



3M™ VHB™ Tape Durability

Technical Bulletin

August, 2018

Summary

This bulletin addresses the long-term durability of 3M™ VHB™ Tapes 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 3M™ 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 is a technological leader in acrylate pressure sensitive adhesive (PSA) technology. 3M™ VHB™ Tapes represent examples of 3M's proprietary, state-of-the-art chemistry. The long-term aging resistance lies in the polymer comprising 3M™ VHB™ 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

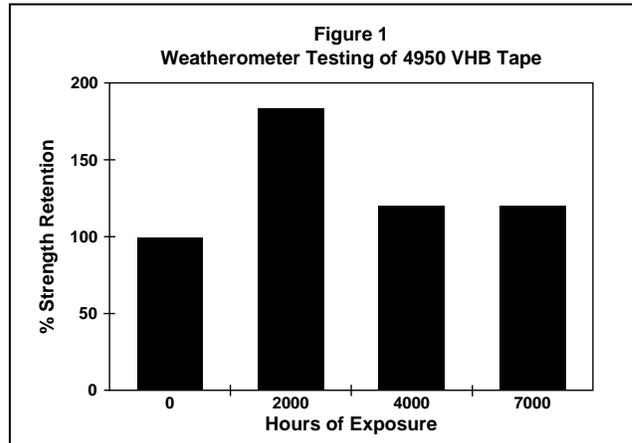
Because of the demanding and diverse applications users have for 3M™ VHB™ Tapes, durability has always been a key interest in the performance of these products. One of the first issues for tapes is retention of tack and adhesion after exposure to elevated temperatures. Bonds made with 3M™ VHB™ Tapes can tolerate periodic, short- term exposures to temperatures up to 300°F (150°C) for most Foam Tapes.

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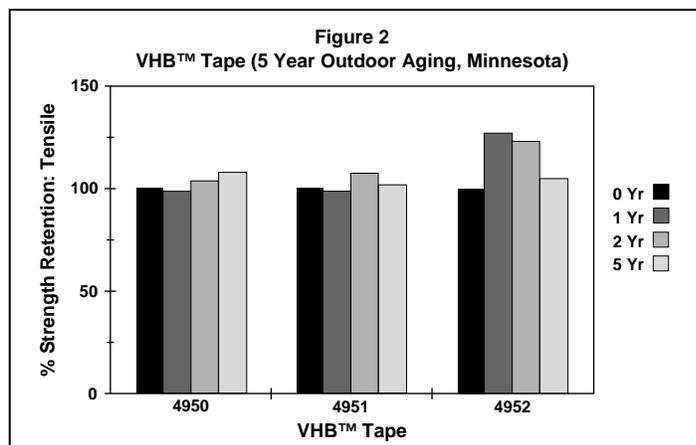
Accelerated Weathering

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 3M™ 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 3M™ VHB™ tape family. These tests typically demonstrate about 100% bond strength retention in certain 3M™ 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 3M™ 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 3M™ VHB™ Tapes.



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Moisture and Solvent Resistance

Adhesion tests have been performed on 3M™ 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 was observed when the bond was broken, indicating 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 3M™ 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 3M™ VHB™ Tape products may withstand occasional contact with these types of chemicals, continuous exposure is not recommended.

UL Listing and Durability Testing

3M™ VHB™ Tape carries 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 3M™ VHB™ Tapes with the UL 746C listing, and substrate combinations, as well as the minimum and maximum listed temperature for each combination.

3M™ VHB™ Tapes UL746C Listings - File MH 17478 Category QQQW2 Component - Polymeric Adhesive Systems, Electrical Equipment			
3M™ VHB™ Tapes/ Product Families	Substrates	Temperature Rating	
		Minimum	Maximum
4919F, 4926, 4936, 4936F, 4941, 4941F, 4947F, 4956, 4956F, 4979F	Ceramic	-35°C	110°C
	Aluminum, Galvanized Steel, Stainless Steel, Enameled Steel, Nickel Coated ABS, Glass (with or without Silane Coating) PVC, Glass/Epoxy, PBT, Polycarbonate, Acrylic/Polyurethane Paint, Polyester Paint	-35°C	90°C
	ABS	-35°C	75°C
4991	Polycarbonate, Aluminum, Acrylic/ Polyurethane Paint, Polyester Paint	-35°	90°C
5915, 5915P, 5915WF, 5925, 5925P, 5925WF, 5930, 5930P, 5930WF, 5952, 5952P, 5952WF, 5962, 5962P, 5962WF	Polycarbonate, Primer 94 Coated Polycarbonate, Aluminum, Acrylic/ Polyurethane Paint, Galvanized Steel, Polyester Paint, Epoxy Paint, Silane Coated Glass, Uncoated Glass, Stainless Steel, Enameled Steel, Glass Epoxy, Polybutylene Terephthalate, Nylon, Polyphenelene Ether (PPE), Acrylic	-35°C	90°C
	Rigid PVC, ABS	-35°C	75°C
	Cellulose Acetate Butyrate	-35°C	90°C
RP16	Aluminum, Silane Coated Glass	-35°C	90°C
	PVC, ABS	-35°C	75°C
RP16, RP25, RP32, RP45, RP62	Galvanized Steel, Enameled Steel, Nylon, Polycarbonate, Glass Epoxy, Phenolic, PPE/PS Blend, PBT, Epoxy Paint, Polyester Paint, Adhesion Promoter 111 Coated Epoxy Paint, Promoter 111 Coated Polyester Paint, Acrylic Urethane Paint, Epoxy/ Polyester Paint	-35°C	90°C
RP62	Stainless Steel, Glass, Acrylic	-35°C	90°C
	PVC, ABS	-35°C	75°C

