



Polymers Useful for Damping

Viscoelastic Damping Polymer 110

VHB™ Adhesive Transfer Tapes 9460 • 9469 • 9473

Technical Bulletin

April, 2003

Description/Features

3M™ Viscoelastic Damping Polymer

- Viscoelastic Damping Polymer 110P02 .002" thick, 58# PCK Paper Liner, 4 mil thick, DS Silicone
- Viscoelastic Damping Polymer 110P05 .005" thick, 58# PCK Paper Liner, 4 mil thick, DS Silicone
- Acrylic polymer
- Heat and Pressure required for lamination and application of the polymer to a substrate
- Typical temperature range for good damping performance: 10-100°C depending on the application frequency

3M™ VHB™ Adhesive Transfer Tapes

- VHB Adhesive Transfer Tape 9460 .002" thick, 58# PCK Paper Liner, 4 mil thick, DS Silicone
- VHB Adhesive Transfer Tape 9469 .005" thick, 58# PCK Paper Liner, 4 mil thick, DS Silicone
- VHB Adhesive Transfer Tape 9473 .010" thick, 58# PCK Paper Liner, 4 mil thick, DS Silicone
- Acrylic polymer
- Pressure used for lamination and application of the tapes to a substrate
- Typical temperature range for good damping performance: 20-65°C depending on the application frequency

Application Ideas

- 3M™ Viscoelastic Damping Polymer 110 and 3M™ VHB™ Adhesive Transfer Tapes 9460, 9469 and 9473 may 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 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 Viscoelastic Damping Polymer 110 and the VHB Adhesive Transfer Tapes 9460, 9469 and 9473 may also be used in vibration and shock isolation designs.
- 3M polymers 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.
- Application of Viscoelastic Damping Polymer 110 and VHB Adhesive Transfer Tapes 9460, 9469 and 9473 require a clean, dry surface free of contamination for best adhesion and damping results.
- Viscoelastic Damping Polymer 110 and VHB Adhesive Transfer Tapes 9460, 9469 and 9473 may be used in applications outside its suggested damping temperature range with acceptable damping performance, as determined by the end 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 environmental performance of the damper.

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Viscoelastic Damping Polymer 110

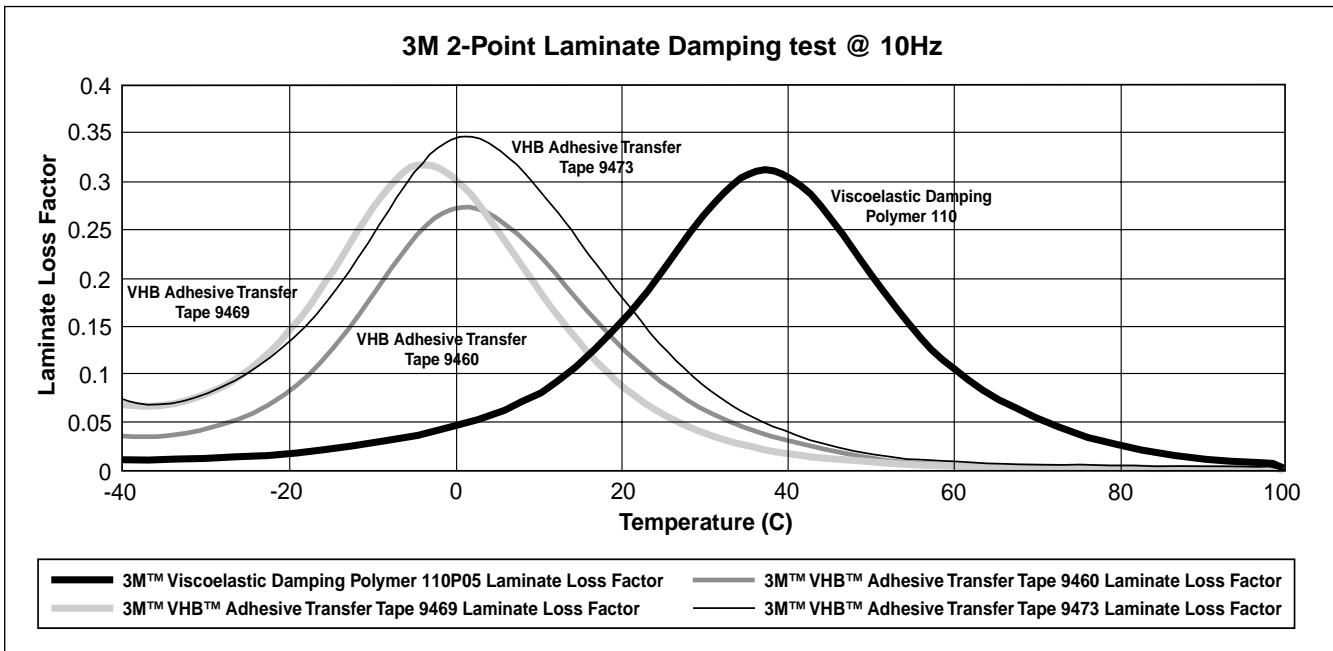
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Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

