



Viscoelastic Damping Polymers

110- • 112- • 130-

Technical Data

February, 1999

Description/ Features

- **110- Viscoelastic Damping Polymer/Liner**
 - 110P02 .002" thick, 58# PCK Paper liner, 4 mil thick, DS Silicone
 - 110P05 .005" thick, 58# PCK Paper liner, 4 mil thick, DS Silicone
 - Acrylic polymer
 - Heat and Pressure required for lamination and application of the 110 to a substrate
 - Typical temperature range for good damping performance: 40-105°C
- **112- Viscoelastic Damping Polymer/Liner**
 - 112P01 .001" thick, 58# PCK Paper liner, 4 mil thick, DS Silicone
 - 112P02 .002" thick, 58# PCK Paper liner, 4 mil thick, DS Silicone
 - 112P05 .005" thick, 58# PCK Paper liner, 4 mil thick, DS Silicone
 - Acrylic polymer
 - Pressure used for lamination and application of the 112 to a substrate
 - Typical temperature range for good damping: 0-65°C
- **130- Viscoelastic Damping Polymer/Liner**
 - 130F02 .002" thick, Polyester Film liner, 2 mil thick, DS Silicone
 - 130F05 .005" thick, Polyester Film liner, 2 mil thick, DS Silicone
 - Acrylic polymer
 - Pressure alone can be used for some applications to laminate the 130 to a substrate, but heat and pressure may be required for acceptable lamination and application results of the 130 to a substrate.
 - Typical temperature range for good damping performance: 20-90°C

Application Ideas

- 3M viscoelastic damping polymers 110-, 112- and 130- are designed to be used in damping applications as free-layer dampers, as part of a constrained layer damping design or as part of a laminate construction.
- 3M damping polymers have been used for constrained layer dampers or multi-layer damped laminates with a variety of substrates, such as stainless steel, aluminum and polyester.
- The 3M polymers 110-, 112-, 130- may also be used in vibration and shock isolation designs.
- 3M viscoelastic damping polymers are enhanced for thermal stability and offer excellent thermal stability and damping performance for long term applications at moderate temperatures and also applications that experience short high temperature excursions.
- Market application areas include: automotive, aerospace, electrical mechanical and general industry.
- Potential applications include disk drive and automotive cover constrained layer dampers, multi-layer laminates using metals or polymeric films, suspension dampers, isolators, panel dampers, pipe dampers, wing dampers, etc.

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Features (continued)

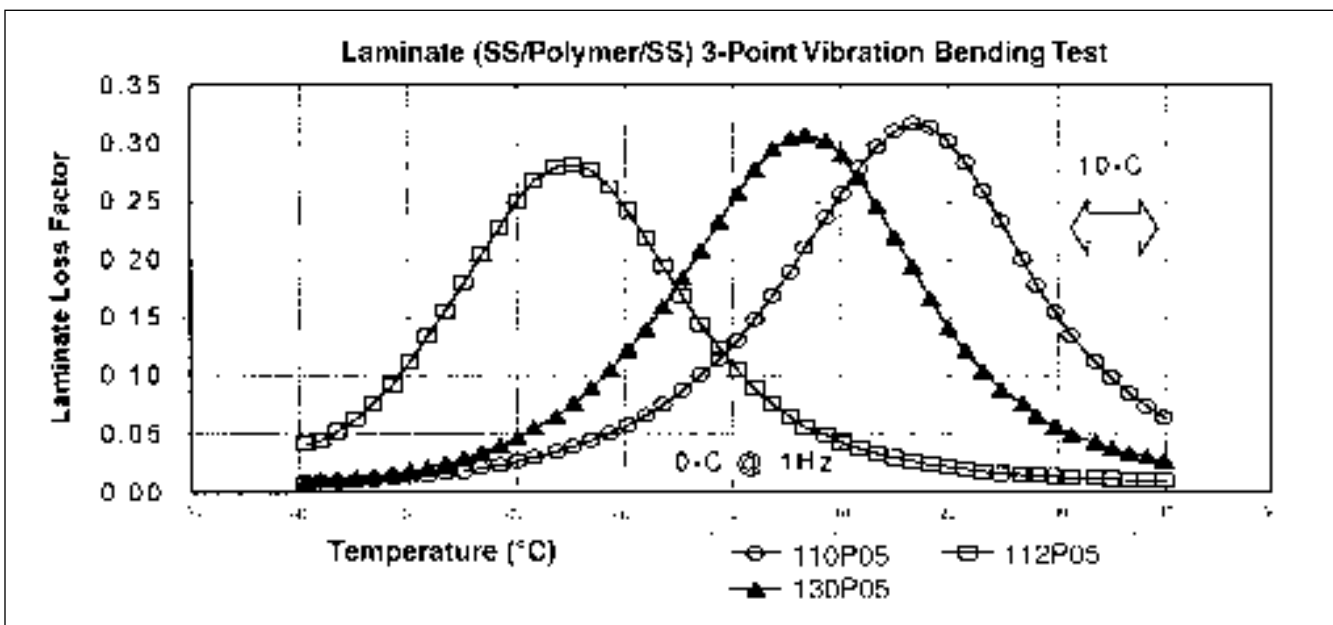
Notes:

