

# PERFORMANCE CALCULATION GUIDE

## HOW TO CALCULATE MOUNT STIFFNESS AND NATURAL FREQUENCY FOR ISODAMP AND VERSADAMP ISOLATORS

### TEMPERATURE/FORMULATION CORRECTION CHART

Temperature F (C)	C-1002 Correction Factor	C-1105 Correction Factor	C-1100 Correction Factor	C-8002 Correction Factor	V-2325 Correction Factor	V-2590 Correction Factor	V-2599 Correction Factor	V-2750 Correction Factor
45F (7C)	8.58	—	—	31.61	0.53	1.85	2.18	1.30
50F (10C)	5.86	—	—	22.22	0.49	1.56	1.85	1.22
55F (13C)	2.80	8.26	—	15.33	0.46	1.24	1.9	1.15
60F (16C)	1.94	5.90	—	10.39	0.43	1.16	1.39	1.10
65F (18C)	1.39	4.28	—	7.95	0.41	1.07	1.27	1.07
70F (21C)	1.00	3.11	8.85	5.28	0.39	0.96	1.14	1.02
75F (24C)	.075	2.28	6.25	3.51	0.37	0.87	1.03	0.97
80F (27C)	0.56	1.70	4.45	2.38	0.35	0.80	0.95	0.91
85F (29C)	0.44	1.30	3.24	1.87	0.34	0.77	0.90	0.87
90F (32C)	0.35	1.00	2.36	1.34	0.33	0.72	0.84	0.81
95F (35C)	0.29	0.78	1.74	1.01	0.32	0.69	0.80	0.76
100F (38C)	0.25	0.63	1.30	0.80	0.32	0.66	0.77	0.71
105F (41C)	0.22	0.51	1.00	0.67	0.31	0.64	0.74	0.67
110F (43C)	0.20	0.42	0.77	0.61	0.31	0.63	0.73	0.65
115F (46C)	0.18	0.34	0.61	0.55	0.30	0.62	0.71	0.63
120F (49C)	0.17	0.29	0.49	0.50	0.30	0.61	0.70	0.61
125F (52C)	0.16	0.28	0.43	0.48	0.30	0.60	0.69	0.60
130F (54C)	0.16	0.27	0.41	0.47	0.30	0.59	0.68	0.60
135F (57C)	0.15	0.24	0.34	0.45	0.29	0.59	0.67	0.59
140F (60C)	0.15	0.22	0.30	0.44	0.29	0.58	0.66	0.58
145F (63C)	0.15	0.20	0.26	0.44	0.29	0.58	0.66	0.58
150F (66C)	0.14	0.19	0.23	0.43	0.29	0.57	0.66	0.58
155F (68C)	0.14	0.18	0.22	0.43	0.29	0.57	0.66	0.58
160F (71C)	0.14	0.17	0.20	0.43	0.29	0.57	0.65	0.58

Non-shaded area indicates peak damping performance temperature range.

Predicting E-A-R isolator performance is simple. Just follow the instructions below and refer to the grommet data tables and performance graphs beginning on Page 4.

### DETERMINING DYNAMIC STIFFNESS

Select a candidate ISODAMP or VersaDamp grommet based on your application parameters—load per isolator, axial (horizontal plate) or radial (vertical plate) orientation, and plate dimensions. Follow these steps to determine a grommet's dynamic stiffness by using the data table and performance graph for the grommet style you have chosen.

- **From the data table**—Locate the load factor for the chosen grommet and orientation (axial or radial). Now, divide the grommet load (lb/grommet) by the load factor. The result is the load ratio.
- **To the performance graph**—Locate the load ratio value on the curve (x-axis), and read the resulting stiffness ratio from the y-axis.
- **Back to the data table**—Multiply this stiffness ratio value by the stiffness factor. And this is the per grommet stiffness (lb/in).

