



Technical Bulletin

3M™ VHB™ Durability

March, 2001

Durability of 3M™ VHB™ Tapes

Summary

This bulletin addresses the long-term durability of VHB™ Acrylic Foam and Adhesive Transfer Tape products and their ability to perform in certain types of demanding environments. This will be addressed from a variety of view-points including chemical composition, resistance to harsh environments, 3M and independent tests for product durability, and certain applications where VHB™ Tape products have demonstrated excellent ability to perform in demanding applications. Test results on moisture resistance, UL durability, accelerated weathering, outdoor weathering, thermal cycling and fatigue resistance will be discussed.

Composition

3M has been a technological leader in acrylate pressure sensitive adhesive (PSA) technology for over 35 years. The VHB™ Acrylic Foam and Adhesive Transfer Tapes represent examples of 3M's proprietary state-of-the-art in this durable chemistry. The long-term aging resistance lies in the polymer comprising VHB™ Adhesive Transfer and Foam Tapes. The chemical bonds that make up the polymer chains consist of carbon-carbon single bonds that are highly resistant to energy in the form of heat or ultraviolet light, as well as chemical attack. In less durable foams or adhesives, such conditions could lead to cleaving of the polymer backbone and thus a weakening of mechanical properties. In the case of acrylic adhesives and foams, however, additional crosslinking is chemically favored over chain scission (cleavage). This means that, rather than undergoing a process of decomposition, the acrylate materials will tend to build modulus very slightly over extended exposures. This translates to a stronger, long lasting bond.

Durability Testing

Temperature Exposure

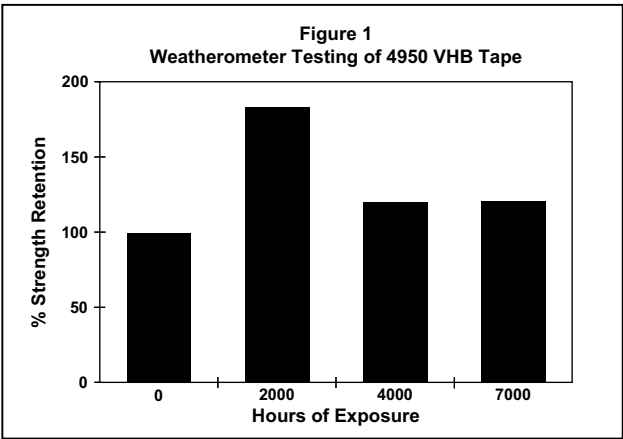
Because of the demanding and diverse applications users have for VHB™ tapes, durability has always been a key interest in the performance of these products. One of the first issues for tapes is retention of tack and adhesion after exposure to elevated temperatures. The VHB™ Adhesive Transfer Tape F-9473PC yielded 92% retention of peel adhesion after the roll was aged for more than 5 years at 150°F (65°C). The initial tack and liner release properties were still excellent. The difference in peel values suggests that a roll of this tape is relatively unaffected by long-term exposure to elevated temperatures. Bonds made with VHB™ Tapes can tolerate periodic, short-term exposures to temperatures up to 300°F (150°C) for most Foam Tapes and 500°F (260°C) for Adhesive Transfer Tapes.

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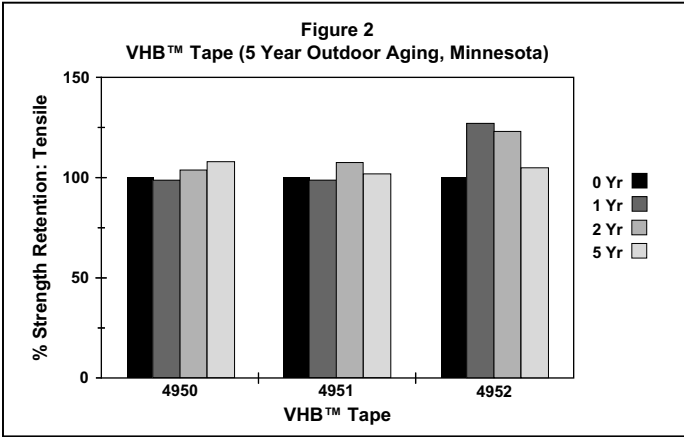
Accelerated Weathering