- Application of 3M viscoelastic damping polymers 110, 112 and 130 require a clean, dry surface free of contamination for best adhesion and damping results.
- 3M viscoelastic damping polymers 110, 112 & 130 may be used in applications outside their suggested damping temperature range with acceptable damping performance, as determined by the user.
- The polymers long term performance in an application is determined by the dampers end use design and the environment it will be exposed to. The typical damping performance temperature ranges noted above are not limits to an applications' long term temperature exposure or short term higher temperature excursions. The damper's construction and application to a substrate will determine the long and short term

Typical Relative Performance Data: Three Point Bending Vibration Test

A three point bending test is a means to compare the relative damping performance of a 3M viscoelastic damping polymer in a three layer laminate design. A layer of a 3M viscoelastic damping polymer is placed between 2 outer stainless steel skins. The laminate is placed into a test system to measure the damping performance of this laminate construction at a specific frequency and over a temperature range. A system "laminate loss factor" can be determined. The laminate loss factor can allow the 3M viscoelastic damping polymers 110, 112 and 130 to be compared to one another for their relative performance at that specific test frequency, temperature and laminate dimensional design.

The three point bending data and the viscoelastic damping polymers nomograph may be used to predict the general performance range for the 3M viscoelastic damping polymers 110, 112 and 130 relative to each other at higher frequencies in a similar laminate construction design. A general extrapolation to higher frequencies, which would shift the temperature scale on the existing 3-point test graph, can be done by estimating from each polymer's nomograph the shift in temperature (delta) that occurs when the polymer goes from the three point test frequency (ex: 1 Hz) to a higher frequency that the viscoelastic damping polymer may be exposed to in a similar but higher frequency application. The temperature shift is found by maintaining the same Loss Factor (Ex: LF = 1 @ 1Hz & 5°C) and shifting the frequency to the desired level (Ex: from 1 Hz to 1 KHz) and determining the temperature delta (Approximately 40-60°C for 110 viscoelastic damping polymer).



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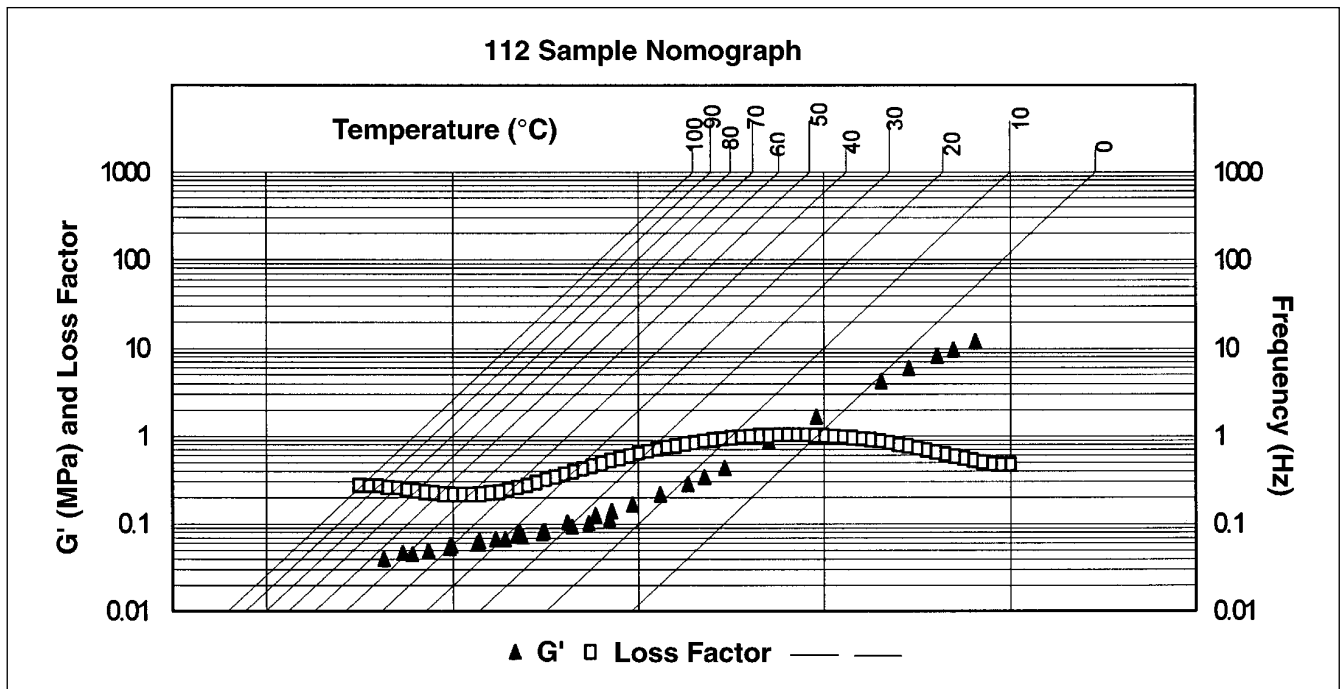
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Nomograph