Typical Relative Performance Data: Two Point Bending Vibration Test

A two point bending test is a means to compare the relative damping performance of a 3M damping polymer in a three layer laminate design. A layer of a 3M 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 Polymer 110 and 3M™ VHB™ Adhesive Transfer Tapes 9460, 9469 and 9473 to be compared to one another for their relative performance at that specific test frequency, temperature and laminate dimensional design.

The two point bending data and the polymers nomograph may be used to predict the general performance range for Viscoelastic Damping Polymer 110 and VHB Adhesive Transfer Tapes 9460, 9469 and 9473 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 2-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 two point test frequency (ex: 10 Hz) to a higher frequency that the 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 = 1.4 @ 10 Hz & 50°C) and shifting the frequency to the desired level (Ex: from 10 Hz to 1 KHz) and determining the temperature delta (Approximately 40°C for Viscoelastic Damping Polymer 110).



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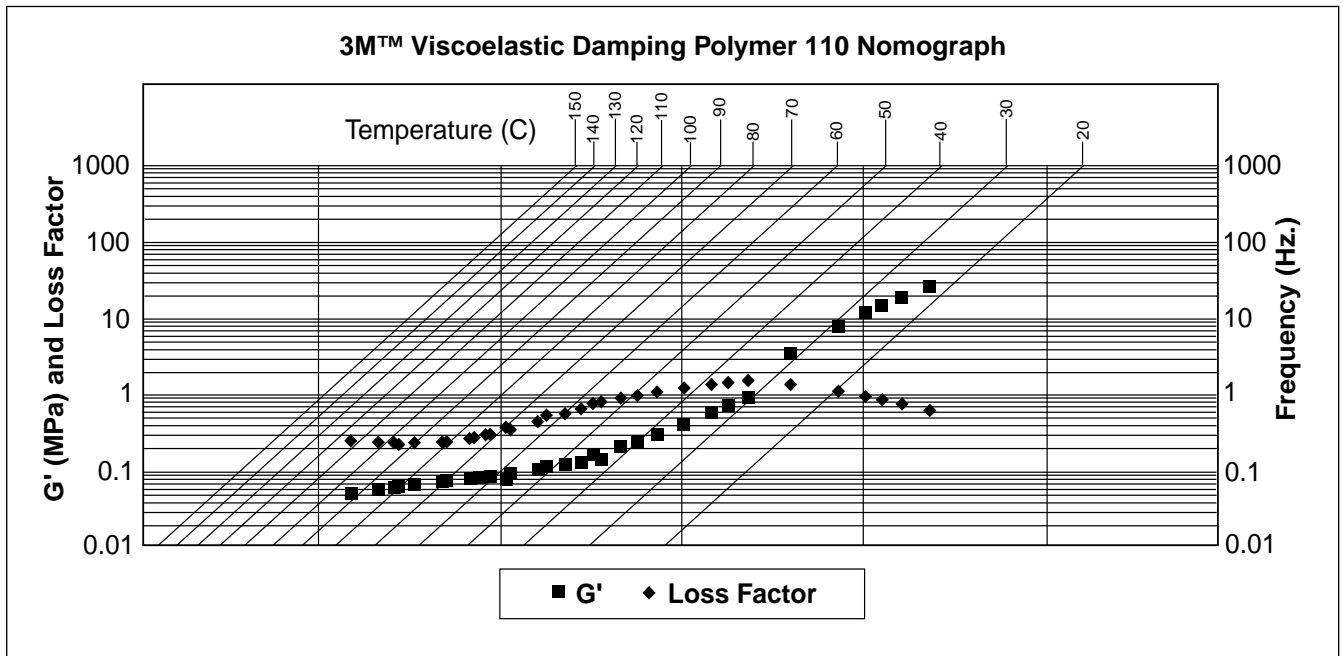
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Nomograph

