

 <b>SURFACE VEHICLE RECOMMENDED PRACTICE</b>	<b>SAE</b> <b>J3001 FEB2011</b>
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Brake Insulator Damping Measurement Procedure	

## RATIONALE

Brake pad insulators are a primary device used in the control of brake squeal for passenger cars throughout the world. Each insulator damping is tuned for a specific application. Because there is currently no recognized standard for measuring insulator damping, the SAE Brake NVH Standards Committee identified the need to establish a measurement standard that would allow one to accurately and consistently measure insulator damping.

### 1. SCOPE

This procedure is applicable to modes between 1500 and 15 000 Hz. The parameters measured with this procedure are defined as the damping factor,  $\xi$  for first three bending modes of the beam. The procedure will focus on bending modes only.

#### 1.1 Purpose

This SAE Recommended Practice is intended to establish a standardized and repeatable method for performing damping measurements on a brake insulator.

### 2. REFERENCES

#### 2.1 Related Publications

The following publications are provided for information purposes and are not a required part of this SAE Technical Report.

D. J. Ewins, Modal Testing - Theory, Practice and Application, Second Edition, 2000, Research Studies Press LTD, England

B&K Technical Review n°1, 1994: "Digital Filter Techniques vs. FFT Techniques for Damping Measurements", Svend Gade & Henrik Herlufsen

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### 3. GLOSSARY AND TERMINOLOGY

#### 3.1 RESONANCE (NATURAL) FREQUENCY

One of the frequencies at which the beam naturally vibrates at when excited in a free-free condition.

#### 3.2 LOSS FACTOR

The energy loss factor,  $\eta$ , which is the percent critical damping divided by 50.

#### 3.3 DAMPING

It is generally expressed as a percentage of critical damping. The damping ratio in % is given by:  $\xi = 50 \times \eta$ .

### 4. ORGANIZATION OF THIS DOCUMENT

The first step is to define the basic measurement configuration and the measurement requirements.

### 5. MEASUREMENT REQUIREMENTS

- Excitation:
  - An electro-magnetic non-contact exciter is the preferred method of excitation. Other methods of excitation such as a hammer may be used with proper care and documentation of equivalent results.
- Response:
  - Typically an accelerometer will be used to measure the response. A single point laser vibrometer or a microphone can also be used. If a transducer other than an accelerometer is used, a comparison test shall be run to show equivalence. The weight of the accelerometer should be less than 1 g.
  - The recommended accelerometer is one with an integrated amplifier or a charge type.
  - Frequency response from 500 to 16 000 Hz  $\pm$  3 dB.
- Dual-channel FFT analyzer capable of calculating a frequency response function (FRF) and simple coherence.

## 6. TEST CONFIGURATION

The preferred measurement setup is shown in Figure 1. This configuration shows the use of an accelerometer for the response measurement and a non-contact exciter for the excitation.

Figure 1 shows the suggested measurement configuration.