Certain other accelerated aging tests have been conducted in weatherometers which subject a bond to heat, humidity and concentrated ultraviolet light exposure. These tests were performed in dynamic shear by making a stainless steel overlap bond with VHB™ tape 4950 and then subjecting the samples to cycling heat, humidity and carbon and arc lamp exposure. Small samples provided an increased amount of edge exposure to UV radiation. Figure 1 indicates that the bond strength does not deteriorate below its original performance level, even after exposure of 7000 hours in the weatherometer under these tests.



Outdoor Weathering

Outdoor weathering decks in Arizona, Florida and other locations around the world are also used to collect data on the long-term performance of the VHB™ tape family. These tests typically demonstrate about 100% bond strength retention in certain VHB™ Tapes after 2 to 5 years aging cycles in the hot, humid climate of Florida, the hot, dry and very sunny climate of Arizona and the cold to hot extremes of Minnesota on bonds to aluminum, glass, PVC and painted metal. Figure 2 shows the constant performance of VHB™ tapes 4950, 4951 and 4952 after 5 years of outdoor aging in Minnesota. Similar results have been obtained in 5 year tests conducted in Japan on the VHB™ tapes.



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Moisture and Solvent Resistance

Adhesion tests have been performed on VHB™ Tape 4945 bonds of aluminum to aluminum that were subjected to over 10 years of submersion in 5% salt water and ordinary tap water. After testing, bright clean aluminum surfaces were observed underneath the adhesive bond. A combination of adhesive and cohesive failure modes were observed when the bond was broken which indicated very high performance levels. Long-term exposure to high humidity or water submersion can have the effect of making a polymer more resilient and tolerant of high elongation. A subsequent lowering in peak force is also measured after many days of exposure, usually on the order of 40%. This effect is typical as it parallels the increase in resilience and is the same trend often seen with structural silicone materials which are also recognized for their durability. Drying of the VHB™ Tape bond, which occurs in a normal environmental cycle, will show that this effect is reversible and that the bond will return to the original dry strength.

After splashes or incidental contact with solvents such as fuels, alcohols, adhesive removers like MEK, and even weak acids or bases, no affect is measured on the bond performance. Only after continuous submersion in harsh fuels or solvents is softening of the adhesive/foam experienced. **Note:** While VHB™ Tape products may withstand occasional contact with these types of chemicals, continuous exposure is not recommended.

UL Listing and Durability Testing

Both transfer tape and foam representatives of the VHB™ Tape family have UL 746C listings which involve stringent qualification tests and periodic monitoring by Underwriter's Laboratories. Qualification for this listing requires high-strength retention after extended exposure to high temperatures, humidity, cold, and cyclic conditions. The table below details VHB™ Tapes with the UL 746C listing, and substrate combinations, as well as the maximum listed temperature for each combination.

3M™ VHB™ Tapes
UL746C Listings - File MH 17478
Category QOQW2 Component - Polymeric Adhesive Systems, Electrical Equipment

Product Families	Substrates	Temp Rating
VHB™ Foam Tapes 4950, 4930, 4920	Aluminum, Stainless Steel, Galvanized Steel, Enameled Steel, Glass/Epoxy, Ceramic	110°C
	PBT	90°C
	Polycarbonate, ABS, unplasticized PVC	75°C
Conformable VHB™ Foam Tapes 4956, 4941, 4936, 4926	Ceramic	110°C
	Aluminum, Stainless Steel, Galvanized Steel, Enameled Steel, Polycarbonate, unplasticized PVC, Glass/Epoxy, PBT	90°C
	ABS	75°C
VHB™ Foam Tape 4945	Phenolic, Aluminum, Galvanized Steel, Alkyd Enamel	110°C
	Polyamide (Nylon), Polycarbonate, ABS	90°C
	Unplasticized PVC	75°C
VHB™ Adhesive Transfer Tapes F-9473PC, F-9469PC, F-9460PC	Stainless, Steel, Glass/Epoxy, Enameled Steel, Ceramic, Phenolic; Nickel Plated Steel (9469 only)	110°C
	ABS, Polycarbonate, Aluminum Galvanized Steel	90°C
	Unplasticized PVC	75°C