The 3M™ Viscoelastic Damping Polymer 110 and 3M™ VHB™ Adhesive Transfer Tapes 9460, 9469 and 9473 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 Viscoelastic Damping Polymer 110 and VHB Adhesive Transfer Tapes 9460, 9469 and 9473 at a specific temperature and frequency.

The Loss Factor and Storage Modulus are found for the Viscoelastic Damping Polymer 110 and VHB Adhesive Transfer Tapes 9460, 9469 and 9473 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.



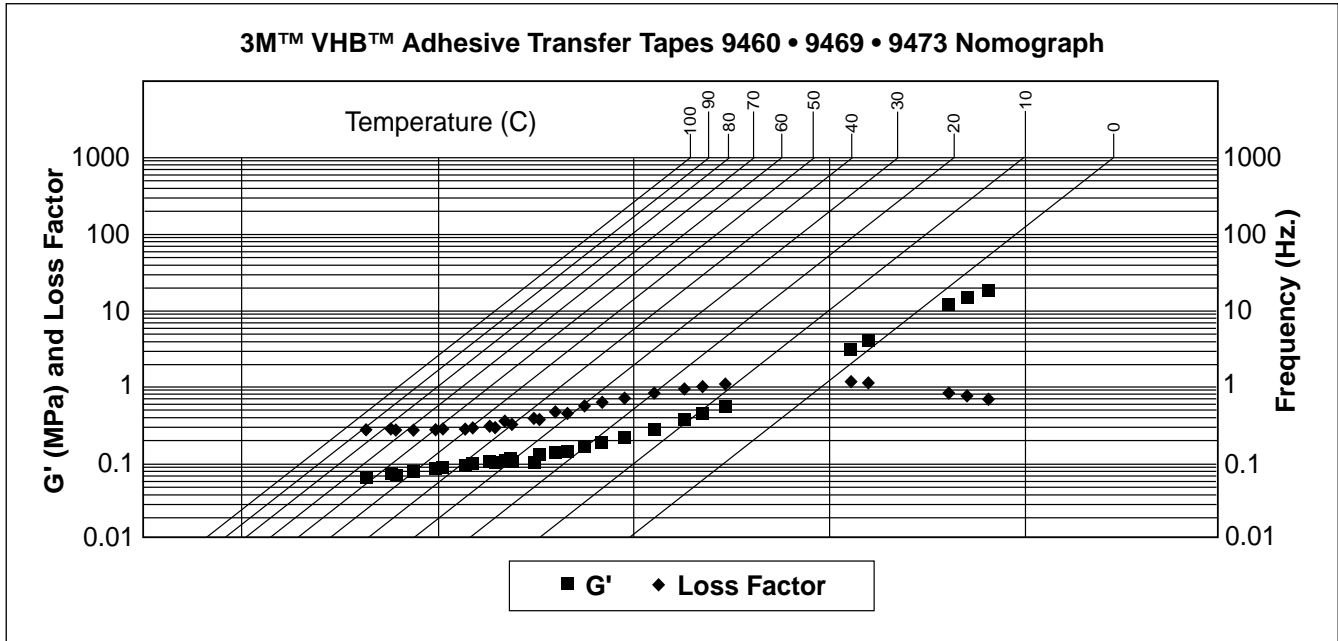
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Nomograph (continued)



Note: The nomographs and 2-point vibration test data for the 3M™ Viscoelastic Damping Polymer 110 and 3M™ VHB™ Adhesive Transfer Tapes 9460, 9469 and 9473 polymers were tested per 3M test methods and test conditions only. The polymers are not certified for damping performance.

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

Viscoelastic Damping Polymer 110P02 – 5-30 $\mu\text{g}/\text{cm}^2$ (Hydrocarbons, organic acids, esters, alcohols, acrylates, acetates, etc.)

VHB Adhesive Transfer Tapes 9460, 9469 and 9473 – See VHB™ specification literature for test method and results.