### CORRECTION FOR ELASTOMER FORMULATION AND OPERATING TEMPERATURE

The stiffness calculated from the grommet data tables and

performance graphs represents the dynamic stiffness for a C-1002 grommet at 70F (21C). The Temperature/ Formulation Correction Chart above makes it easy to determine the dynamic stiffness of any ISODAMP or VersaDamp grommet for any operating temperature.

Simply multiply the correction factor from this chart by the stiffness just calculated to get the dynamic stiffness value (lb/in) of the grommet in the material of choice for your operating temperature range.

### NATURAL FREQUENCY CALCULATION

Calculations from the grommet data tables and grommet performance graphs are intended to determine dynamic stiffness values for E-A-R grommets. This stiffness data is basic to predicting overall system response and system natural frequency.

The natural frequency of a particular E-A-R grommet can now be calculated using the following formula:

$$F_n = 3.13 \sqrt{K \div W}$$

WHERE:  $F_n$  = Natural frequency of the grommet (Hz)

$K$  = Dynamic stiffness (lb/in)

$W$  = Load per grommet (lb)



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## HOW TO CALCULATE VIBRATION ISOLATION PERFORMANCE

# Vibration Isolation

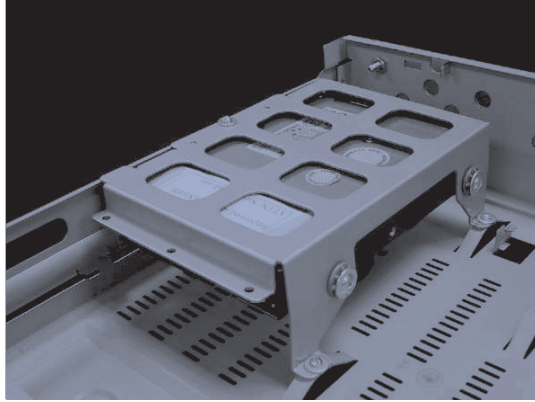


Figure 1

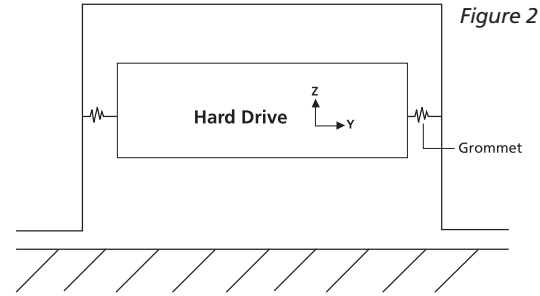


Figure 2

$K$  = Dynamic stiffness (lb/in)  
 $W$  = Load per grommet (lb)

**Natural Frequency (Hz)**  
 (resonance)

$$F_n = 3.13 \sqrt{K \div W}$$

**Cross-Over Frequency**  
 (where isolation begins)

$$F_x = 4.42 \sqrt{K \div W} = \sqrt{2} F_n$$

**Peak Transmissibility**  
 (maximum amplification)

$$T_{max} = \frac{\sqrt{1 + \eta^2}}{\eta}$$

### EXAMPLE CALCULATION: COMPUTER HARD DRIVE

#### Problem Statement

• Our example is a 1.5 lb hard drive isolated with four G-411-2 (ISODAMP C-1105) grommets at 100F. Lateral hard drive vibration produces axial grommet deflection (y direction, see Figure 2). We therefore will utilize the axial mount data for the stiffness calculation. Four grommets will be used to support the hard drive. Two grommets are shown in Figure 1 and two are located on the opposite side.