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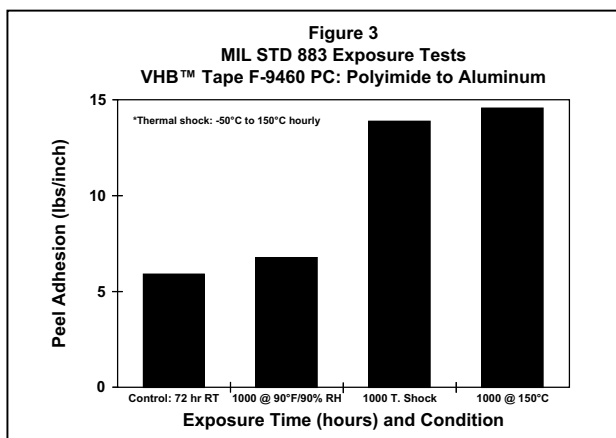
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Clarity

Since the introduction of the clear VHB™ Acrylic Tapes 4910 and 4905, the additional issue of long-term clarity and appearance consistency is commonly asked. Tests have been run for 3000 hours in an accelerated weathering machine which exposes bonds to high temperatures and intense ultraviolet (UV) light. To measure clarity, 3 mm float glass plates were bonded together with VHB™ Tape 4910, the 0.040" thick transparent VHB™ Tape. The percent transmittance was monitored periodically during the exposure cycle, beginning at 88.2% and finishing at 87.3%. After this long, harsh exposure, only a 1% change in transmittance was observed. In high humidity environments, however, the VHB™ Tapes 4910 and 4905 may take on a hazy appearance due to slight absorption of water molecules. Because the same acrylic polymers are used throughout the VHB™ Tape family, these results suggest inherent stability of the whole family.

Thermal Shock

The VHB™ Tapes have also performed well in tests, similar to MILSTD 883, which are commonly used to qualify durable products for the electronics industry. Under this testing, protocol bonds are subjected to 1000 hours at 150°C, 1000 hours at 85°C and 85% relative humidity, and 1000 hours of thermal shock which cycles hourly from -50°C to 150°C. Figure 3 shows the excellent performance of the VHB™ Adhesive Transfer Tape F-9460PC in similar testing which involved bonding polyimide to aluminum. Typically the bond strength increases with time due to the high performance PSA's more complete wet out of the surfaces.



Fatigue

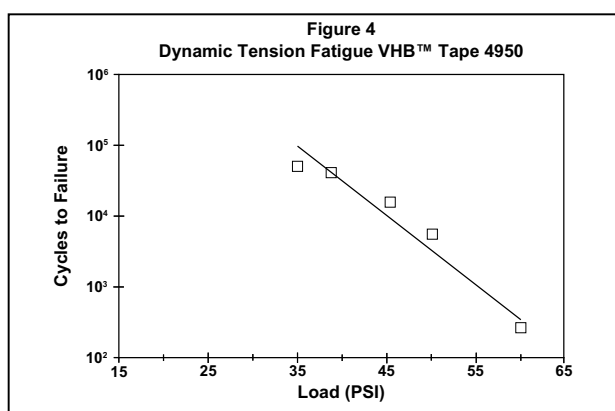
Another durability issue is fatigue resistance. Many types of adhesive tests are run in a short-term peel, shear or tensile mode where the sample is broken in a matter of a few seconds. These tests are convenient for quick characterization of the peak force holding capability, but do not offer any information about a product's ability to tolerate vibration or repetitive strains. Because users have used VHB™ Tapes in many applications which require fatigue resistance, such as trucks or trailers, signs and building panels, a test has been designed by 3M to characterize this property.