Typical Total Ionics by Ion Chromatograph

Viscoelastic Damping Polymer 110P02 – $<1 \mu\text{g}/\text{cm}^2$ (Chloride, Nitrate, Sulfate)

VHB Adhesive Transfer Tapes 9460, 9469 and 9473 – To be determined.

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

Poissons Ratio for Viscoelastic Damping Polymer 110 and VHB Adhesive Transfer Tapes 9460, 9469 and 9473: Approximately 0.49.

Density for Viscoelastic Damping Polymer 110 and VHB Adhesive Transfer Tapes 9460, 9469 and 9473: Approximately 0.9-1.0 g/cc.

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

	SS @ 15 min. RT	SS @ 72 Hr RT	SS @ 72 Hr 158F
3M™ Viscoelastic Damping Polymer 110P02	N/A	44	61
3M™ Viscoelastic Damping Polymer 110P05	N/A	19	48
3M™ VHB™ Adhesive Transfer Tape 9460	See VHB Adhesive Transfer Tape specific literature for test methods and results.		
3M™ VHB™ Adhesive Transfer Tape 9460			
3M™ VHB™ Adhesive Transfer Tape 9460			

***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)

Viscoelastic Damping Polymer 110P02 – 21 g/inch width.

VHB Adhesive Transfer Tapes 9460, 9469 and 9473 – N/A.

Damping Polymer Application Instructions

In many applications of the VHB Adhesive Transfer Tapes 9460, 9469 and 9473 to a constraining layer or substrate the 3M Adhesive Transfer Tape need only pressure to provide adequate bonding at room temperature 70°F (21°C). The Viscoelastic Damping Polymer 110 requires heat and pressure for adequate bonding conditions.

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.

• Surface Preparation

For an acceptable bonding of the Viscoelastic Damping Polymer 110 and VHB Adhesive Transfer Tapes 9460, 9469 and 9473 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 contaminates.

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

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Damping Polymer Application Instructions (*continued*)

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 and 3M™ VHB™ Adhesive Transfer Tapes 9460, 9469 and 9473 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 or if additional surface treatments are required to achieve the desired bond strength and environmental performance.

- **Application**

The VHB Adhesive Transfer Tapes 9460, 9469 and 9473 polymers are tacky at room temperature 70°F (21°C). The VHB Adhesive Transfer Tapes 9460, 9469 and 9473 polymers require only rolling or squeegeeing methods to apply pressure to the 3M polymer 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 VHB Adhesive Transfer Tapes 9460, 9469 and 9473 polymer bond will typically build with time or exposure to higher temperature.

The Viscoelastic 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 Viscoelastic Damping 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 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 Viscoelastic Damping Polymer 110 and VHB Adhesive Transfer Tapes 9460, 9469 and 9473 during bonding. Temperatures above 250°F (121°C) 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 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 polymer layer to a structure to be damped (car door panels, disk drive covers).