The 3M viscoelastic damping polymers 110, 112 and 130 damping properties are shown in the “reduced temperature format” nomograph. The nomograph shows the viscoelastic damping polymers Loss Factor and Storage Modulus for various frequencies and temperatures in a single graph. The Shear (Storage) Modulus and Loss Factor are intensive properties of the viscoelastic damping polymer alone.

The Loss Factor and Storage Modulus are the key measurement parameters and determine the level of potential damping capability that exists in the 3M viscoelastic damping polymers 110, 112 and 130 at a specific temperature and frequency.

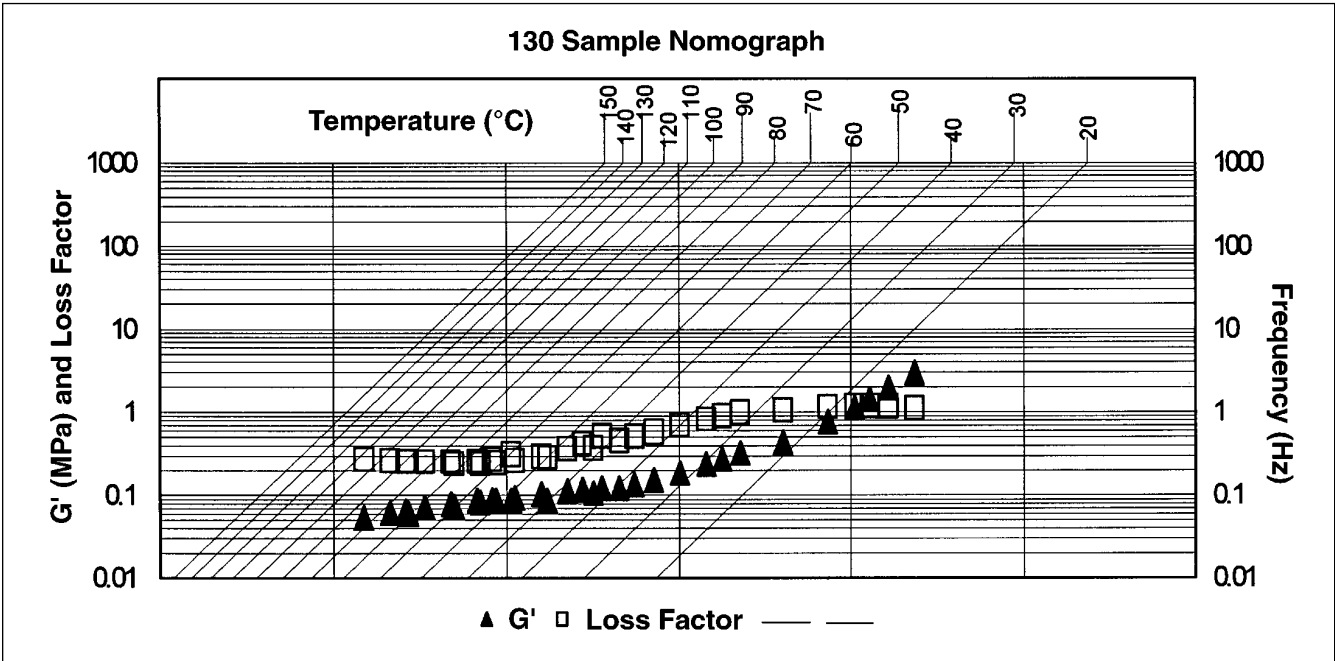
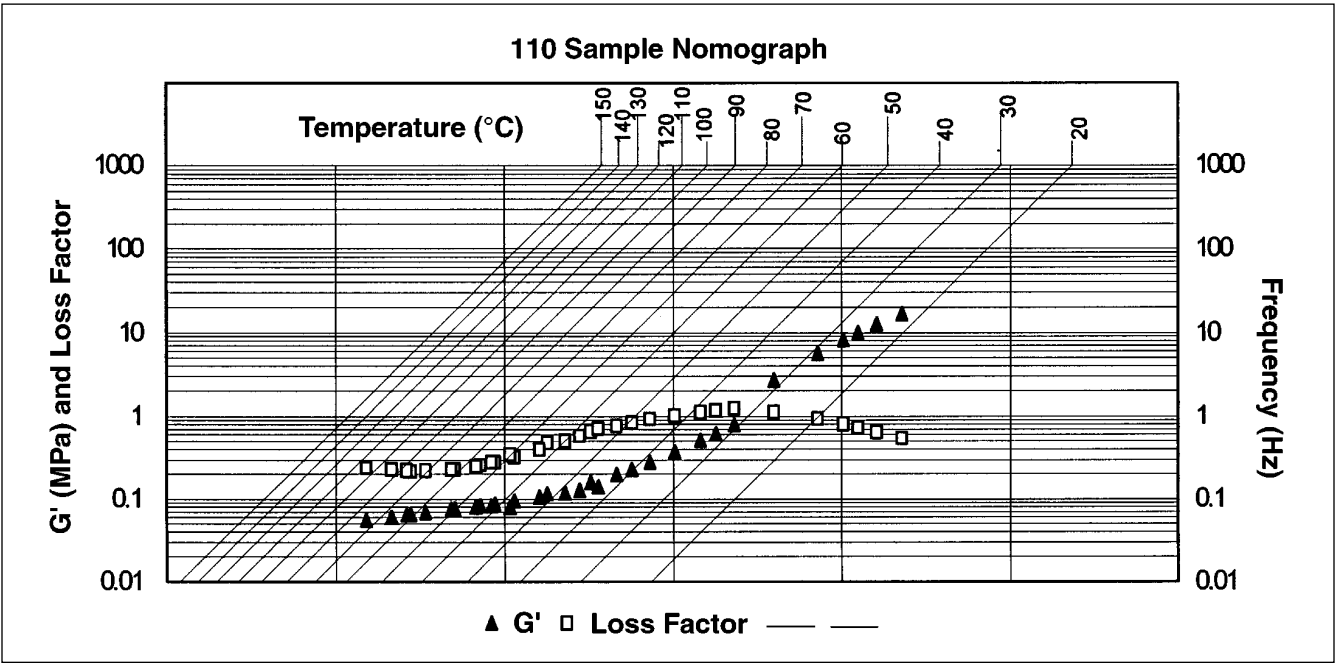
The Loss Factor and Storage Modulus are found for the 3M viscoelastic damping polymers 110, 112 and 130 by selecting the frequency desired of an application and extending a horizontal line from that frequency until the desired application temperature isotherm is intersected. Extend a vertical line from this first intersection point of the desired frequency and temperature isotherm so that it intersects the Loss Factor and Storage Modulus curves. The Loss Factor and Storage Modulus values are found on the left hand scale by extending a line horizontally from these second intersection points on the Loss Factor and Storage Modulus performance curves.



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Nomograph (continued)



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Typical Total Outgass Material by GC/MS (Modified ASTM 4526)

110P02- 5-30 µg/cm² (Hydrocarbons, organic acids, esters, alcohols, acrylates, acetates, etc.)

112P02-10-30 µg/cm² (Hydrocarbons, organic acids, esters, alcohols, acrylates, acetates, etc.)

130F02-10-30 µg/cm² (Hydrocarbons, organic acids, esters, alcohols, acrylates, acetates, etc.)

