



2022-038.1R  
April 18, 2022

Dipl.-Ing. Denis Blanchet  
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Subject: **Results of Oberst Bar Vibration Damping Test of One Bar**  
dBVibroAcoustics s.r.o. Purchase Order No. 20220321-1A  
Kolano and Saha Engineers, Inc. Project No. 2022-038.1

Dear Mr. Blanchet:

At your request, Kolano and Saha Engineers, Inc. (K&SE) conducted an Oberst bar damping test to evaluate the damping performance of one constrained layer beam that you provided. The scope of the study was to determine the material properties of the viscoelastic material (VEM) that include the material loss factor and the shear modulus of the VEM. The loss factor is the modal loss factor.

This report includes the following:

- Letter
- Figure 1
- Tables 1 and 2
- Exhibit 1A

### **Test Sample**

One viscoelastic material (VEM) was sandwiched between two 1 mm thick steel bars to form a constrained layer configuration. In this report a sandwiched beam is identified as a constrained layer construction. The VEM that was tested is:

#### **Manufacturer Data**

<b><u>Sample No.</u></b>	<b><u>Sample Description</u></b>	<b><u>Thickness (mm)</u></b>	<b><u>Density (kg/m<sup>3</sup>)</u></b>
S1	Damping Rubber #3 (19+31)	0.1945	1310

Measured thickness and surface density information is provided for the VEM only i.e., without steel bars and for “information purposes only”.

### **Test Method and Measurements**

Measurements were made in accordance with SAE Standard J1637 Feb22, “*Laboratory Measurement of the Composite Vibration Damping Properties of Materials on a Supporting Steel Bar*”, as much as possible. However, the bar size and the test temperatures were different from what is mentioned in the standard. Kolano and Saha Engineers, Inc. is accredited by ANSI National Accreditation Board (ANAB) to perform this test per ISO/IEC 17025.

The nominal dimensions of the steel bars were: total length 290 mm, mounted free length 254 mm, thickness 1 mm, and width 20 mm. The VEM was bonded in between two steel bars (from just after

the clamping area to the free end). The gap between the two steel bars in the clamping area was filled by filler materials such as steel shim stock. This prevented putting any clamping force on the VEM so the measurements can be done properly. The test bar was prepared by the VEM manufacturer Trelleborg Sealing Solutions Kalmar AB. dBVibroAcoustics sent the bar to K&SE for measurements. Figure 1 shows a schematic of a typical test bar. The test bar was tested at three different temperatures. These were 20°C, 50°C, and 100°C.

Tests were made on a K&STLE DAMP® fixture to measure various modes of vibration that were generally between 100 Hz and 1000 Hz for each test bar using a random signal. The resonant frequency and the half power bandwidth frequency (frequency difference between 3 dB downpoints from the resonant peak where possible) of each mode needed for composite loss factor ( $\eta_c$ ) computation was read directly from the K&STLE DAMP® automated system developed through MATLAB. A complete description and calibration records of the instrumentation used are on file with K&SE. In testing between two consecutive temperatures (i.e., between 20°C and 50°C; and between 50°C and 100°C), the bar was kept in the temperature chamber for 90 minutes. It took approximately 60 minutes to transition from one temperature to another, allowing for approximately 30 minutes to be conditioned (soaked) at that temperature before measurements.

The precision of measurement by this method, based on 95% confidence limit, is greater than sample to sample variation. The repeatability of tests made of identical samples at K&SE is expected to be within the coefficient of variation of 20%, as mentioned in the SAE Standard.

## **Results**

The measured composite loss factor results of the VEM, under constrained layer configuration, are presented in tabular form in Table 1. The computed material loss factor and material shear modulus values have also been presented in this table. Computation of material properties were based on Equations 8 and 9 of ASTM standard E756-05 (Reapproved 2017), where the bare bar information was obtained from theory using Equation 2 of the ASTM standard and using 7850 kg/m<sup>3</sup> as the density of steel. The equations for computing the material properties are also provided in Table 2.