• Selection of a Damping Polymer

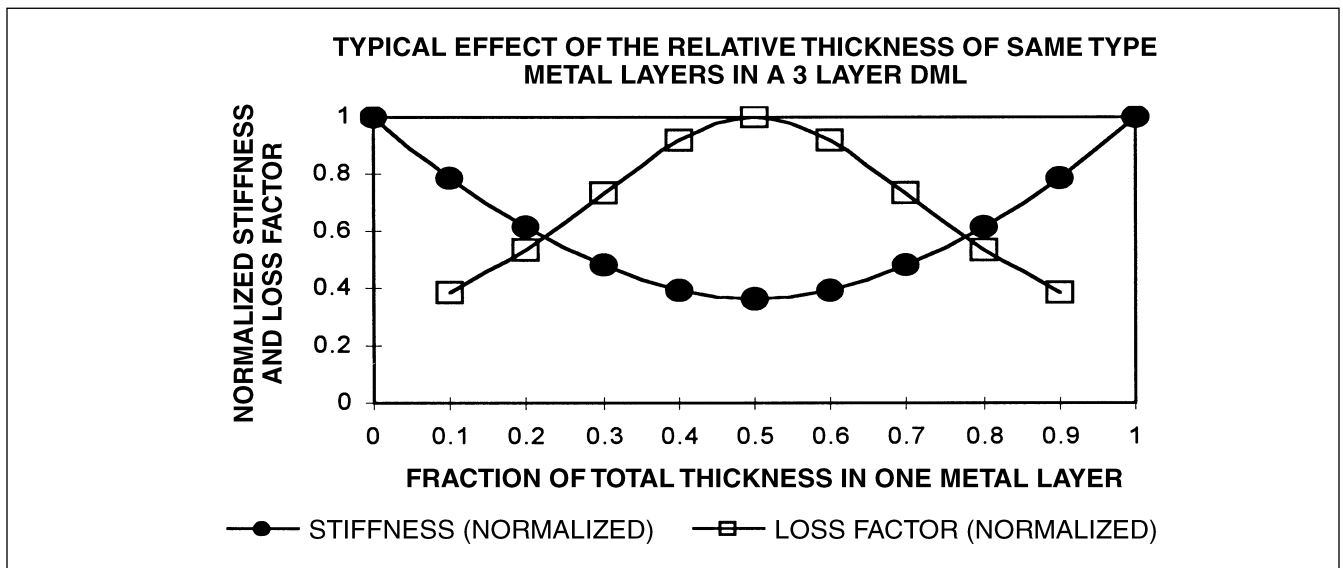
The selection of a 3M damping polymer can be accomplished by determining the operating temperature and frequency ranges of the application that is desired to be damped. The temperature and frequency ranges are used with the Nomograph to determine which polymer has the most optimal performance (high Loss 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 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 damping polymer thickness of about one mil and where the ratio of the metal layers combined thickness to the thickness of the damping polymer is in the range of about 20:1 to about 50:1.

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



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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 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 it’s typical thickness ($EM = \text{thickness} * \text{modulus}$).

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 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 Damping Polymer thickness of two to ten mils.

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Shelf Life

Product shelf life is 2 years from date of manufacture when stored at room temperature conditions (72°F [22°C] and 50% RH) in the products original packaging.

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 Electronics Markets Materials Division, Building 21-1W-10, 900 Bush Avenue, St. Paul, MN 55144-1000. Our fax number is 651-778-4244. In Canada, phone: 1-800-364-3577. In Puerto Rico, phone: 1-787-750-3000. In Mexico, phone: 52-70-04-00.

Certification/Recognition

MSDS: 3M has not prepared a MSDS for these products which are not subject to the MSDS requirements of the Occupational Safety and Health Administration's Hazard Communication Standard, 29 C.F.R. 1910.1200(b)(6)(v). When used under reasonable conditions or in accordance with the 3M directions for use, these products should not present a health and safety hazard. However, use or processing of the product in a manner not in accordance with the directions for use may affect their performance and present potential health and safety hazards.

TSCA: These products are defined as articles under the Toxic Substances Control Act and therefore, are exempt from inventory listing requirements.

UL: The 3M™ VHB™ Adhesive Transfer Tapes 9460, 9469 and 9473 products have been recognized by Underwriters Laboratories Inc. per UL-746C.

The products meet the UL-746C test requirement of maintaining at least 50% of their initially tested Overlap Shear strength after heat aging for 1000 hours at the test temperature. See UL file #MH17478 for details on polymer performance on specific substrates and testing temperatures.

Additional testing completed and passed per UL-746C test methods include:

- Effect of Humidity: 7 days @ 95% Relative Humidity (RH) @ 60°C.
- Effect of Environmental Cycling (3 cycles): 1 cycle = 24h immersed in 25°C water / 24h @ rated temperature / 96h @ 35°C @ 90% RH / 8 h @ -35°C.

Note: 3M™ Viscoelastic Damping Polymer 110 has not been tested per UL-746C or UL-746A test procedures.

Product Use

All statements, technical information and recommendations contained in this document are based upon tests or experience that 3M believes are reliable. However, many factors beyond 3M's control can affect the use and performance of a 3M product in a particular application, including the conditions under which the product is used and the time and environmental conditions in which the product is expected to perform. Since these factors are uniquely within the user's knowledge and control, it is essential that the user evaluate the 3M product to determine whether it is fit for a particular purpose and suitable for the user's method of application.

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ISO 9002

This Electronics Markets Materials Division product was manufactured under a 3M quality system registered to ISO 9002 standards.



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