Typical Total Ionics by Ion Chromatograph

110P02- <1 µg/cm² (Chloride, Nitrate, Sulfate)

112P02- <1 µg/cm² (Chloride, Nitrate, Sulfate)

130F02- <1 µg/cm² (Chloride, Nitrate, Sulfate)

Typical Performance Values used in Finite Element Analysis (FEA) of Damping Applications

Poissons Ratio for 110, 112 and 130 Viscoelastic Damping Polymers: Approximately 0.49

Density for 110, 112 and 130 Viscoelastic Damping Polymers: Approximately 0.9-1.0 g/cc

Typical 90-Degree Peel Data* (2-mil Aluminum backing @ 12" or 1"*** min. peel rate: ounce/1/2 inch width)

3M Viscoelastic Damping Polymer	SS @ 15 min. RT	SS @ 72 Hr RT	SS @ 72 Hr 158°F
110P02**	N/A	44	61
110P05**	N/A	19	48
112P01	22	38	45
112P02	28	50	65
112P05	36	72	105
130F02**	19	40	33
130F05**	27	56	49

Note: *Peel test results will vary due to substrate type and condition, backing material properties and the speed of the test set-up. Test results may also be shocky in release from a substrate due to the storage modulus and bond characteristics of the polymer to a substrate and the test conditions.

Typical Liner Release Values (180 degree Liner removal)

110P02 - 21 g/inch width

112P02 - 26 g/inch width

130F02 - 23 g/inch width

Viscoelastic Damping Polymer Application Instructions

In many applications of the 3M viscoelastic damping polymer 112 to a constraining layer or substrate, the 3M polymer 112 needs only pressure to provide adequate bonding at room temperature (21°C). The 110 polymer requires heat and pressure for adequate bonding conditions. The 3M polymer 130 for some applications needs only pressure for an adequate bonding at 21°C, while many applications using the 3M polymer 130 require heat and pressure for an adequate bonding.

For high strain applications and/or some surface types, the damping polymers may require an additional surface attachment means, such as a surface primer or epoxy bonding material to provide an adequate bond to a surface.

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Viscoelastic Damping Polymer Application Instructions (*continued*)

• Surface Preparation

For an acceptable bonding of the 3M viscoelastic damping polymers 110, 112 and 130 to a surface, it is necessary for surfaces to be dry and free of any wax, grease, dust, dirt, oil, scale or any other contaminants or loose or weakly attached surface finishes or coatings. The importance of contamination free surfaces cannot be over emphasized. Typical cleaning solvents like isopropyl alcohol or heptane can be used. More aggressive solvents may be needed for difficult to remove contaminants.

Note: Carefully read and follow manufacturer's precautions and directions for use when using cleaning solvents.

Extremely contaminated surfaces may require special attention. Sanding or grinding will remove heavy contamination. Follow with a solvent wipe as indicated above. Sandblasting and grinding to finish should be done ONLY on surfaces completely free of oil, grease, wax, silicone-based materials or other organic residues.

Sandblasting and grinding can drive or push oils and other residual materials into the substrate surface leading to adhesion reduction or bond failure of the polymer after an initial bond is made. Sandblasting and grinding should be done with materials that do not leave a residue or grit remaining on or in the surface.

Note: Wear appropriate personal protective equipment for sandblasting and grinding operations.

• Surface Type:

The 3M viscoelastic damping polymer 110, 112 and 130 will form good bonds when properly applied to many high surface energy materials. Materials with a surface energy below 100 dynes/cm² should be tested to determine if a suitable development of an adequate bond for a given end use application will occur.

• Application

The 3M viscoelastic damping polymer 112 is tacky at room temperature 70°F (21°C). The 3M polymer 112 requires only rolling or squeegeeing methods to apply pressure to the 3M polymer 112 to make an adequate bond to a contamination free surface. Air entrapment should be avoided to ensure a good bond.

A good method is to first attach one edge of the damping material and/or damper to the substrate, then gradually lower the damper onto the surface at an angle (30-90°) while continually applying uniform pressure to the damper of 10-15 psi (6.9-10.3 x 10⁴ pascals). A squeegee or wood/rubber roller will help maintain uniform pressure across a wide area. Every effort must be made to avoid air entrapment while placing the damping polymer and/or damper on to a substrate.

The 3M polymer 112 bond will typically build with time or exposure to higher temperature.