Table 1 also provide the interpolated values for composite loss factor, material loss factor, and material shear modulus. These values are computed at 200 Hz, 400 Hz, 600 Hz, and 800 Hz for each temperature. These values are based on linear interpolation of two sets of data points where the frequency and the loss factor/modulus information are provided in a logarithmic scale, per Equation 3 in the SAE J1637. The composite loss factor values at different temperatures are also presented graphically in Exhibit 1A.

Mr. Blanchet, we appreciate this opportunity to be of service to dBVibroAcoustics s.r.o. Please contact us should you have any questions. We look forward to working together again.

Sincerely,

**KOLANO AND SAHA ENGINEERS, INC.**



Codi Anderson  
**Associate Project Engineer**

Reviewed by

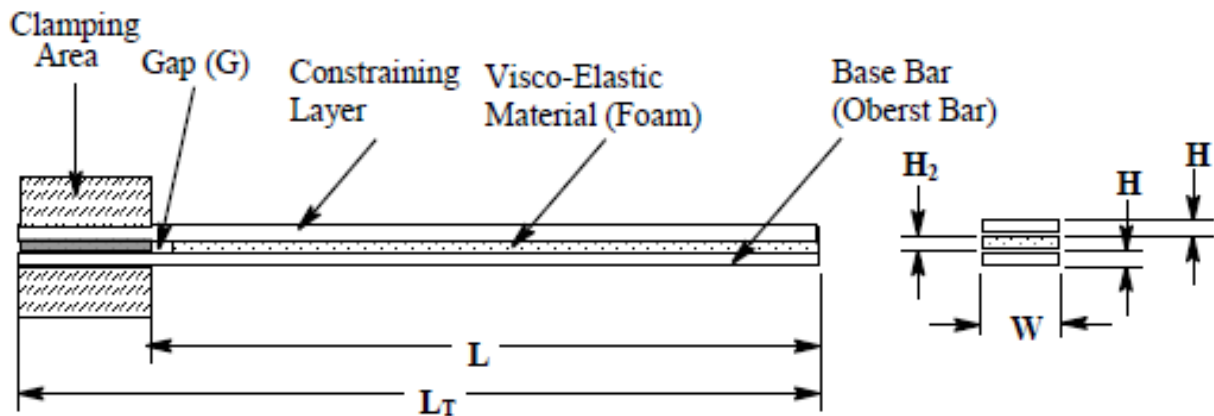


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**Principal Consultant**

**FIGURE 1**

**A TYPICAL TEST SAMPLE FOR  
OBERST BAR DAMPING TEST**

**Typical Oberst Bar with Roots**



**LEGEND**

L	=	Free Length of the Oberst Bar: 254 mm This is also the Length of the Damping Material
L <sub>T</sub>	=	Total Length of the Oberst Bar: 290 mm
W	=	Width of the Oberst Bar: 20 mm
H <sub>2</sub>	=	Thickness of the Damping Material: 0.1945 mm
H	=	Thickness of the Constraining Layer: 1 mm

**NOTE**

The damping material should not touch the clamping mechanism or the test fixture. The gap (G) between the clamping device and the material should be less than or equal to 0.5 mm.

The damping material was a constrained layer damper.

Table 1

Kolano and Saha Engineers, Inc.

Project No. 2022-038.1

Test Date Mar 23, 2022

**DAMPING RESULTS FROM OBERST BAR TESTS USING K&STLE DAMP****Tests Conducted for:** dBVibroAcoustics s.r.o.**Sample Manufacturer:** Trelleborg Sealing Solutions Kalmar AB**Sample Description:** S1: Damping Rubber #3 (19+31)**Cure Cond:****Sample Type:** Constrained**Classification:**

		Manf. Data VEM	Meas. Data Test Bar	Steel Bar	Units
<b>Sample Information</b>	Thickness:	0.1945	0.2	1	mm
	Surf. Dens:	0.25	0.25	7.85	kg/m <sup>2</sup>
	Density:	1310	1310	7850	kg/m <sup>3</sup>
	Free Length:	254	254	254	mm