#### Stiffness and Natural Frequency Calculation

- Load per grommet:  $1.5 \text{ lb} \div 4 = 0.375 \text{ lb/grommet}$
- From the data table on Page 4: load factor = 1.8
- Divide load per grommet by load factor to get load ratio:  
 $0.375 \div 1.8 = 0.208$
- Use the performance graph to determine the stiffness ratio: load ratio of 0.208 corresponds to stiffness ratio of 3.0
- From the data table: stiffness factor = 1911 lb/in
- Effective stiffness is stiffness factor x stiffness ratio:  $1911 \text{ lb/in} \times 3 = 5733 \text{ lb/in}$
- Determine the temperature correction factor for C-1105 material @ 100F. Temperature correction factor=0.63.
- Actual grommet dynamic stiffness:  $5733 \text{ lb/in} \times 0.63 = 3612 \text{ lb/in}$
- Natural Frequency  $F_n = 3.13 \sqrt{(3612 \div 0.375)} = 307 \text{ Hz}$

#### Isolation Performance Calculation

- Cross-Over Frequency =  $\sqrt{2} \times 307 = 434 \text{ Hz}$
- $F_d$  = Resonant Frequencies to avoid in computer housings: 1000 to 2000 Hz.
- Frequency Ratio =  $F_d / F_n = 1000 \text{ Hz} \div 307 \text{ Hz} \ \& \ 2000 \text{ Hz} \div 307 \text{ Hz} = 3.25 \ \& \ 6.5$
- Per the graph in Figure 3 using frequency ratios, there will be 0.3 to 0.15 Transmissibility (or 70 percent to 85 percent isolation) in that range
- To estimate peak transmissibility as shown in Figure 3, use loss factor from the material nomogram (Figure 4) and equation at left. ( $\eta_m = 0.8, T_{max} = 1.6$ )

Note: For instructions on how to read a material nomogram, see Page 18.

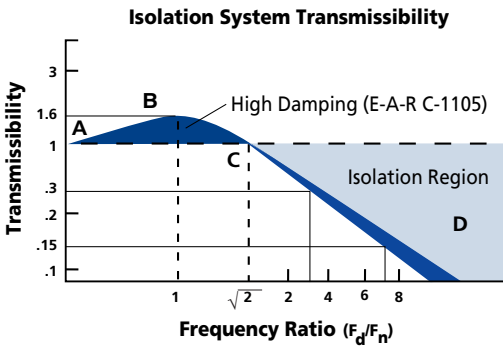


Figure 3

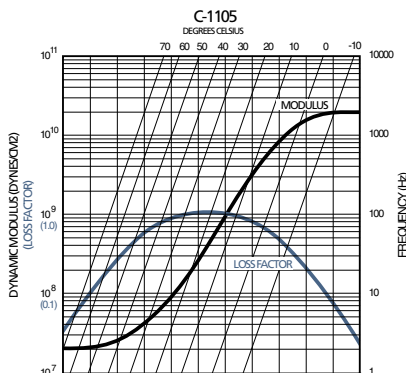


Figure 4



## HOW TO CALCULATE SHOCK RESPONSE PERFORMANCE

# Shock Protection

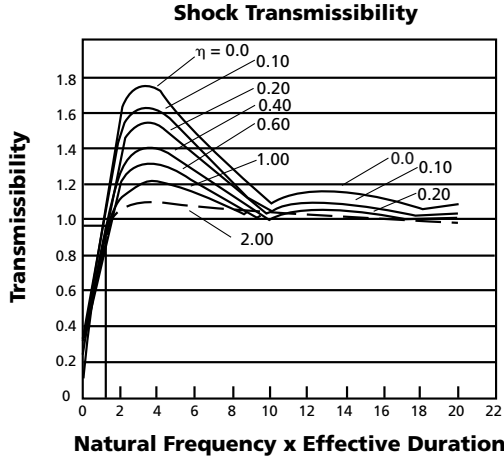


Figure 1

$K$  = Dynamic stiffness (lb/in)  
 $W$  = Load per grommet (lb)