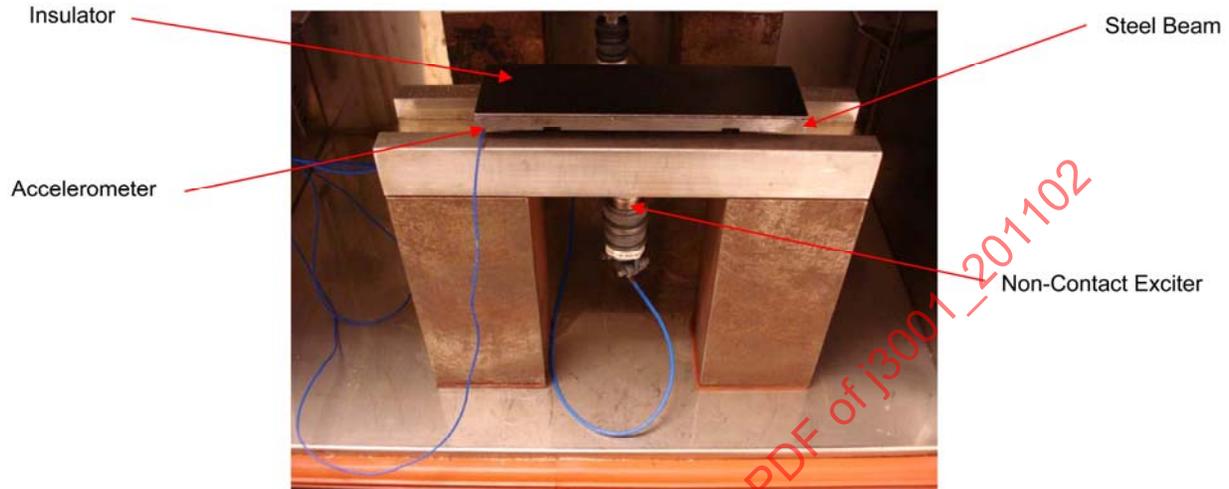


FIGURE 1 - BRAKE PAD INSULATOR DAMPING MEASUREMENT SETUP

## 7. OPERATION

The measurement will be on a standardized steel beam (O-1 Oil Hardening Cold Work Tool Steel, ASTM A681, SAE J437/438 or DIN1.2510), 130\*38\*6 mm. The 1<sup>st</sup> 3 bending modes will be located around 1900, 5100, and 9900 Hz.

The brake insulator will be bonded to the steel beam according to the insulator manufacturer's bonding guidelines.

The accelerometer will be bonded to the steel beam using a thin layer of Loctite 4203 adhesive. The position of the accelerometer and its cable are indicated on Figures 1 and 2.

The beam will be located on silicone rubber mounts.

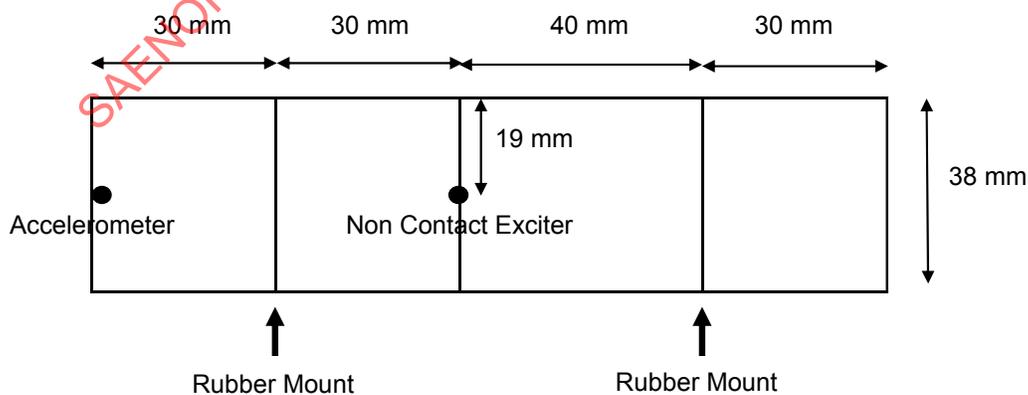


FIGURE 2 - LOCATION OF EXCITER, ACCELEROMETER AND RUBBER MOUNTS

Connect the exciter to channel 1 and the accelerometer to channel 2 of the analyzer.

Prepare the analyzer for data acquisition and analysis according to the following:

- Analyzer frequency range from 1500 to 15 000 Hz
- Excitation will be "Chirp" (1500 to 15 000 Hz,  $1/\Delta f$  duration)
- 24 averages minimum, free run
- The maximum value of frequency resolution should be 1 Hz
- Hanning window shall be used for the exciter and the accelerometer
- Setup the exciter level to get good FRF, with minimum noise and clear peaks (Figure 3)
- Record the analyzer setup

It is important to adjust the analyzer so that the FRF between the accelerometer and the exciter and the coherence function are both displayed as shown in Figure 3.

The analyzer should be configured to average the results of the multiple acquisitions to obtain a high quality signal. The quality of the signal will be judged by the computed coherence. Reject the measurement if the coherence is below 0.95 for the resonances.

Identify the 3 resonance frequencies on the FRF (Figure 3). The loss factor for each natural frequency shall be measured using the half-power or 3 dB method. The loss factor is defined by  $\eta = \frac{\Delta f}{f}$  where  $\Delta f$  is the frequency bandwidth at 3 dB below the resonant peak and  $f$  is the resonant peak frequency. The damping ratio in % is then given by  $\xi = 50 \times \eta$ .

Some analyzers have a function which gives you the damping ratio  $\xi$  in %, by placing the screen cursor on the resonance peak. A more sophisticated technique can also be used; single degree of freedom identification method.

