

3M™ VHB™ Structural Glazing Tape



2007



3M™ VHB™
**Structural
 Glazing Tape**
 TECHNICAL GUIDE

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Introduction

This technical guide is intended to give guidance on the proper fabrication methods used in the assembly of a 3M™ VHB™ Tape structurally glazed curtain wall system. Also included are the procedures associated with a proper quality assurance and warranty program. This guide should be considered as a reference document only and should not be considered as a comprehensive process guide or quality assurance program for all applications due to the variability of design and performance requirements associated with different applications. Therefore, it is recommended that the customer contact a 3M Sales Representative or the 3M Technical Support Center when considering the 3M™ VHB™ Structural Glazing Tape process for a structural glazing application.

Technical Support Center

All 3M™ VHB™ Structural Glazing Tape projects require a thorough application assessment by the 3M Technical Support Center prior to the initiation of each project. 3M requires the customer to work with a 3M Sales Representative and a Technical Service Representative to initiate a 3M™ VHB™ Tape structural glazing application. Each project must be reviewed and approved by 3M before the 3M™ VHB™ Structural Glazing Tape can be used on a project. Use the appropriate regional telephone number listed below to initiate the 3M™ VHB™ Structural Glazing Tape process. ***Be sure to ask for 3M™ VHB™ Structural Glazing Tape Sales, Technical or Marketing support.***

United States:

Technical Service – Steve Austin 651-736-1259

Marketing – Mark Jennings 651-736-6076

Or for your local 3M Sales Representative – 1-800-362-3550

For a global 3M contact list please see page 27.

Product Portfolio

3M™ VHB™ Structural Glazing Tape G23F

3M™ VHB™ Structural Glazing Tape G23F is a gray closed cell, double sided acrylic foam tape that has the capability to develop very high bond strength and excellent long term holding power when bonded to glass and metal framework. It was developed to replace silicone structural sealants in structurally glazed curtain wall systems.

Construction:

Adhesive: Multi-Purpose Acrylic – 2 sided
Adhesive Carrier: Conformable Acrylic Foam (closed cell)
Thickness: 0.090 in. (2.3 mm)
Density: 42 lb./ft³ (673 kg/m³)
Liner: Red polyethylene film
Tape Color: Gray

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

1. Peel Adhesion: 25 lb./in width (440 N/100 mm)
(stainless steel, ASTM D 3330)
2. Normal Tensile: 70 lb./in² (480 kPa)
(aluminum T-block, ASTM D 897)
3. Dynamic Overlap Shear: 65 lb./in² (450 kPa)
(stainless steel, ASTM D 1002)

3M™ VHB™ Structural Glazing Tape B23F

3M™ VHB™ Structural Glazing Tape B23F is a black closed cell, double sided acrylic foam tape developed to replace silicone structural sealants in structurally glazed curtain wall systems.

Construction:

Adhesive: Multi-Purpose Acrylic - 2 sided
Adhesive Carrier: Conformable Acrylic Foam (closed cell)
Thickness: 0.090 in. (2.3 mm)
Density: 45 lb./ft³ (720 kg/m³)
Liner: Red polyethylene film
Tape Color: Black

Performance Properties: Comparable to the typical results for the 3M™ VHB™ Tape G23F. This technical information and data should be considered representative or typical only and should not be used for specification purposes.

1. Peel Adhesion: 25 lb./in width (440 N/100 mm)
(stainless steel, ASTM D 3330)
2. Normal Tensile: 70 lb./in² (480 kPa)
(aluminum T-block, ASTM D 897)
3. Dynamic Overlap Shear: 65 lb./in² (450 kPa)
(stainless steel, ASTM D 1002)

3M™ VHB™ Structural Glazing Tape 4972 (Brazil)

3M™ VHB™ Structural Glazing Tape 4972 is used exclusively in Brazil and other parts of South America for structural glazing. This product is very similar to the 3M™ VHB™ Structural Glazing Tape G23F with the primary difference being thickness of the acrylic foam tape. This tape has been successfully used for this application in South America since 1990 which demonstrates the capability and long term durability of 3M™ VHB™ Structural Glazing Tape for this application.

Construction:

Adhesive: Multi-Purpose Acrylic - 2 sided
Adhesive Carrier: Conformable Acrylic Foam (closed cell)
Thickness: 0.080 in. (2.0 mm)
Density: 45 lb./ft³ (720 kg/m³)
Liner: Green polyethylene film
Tape Color: Gray

Performance Properties: Comparable to the typical results for the 3M™ VHB™ Structural Glazing Tape G23F listed. This technical information and data should be considered representative or typical only and should not be used for specification purposes.