**Natural Frequency (rad/sec)**  
 (resonance)

$$\omega_n = 19.65 \sqrt{K \div W}$$

**Shock Input: Half Sine**  
**(100G, 2ms)**

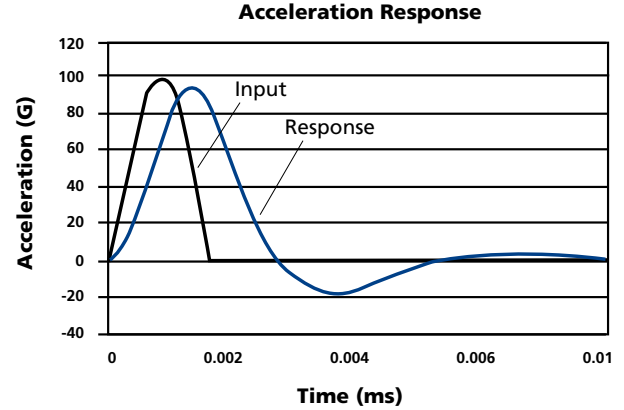


Figure 2

### COMPUTER HARD DRIVE SHOCK PROTECTION

#### Problem Statement

• Our example is a 1.5 lb hard drive isolated with four G-411-2 grommets at 100F. The shock input: Half Sine 100G @ 2ms. The shock input creates radial loading of grommets (z direction in Figure 2, Page 11). Therefore, we will utilize radial mount data for our stiffness calculation. Four grommets are used to support the hard drive (see Figure 1, Page 11).

#### Stiffness and Natural Frequency Calculation

- Load per grommet: 1.5 lb ÷ 4 = 0.375 lb/grommet
- From the data table on Page 4: load factor = 0.9
- Divide load per grommet by load factor to get load ratio: 0.375 ÷ 0.9 = 0.417
- Use the performance graph to get the stiffness ratio: load ratio of 0.417 corresponds to stiffness ratio of 1.5
- From the data table: stiffness factor = 1153 lb/in
- Effective stiffness will be stiffness factor x stiffness ratio = 1.5 x 1153 = 1730 lb/in
- Determine the temperature correction factor for C-1105 material @ 100F. Temperature correction factor = 0.63.
- Actual grommet dynamic stiffness: 1730 lb/in x 0.63 = 1090 lb/in
- Natural Frequency  $\omega_n = 1059$  rad/sec (167 Hz)

#### Shock Protection Performance Calculation

- Effective time duration for half sine shock is 0.637 x actual duration: 0.637 x 0.002 sec = 0.00127 sec
- Take natural frequency x effective duration = 1059 rad/sec x 0.00127 sec = 1.35 and find response in Figure 1 using loss factor = 1.0 curve.
- Transmissibility is just slightly less than one. Calculated time response (via computer algorithm) in Figure 2 confirms this. Often, this is quite acceptable where the designer wants to ensure that the system does not amplify shock.
- Peak deflection for this system is 0.022 inch as determined from graph in Figure 3 using the C-1105 material. A curve is shown for poorly damped material such as natural rubber ( $\eta_m=0.1$ ). The peak displacement would then be 0.039 inch which is 77 percent higher than the ISODAMP C-1105 material. This graph is valid for 100G, 2ms half sine pulses only.
- Additional theory on shock protection calculations can be found in most shock and vibration handbooks.

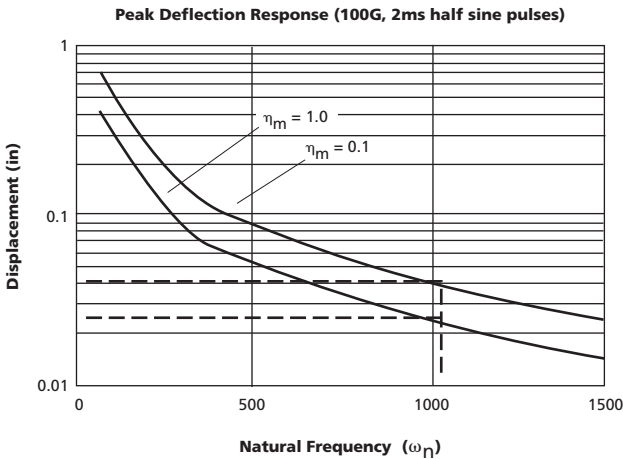


Figure 3