The 3M damping polymer 110 is relatively tack free at room temperature 70°F (21°C). Heat and pressure are required to bond to a surface. A suggested bonding cycle is five (5) to fifteen (15) minutes at 200-225°F (92-107°C) with 10-15 psi of pressure. The substrate and damping polymer and/or damper should reach the temperature and time range suggested for best bonding results. The dwell time suggested is for the entire assembly at bonding temperature and does not include warm-up time. A heat lamp or heat gun may be used to warm the substrate to 100°F (38°C) or above to make the 3M polymer 110 tacky enough to stay in position until the assembly is placed into a fixture to apply the needed bond pressure while being heated in an air circulating oven or other heating means. Vacuum pad applicators have also been found to be useful for laminating flat panel sheets.

The 3M viscoelastic damping polymer 130 is somewhat tacky at room temperature (21°C). The 3M polymer 130 may be able to be applied with the 3M polymer 112 application suggestions to some substrates and damper designs with acceptable bonding results. Most applications will require the 3M polymer 130 polymer to be bonded with the 110 application suggestions for best bonding results. Each application surface needs to be tested to determine the best application method for the 3M polymer 130.

The viscoelastic damping polymer silicone release liner is not intended to be part of an end use application.

Pressures above 50 psi (3.45 x 10⁵ pascals) should be avoided for 3M polymers 110, 112, and 130 bonding. Temperatures above 250°F should be avoided. Air entrapment should be avoided to ensure a good bond.

For high strain applications and/or some surface types and/or where geometric design restrictions limit the ability to meet the desired pressure and temperature bonding requirements, the damping polymers may require an additional surface attachment means, such as an epoxy bonding material to provide an adequate bond to a surface.

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General Damper Design Information

Most applications use the 3M viscoelastic damping polymers as part of a Damped Metal Laminate (DML = #1 metal or plastic layer/Viscoelastic Damping Polymer/#2 metal or plastic layer) formed into a finished article (valve cover, oil pan, brackets, etc.) or as part of a Constrained Layer Damper (CLD = Constraining layer of metal or plastic/viscoelastic damping polymer) that is attached via the Viscoelastic Damping Polymer layer to a structure to be damped (car door panels, disk drive covers).

• Selection of a Viscoelastic Damping Polymer

The selection of a 3M viscoelastic damping polymer can be accomplished by determining the operating temperature and frequency ranges of the application that is desired to be damped. The temperature and frequency ranges are used with the Nomograph to determine which polymer has the most optimal performance (high Loss Factor and high Storage Modulus) over the temperature and frequency range of the application. Some applications may require one or more viscoelastic damping polymer types in a multi-layer design to ensure acceptable performance at all temperature and frequencies of an application.

