeaker excitation has been determined. In addition, the radiated sound intensity has been measured in $1/3^{rd}$-octave bands for the five principal surfaces (bottom, front, back and sides) of the oil pan. Radiated sound power levels have thereafter been calculated from these intensity measurements.

3 - RESULT

Loss factors for the individual modes in a frequency range up to about 1200 Hz (low modal overlap) has been estimated by modal analysis curve fitting, see Figure 2. The radiated sound power levels measured by sound intensity in $1/3^{rd}$-octave bands, the improved airborne sound isolation of the Duru-Lam oil pan is illustrated by Figure 3.

4 - SUMMARY AND CONCLUSIONS

The results show that the internal vibration damping of thin steel-sheet components can be increased considerably by using Duru-Lam. The composite loss factors to be expected for the laminates are typically in the 10-15 % range, and somewhat higher above 1 kHz. The radiated noise from the mounted oil pan was reduced typically by 5 dB when using the Duru-Lam. Considering that the adhesion (bonding) strength of the Duru-Lam products is superior, an overall comparison may well be in favour of Duru-Lam in many practical situations. For applications where delamination problems occur today or where delamination risk has made the use of sandwich damping impossible, Duru-Lam offer new possibilities. However, a further optimisation in detail of the loss factor for the laminates should be carried out. It will be an essential competitive edge to be able to maximise the achievable loss factor without sacrificing any

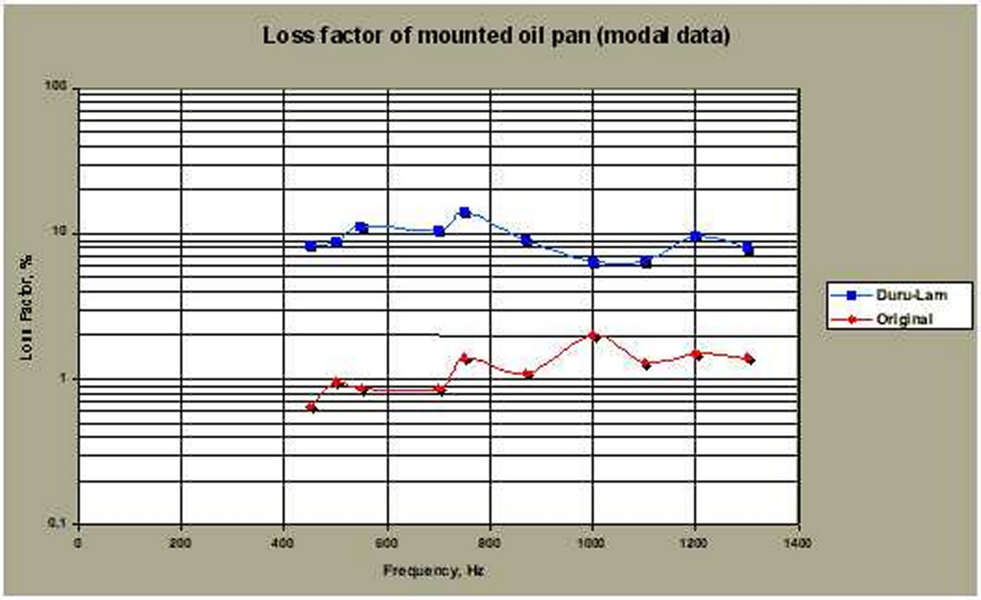

Figure 2: Loss factor for the oil pan made of Duru-Lam compared to undamped oil pan.

or too much of the adhesion strength. It is also essential to develop a range of laminates using rubbers with glass transition regions at higher temperatures.

ACKNOWLEDGEMENTS
Measurements was carried out by Ramin Gahlehie, Ingemansson Automotive AB.

REFERENCES

1. **Nashif A, et al**, *Vibration Damping*, J Wiley&Sons, 1985

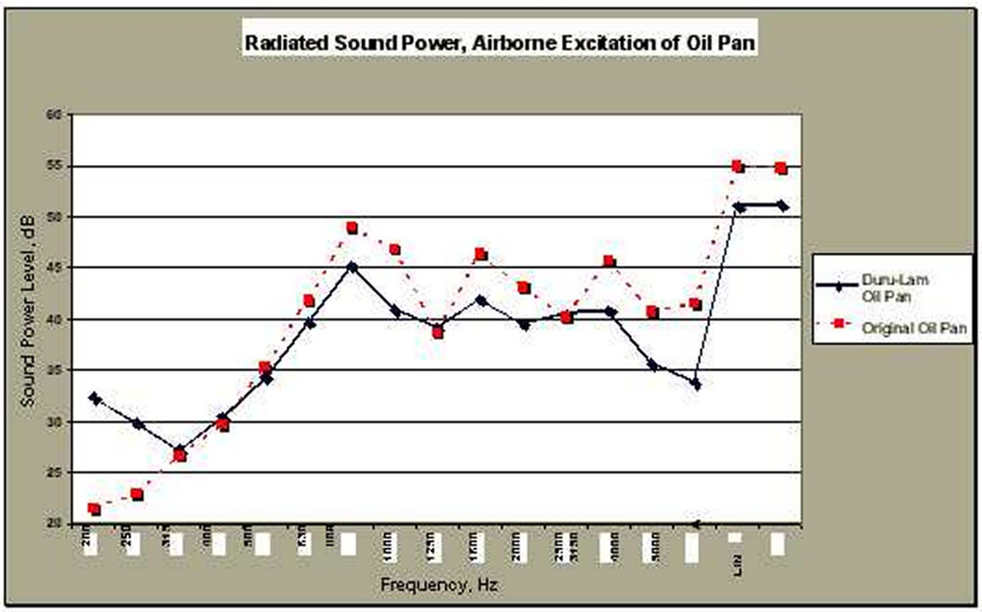

Figure 3: Radiated sound power level with airborne sound excitation for the oil pan made of Duru-Lam compared to undamped oil pan.