Current listings of all 3M VHB Tapes can be found at www.ul.com

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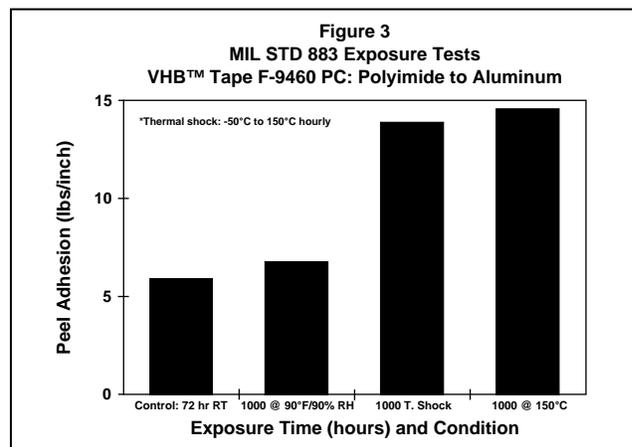
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Clarity

Since the introduction of the clear 3M™ VHB™ 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 3M™ VHB™ Tape 4910, a 0.040" thick, transparent foam 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, 3M™ 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 3M™ VHB™ Tape, these results suggest inherent stability of the whole family.

Thermal Shock

The 3M™ 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 3M™ 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

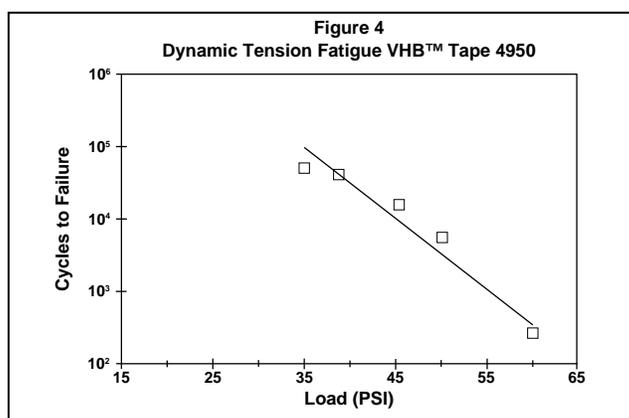
Another durability issue is fatigue resistance. Many types of adhesive tests are run in a short-term peel, shear or tensile mode where the sample is broken in a matter of a few seconds. These tests are convenient for quick characterization of the peak force holding capability, but do not offer any information about a product's ability to tolerate vibration or repetitive strains. Because users have used 3M™ 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; 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 3M™ VHB™ Tapes, this is typically about 20 psi for one million cycles of full reversal loading. These 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 3M™ VHB™ Tape's durability are existing applications in the field. 3M™ VHB™ Tapes have been used in applications dating back to 1980.

One of the oldest and most visible applications for the 3M™ VHB™ Foam Tapes is on ambulance bodies. The aluminum panels comprising the body of an ambulance can be bonded onto the frame with 3M™ 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 such as the Walt Disney Concert Hall in Los Angeles, California and composite ceiling panels in the O'Hare Airport in Chicago, Illinois. Architectural signs and traffic signs using 3M™ 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 3M™ VHB™ Tape durability came from testing 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 3M™ VHB™ Tape 4950. After approximately 300,000 simulated miles on the harsh Durability Track, the 3M™ VHB™ Tape bonds remained completely intact. This is particularly impressive as some mechanically joined and welded parts experienced failures and required repairs for the test to continue.

One of the most demanding applications for 3M™ 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. 3M™ 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.

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Many factors beyond 3M's control and uniquely within user's knowledge and control can affect the use and performance of a 3M product in a particular application. As a result, customer is solely responsible for evaluating the product and determining whether it is appropriate and suitable for customer's application, including conducting a workplace hazard assessment and reviewing all applicable regulations and standards (e.g., OSHA, ANSI, etc.). Failure to properly evaluate, select, and use a 3M product and appropriate safety products, or to meet all applicable safety regulations, may result in injury, sickness, death, and/or harm to property.

Warranty, Limited Remedy, and Disclaimer

3M warrants for 24 months from the date of manufacture that 3M™ VHB™ Tape will be free of defects in material and manufacture. 3M MAKES NO OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR ARISING OUT OF A COURSE OF DEALING, CUSTOM, OR USAGE OF TRADE. This warranty does not cover damage resulting from the use or inability to use 3M™ VHB™ Tape due to misuse, workmanship in application, or application or storage not in accordance with 3M recommended procedures (except to the extent 3M approves and issues a specific application warranty, for which the customer must apply, receive 3M approval, and meet all applicable warranty and process requirements, the additional details, terms, and conditions of which are available from 3M). If a 3M product does not conform to this warranty, then the sole and exclusive remedy is, at 3M's option, replacement of the 3M product or refund of the purchase price.

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Except for the limited remedy stated above, and except to the extent prohibited by law, 3M will not be liable for any loss or damage arising from or related to the 3M product, whether direct, indirect, special, incidental, or consequential (including, but not limited to, lost profits or business opportunity), regardless of the legal or equitable theory asserted, including, but not limited to, warranty, contract, negligence, or strict liability.



This Industrial Adhesives and Tapes Division product was manufactured under a 3M quality system registered to ISO 9001 standards.



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