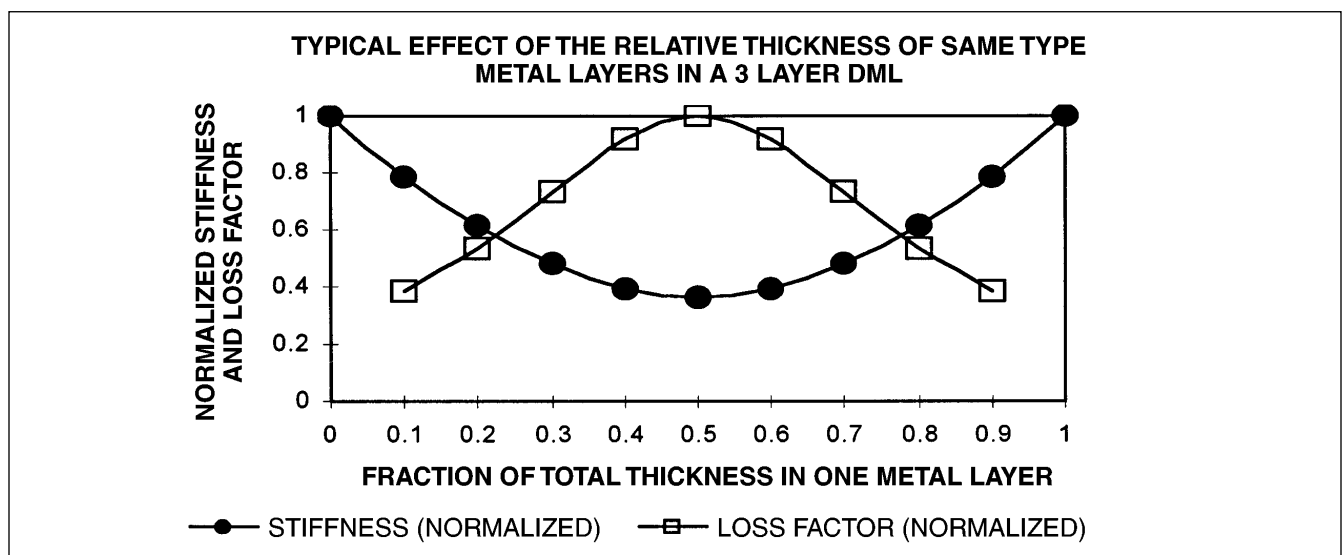
• DML Design Information

Based on the temperature and frequencies range of the application, an initial 3M viscoelastic damping polymer can be selected. The metal or plastic layers of the DML are selected based on the static, dynamic and/or acoustic requirements of the DML application. Excellent damping occurs when the metal or plastic layers of a DML are equal in overall effective modulus. For the same metal or plastic type being used in a DML design, this would equate to equal thicknesses for each metal or plastic layer.

When the same metal or plastic layer types are used in a DML, the change in the ratio of the thickness of the layers to each other effects the overall damping in the DML and DML stiffness. As a layer becomes a percentage thicker than the another metal layer, while the DML maintains a constant overall thickness, the stiffness of the DML increases while the overall damping is reduced as is shown in the following graph of the “Typical Effect of the Relative Thickness of Same Type Metal Layers in a 3 Layer DML”. This graph would be associated with a typical three layer DML design with a viscoelastic damping polymer thickness of about one mil and where the ratio of the metal layers combined thickness to the thickness of the Viscoelastic Damping Polymer is in the range of about 20:1 to about 50:1.

The thickness of the viscoelastic damping polymer layer in DML design is typically one to five mils with the most typical thickness range being one to two mils.

Very large displacement DML designed dampers to be used in high strain applications and isolator designs in a DML configurations may use significantly thicker viscoelastic damping polymer layers.



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General Damper Design Information (*continued*)

• CLD Design Information

Based on the temperature and frequency range of the application, an initial 3M viscoelastic damping polymer can be selected. The metal or plastic layers of the CLD are selected based on the degree of damping and/or acoustic performance needed in the application. The CLD is typically not designed to be a contributor to the static or dynamic structural requirements of the end use application. The CLD will add some stiffness to a structure, but typically a small amount compared to the structure it is being applied to.

Excellent damping occurs when the constraining layer of a CLD is equal in effective modulus to the structure's surface effective modulus that it is being attached to and the CLD also covers at least 90% of the vibrating surface. The CLD will follow the basic "Typical Effect of the Relative Thickness of Same Type Metal Layers in a 3 Layer DML" graph with respect to how effective the CLD may be when a CLD is attached to a structure of the same metal type. The closer the effective modulus of the CLD is to the effective modulus of the structure surface, the better the CLD may perform. Effective modulus equals the structure or constraining layer modulus multiplied by its typical thickness.

The typical CLD with an optimum constraining layer thickness design covers about 30-90% of the surface area of the actively vibrating surface of a structure for acceptable damping performance. The CLD is typically placed in the area of highest strain on the surface of the structure. The surface area covered is dependent on the degree of damping needed to be effective for the application.

Cantilevered structures can achieve improved damping if the CLD is positioned near edges or the root of the structure to be in the area of highest strain.

The typical CLD's viscoelastic damping polymer layer is between two and twenty mils thick. Most typically two to ten mils thick. CLD's with very thick Constraining Layers or very rough surfaces may use a thicker viscoelastic damping polymer.

A typical CLD will cover 50-80% of a vibrating surface, have a constraining layer with an effective modulus of 30-80% of the structures vibrating surface effective modulus and have a 3M Viscoelastic Damping Polymer thickness of two to ten mils.

Note: The above technical information and data should be considered representative or typical only and should not be used for specification purposes.

For Additional Information

To request additional product information or to arrange for sales assistance, call toll free 1-800-362-3550. Address correspondence to: 3M Bonding Systems Division, 3M Center, Building 220-7E-01, St. Paul, MN 55144-1000. Our fax number is 651-733-9175. In Canada, phone: 1-800-364-3577. In Puerto Rico, phone: 1-809-750-3000. In Mexico, phone: 5-728-2180.

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