TEST TEMPERATURE	Measured Data			Computed Data	
	MODE	RESONANT FREQUENCY	COMPOSITE LOSS FACTOR	MATERIAL LOSS FACTOR	MATERIAL SHEAR MODULUS
		$f_c$ (Hz)	$\eta_c$	$\eta_1$	G (Pa)
20 °C (68 °F)	2	165	0.048	0.306	2.39E+07
	3	440	0.093	0.428	3.88E+07
	4	831	0.147	0.591	5.26E+07
	5	1284	0.156	0.501	5.92E+07
	Interpolated	200	0.055	0.327	2.63E+07
		400	0.087	0.414	3.70E+07
		600	0.116	0.501	4.50E+07
		800	0.143	0.580	5.16E+07
50 °C (122 °F)	2	148	0.057	0.199	9.70E+06
	3	371	0.092	0.252	1.37E+07
	4	661	0.110	0.286	1.64E+07
	5	995	0.147	0.397	1.66E+07
	6	1438*2.5	0.170	0.482	2.06E+07
	Interpolated	200	0.066	0.215	1.09E+07
		400	0.094	0.256	1.40E+07
		600	0.107	0.280	1.59E+07
		800	0.126	0.333	1.65E+07
100 °C (212 °F)	2	129	0.070	0.187	4.33E+06
	3	314	0.075	0.197	5.87E+06
	4	555	0.072	0.215	6.57E+06
	5	854	0.063	0.231	6.81E+06
	6	1227	0.056	0.245	7.43E+06
	Interpolated	200	0.073	0.192	5.03E+06
		400	0.074	0.204	6.16E+06
		600	0.070	0.217	6.62E+06
		800	0.064	0.228	6.77E+06

## Table 2

### EQUATIONS FOR COMPUTING THE LOSS FACTOR AND MODULUS OF DAMPING MATERIALS

*Bare bar:*

$$E = (12 \rho l^4 f_n^2) / (H^2 C_n^2)$$

where:

$E$	= Young's modulus of steel bar (bare bar), Pa,
$\rho$	= density of bare bar, kg/m <sup>3</sup> ,
$l$	= length of bar (same as free length L), m,
$f_n$	= the resonance frequency for mode n, Hz,
$H$	= thickness of bar in vibration direction, m,
$n$	= mode number: 1, 2, 3, ..., and
$C_n$	= coefficient for mode n, of cantilever bar,

where:

$$C_1 = 0.55959, C_2 = 3.5069, C_3 = 9.8194, C_4 = 19.242, C_5 = 31.809, \text{ and } C_n = (\pi/2)(n - 0.5)^2, \text{ for } n > 3$$

*Sandwiched Specimen* (constrained layer) – Calculate the shear modulus and the loss factor of the damping material from the expressions:

$$G_2 = \left[ \frac{(A - B) - 2(A - B)^2 - 2(A\eta_s)^2}{((1 - 2A + 2B)^2 + 4(A\eta_s)^2)} \right] * \left[ \frac{2\pi C_n E H H_2}{l^2} \right]$$