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Fatigue (*continued*)

In a constant stress machine, tension samples were cyclically loaded over a range of stresses. The loads were chosen so that bond failures would occur over a broad range of times. As the load decreases, the specimens will survive more and more cycles and this trend can be plotted semi-log as in Figure 4. The semi-log plot yields a straight line which can be used to help predict longer term performance at lower stresses not practical to measure. Given a product lifetime estimate for cyclic loading, the data can be extrapolated to estimate the maximum tolerable design stress. For Acrylic Foam Tapes, this is typically about 20 psi for one million cycles of full reversal loading. VHB™ Tapes tend to perform well in these types of tests because of their inherent viscoelasticity. The acrylic foam and adhesive absorb energy and relax stresses internally, thus helping protect the adhesive bond on the substrate.



Application Examples of Durability

While positive test results are always encouraging, some of the best examples of VHB™ Tape's durability are existing applications in the field. VHB™ Adhesive Transfer Tapes have been used since the mid 1970's and VHB™ Acrylic Foam Tapes have applications dating back to 1980.

One of the oldest and most visible applications for the VHB™ Foam Tapes is on ambulance bodies. The aluminum panels comprising the body of an ambulance can be bonded onto the frame with VHB™ Tape. These applications require durability in harsh conditions on rugged vehicles that are in service for many years.

Another example of durable applications with excellent performance have been curtain wall constructions such as the Singapore Treasury Building. Here the exterior panels are stiffened against wind loads by attaching unseen stiffeners to the inner surface. These bonds must sustain wind loads, daily thermal expansion and contraction cycles, and elevated temperatures. Similar curtain wall and facade applications exist around the world. Architectural signs and traffic signs using VHB™ Tapes have also been standing up to constant weathering, buffering winds, and occasional storms since the early 1980's.

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Application Examples of Durability (continued)

Another example of VHB™ Tape durability has been generated at the Bendix Automotive Proving Grounds in Indiana. A full size semi-truck with sleeper cab was constructed with all exterior panels and doors taped to an underlying frame with VHB™ Tape 4950. After approximately 300,000 simulated miles on the harsh Durability Track, the VHB™ Tape bonds remained completely intact. This is particularly impressive in light of the fact that some mechanically joined and welded parts experienced failures and required repairs for the test to continue.

One of the most demanding applications for VHB™ Tape has been on aircraft exteriors. Several commercial aircraft models have incorporated stainless steel anti-chafing strips bonded to the aluminum wing flaps. These panels help prevent abrasion and chafing between the flap and underside of the wing during movement of the flaps for take offs, landings, and in-flight vibration. VHB™ Adhesive Transfer Tape 9473 continues to be a means for bonding these panels into place. This application has been in use since 1984. Durability is particularly key in this application since the bond can be subjected to high skin temperatures in direct sunlight on the ground and -65°F (-54°C) at high altitudes. In addition, this cycle can be repeated several times per day.

Recognition/ Certification

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 products 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.

For Additional Information

To request additional product information or to arrange for sales assistance, call toll free 1-800-362-3550 or visit www.3M.com/bonding. 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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Limited Warranty

3M warrants for 24 months from the date of sales or delivery, whichever occurs first, that 3M brand VHB™ Tape will be free of defects in material and manufacture. 3M MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. This Limited Warranty does not cover damage resulting from the use or inability to use 3M brand VHB™ Tape due to misuse, workmanship in application, or application or storage not in accordance with 3M recommended procedures.

Limitation of Remedies and Liability

If the 3M product is proved to be defective, THE EXCLUSIVE REMEDY, AT 3M'S OPTION, SHALL BE TO REFUND THE PURCHASE PRICE OF OR TO REPAIR OR REPLACE THE DEFECTIVE 3M PRODUCT. 3M shall not otherwise be liable for loss or damages, whether direct, indirect, special, incidental, or consequential, regardless of the legal theory asserted, including, but not limited to, contract, negligence, warranty, or strict liability.

ISO 9002

This Bonding Systems Division product was manufactured under a 3M quality system registered to ISO 9002 standards.



Bonding Systems Division

3M Center, Building 220-7E-01
St. Paul, MN 55144-1000



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