and

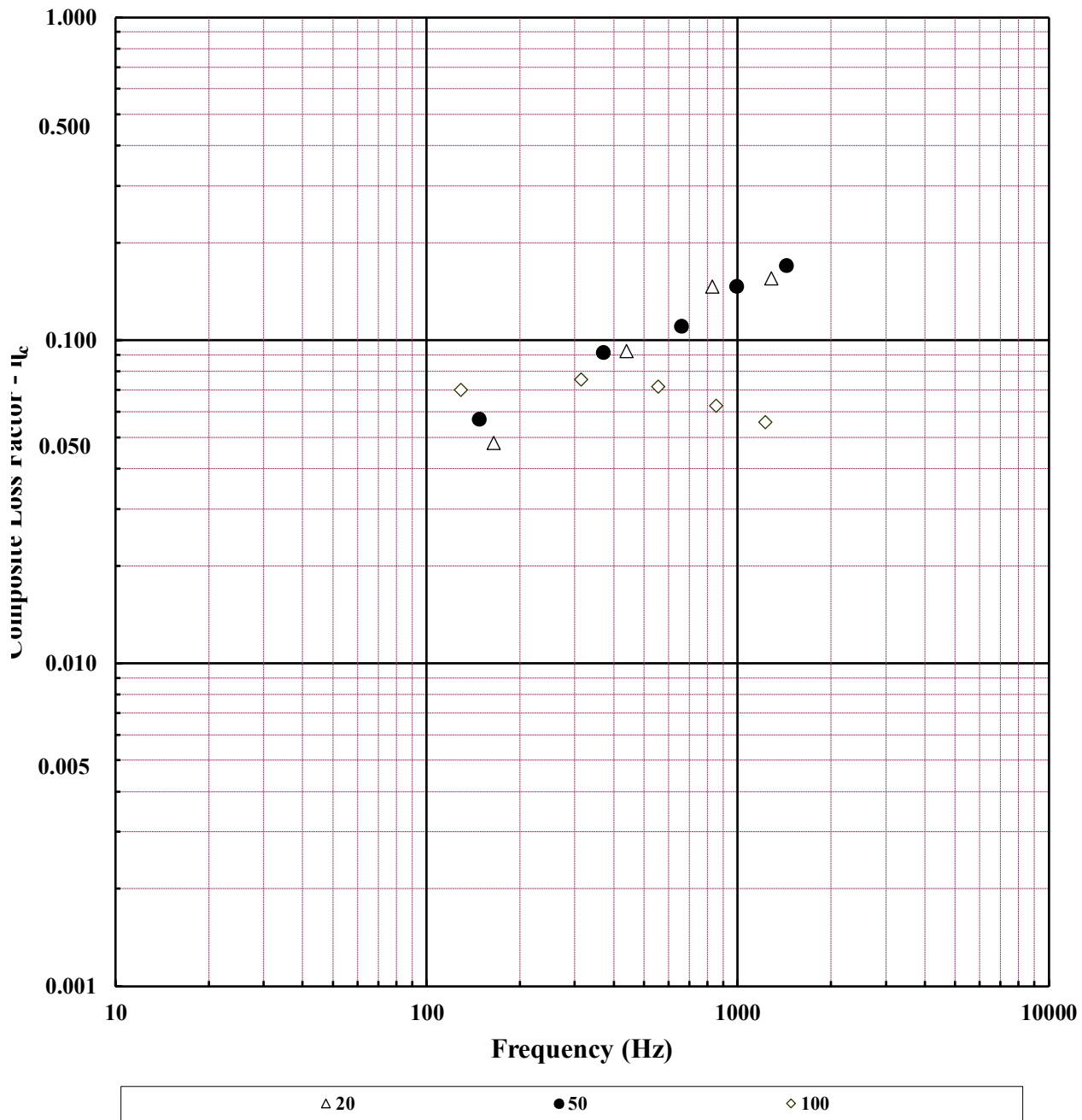
$$\eta_2 = \frac{A\eta_s}{(A - B - 2(A - B)^2 - 2(A\eta_s)^2)}$$

where:

$G$	= shear modulus of damping material, Pa,
$E$	= Young's modulus of Oberst bar, Pa
$f_n$	= resonance frequency for mode $n$ of Oberst bar, Hz
$f_s$	= resonance frequency for mode $s$ of composite bar, Hz
$s$	= index number: 1, 2, 3, ... ( $s \equiv n$ )
$\Delta f_2$	= half-power bandwidth for mode $s$ of composite bar, Hz
$\eta_s$	= $\Delta f_s / f_s$ , loss factor of sandwiched specimen, dimensionless
$\eta_2$	= shear loss factor of damping material, dimensionless
$H_2$	= thickness of damping material, m
$H$	= thickness of Oberst bar, m
$T$	= $H_2/H$ , thickness ratio
$l$	= length of bar, m
$\rho_2$	= density of damping material, kg/m <sup>3</sup>
$\rho$	= density of Oberst bar, kg/m <sup>3</sup>
$D$	= $\rho_2/\rho$ , density ratio
$A$	= $(f_s/f_n)^2(2+DT)(B/2)$
$B$	= $\frac{1}{6(1+T)^2}$
$C_n$	= coefficient for mode $n$ , of cantilever bar (see Bare Bar)

**COMPOSITE LOSS FACTOR FROM OBERST BAR DAMPING TESTS**

Tests Conducted for: dBVibroAcoustics s.r.o.



Sample Description: S1: Damping Rubber #3 (19+31)

Meas. Sample Thickness: 0.2 mm

Meas. Sample Surf. Dens: 0.25 kg/m<sup>2</sup>