Adhesion Promoters

Silane Coupling Agents – 3M™ Silane Glass Treatment AP115

Silane coupling agents are required when bonding 3M™ VHB™ Structural Glazing Tape to a bare glass surface. Glass is known to be a hydrophilic (water loving) surface and this characteristic makes the acrylic adhesive bond susceptible to change under high humidity conditions or when exposed to moisture. Simple surface treatment with a silane coupling agent diluted in a mixture of alcohol and water can help to reduce the “water loving” nature of the glass and enhance the tape bond in high moisture environments. 3M has tested silane coupling agents and has found 3-Glycidoxypropyl trimethoxysilane resin (Dow Corning Z-6040 Silane) to provide the best performance for this application. This silane coupling agent is available premixed and ready to use in various quantities from 3M.

3M™ Primer 94

3M™ Primer 94 is a one-part solvent based primer. It can be used to promote adhesion of 3M™ VHB™ Structural Glazing Tape to

metal frames especially when the frame has been overcoated with paint. This primer may also be required on glass when a reflective coating is present on the interior side of a glass panel. A 3M Technical Service Representative will help you determine if a primer is needed to achieve high bond strength of the tape to a metal frame or reflective coated glass.

3M™ Adhesion Promoter 111

3M™ Adhesion Promoter 111 (AP 111) is an isopropyl alcohol based solution used to promote adhesion of 3M™ VHB™ Structural Glazing Tapes to metal frames especially when the frame has been overcoated with PVDF based paints. A 3M Technical Service Representative will help you determine if a primer is needed to achieve high bond strength of the tape to a metal frame

Abrasion Pads

Scotch-Brite™ General Purpose Hand Pad 7447

These abrasive pads may be used to lightly abrade the metal frame bonding surface to increase bond strength of the tape to the metal frame. They are available in maroon or green colors

and can be used by hand or attached to a power palm sander. Testing by a 3M Technical Service Representative will determine if abrasion is required to achieve high bond strength to a specific metal frame finish.

Introduction and Background

3M™ VHB™ Structural Glazing Tape is a high performance bonding material used to attach glass to structural glazing frames replacing commonly used mechanical fasteners, gaskets or structural silicone sealants. 3M™ VHB™ Acrylic Foam Tapes have been demonstrated to be very capable bonding products since 1980, providing an often ideal combination of performance, durability, and ease of use. They have been successfully used in a wide variety of demanding industrial applications in areas such as commercial building construction and transportation markets. More specifically, they have been used in thousands of international applications as the main bonding agent for structural glazing of glass curtain walls since 1990. This along with independent, third party test results demonstrates the capability of 3M™ VHB™ Structural Glazing Tape for this application.

Conventional methods of bonding the structural glazing glass panels to a metal frame employ either single part or two part silicone structural sealants. In this system, a double-sided open cell foam tape (spacer tape) is typically used to give temporary holding of the glass and for creating the necessary open space for the structural sealant. The dimension of the spacer tape is decided based on the desired sealant bite and bead thickness. The bond should not be disturbed during the curing of silicone sealant, and it may take days to weeks to achieve handling strength. 3M™ VHB™ Structural Glazing Tape provides an alternative bonding method that can provide the performance needed for the application, yet with some significant benefits.

Potential advantages include:

- Faster assembly
- Lower total cost
- Low mess and less waste
- Immediate handling strength – no long cure time
- Reduced space requirements – no storage of curing units
- Improved aesthetics – no color mismatch between structural silicone and spacer tape/gasket. Also, no voids or streaks as in structural silicone.
- Consistent bond line thickness and width – precise delivery of bonding agent
- 100% nondestructive, in process testing capability – test all panels

3M™ VHB™ Structural Glazing Tape replaces both spacer tape and structural sealant and there is no curing reaction involved in bond strength development.

3M™ VHB™ Structural Glazing Tape Properties and Performance

Structural glazing requires joining systems that meet the highest requirements for adhesive and cohesive strength, weathering resistance and durability. In addition to the performance, the long-term durability of 3M™ VHB™ Structural

Glazing Tape is also critical for these applications. The typical physical properties and performance characteristics such as normal tensile strength, dynamic and static shear strength etc. are well known resulting in the establishment of simple, useful, and conservative design guidelines for tape performance that can be used in design calculations. These design criteria provide sufficient performance for this application, while incorporating safety factors typical of the industry.

Composition

3M has been a technological leader in acrylate pressure sensitive adhesive (PSA) technology for over 40 years. 3M™ Acrylic Foam Tapes and Adhesive Transfer Tapes represent examples of 3M's proprietary state-of-the-art durable chemistry. The long-term aging resistance lies in the polymer comprising these 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

The ability of acrylic adhesives to withstand cold and hot temperatures, UV light exposure, humidity, and other environmental conditions has been documented through both real-life and accelerated aging studies. Accelerated aging tests are conducted by subjecting bonded samples to cycling heat, humidity and xenon arc UV lamp exposure, and measuring the dynamic tensile, shear and peel strength values. These tests demonstrate the bond strength does not deteriorate below its original performance level, even after exposure of 10,000 hours in these extreme weather-o-meter tests.

Real life aging studies take considerably longer to conduct and one must wait for years to learn the behavior of the tape when subjected to weathering conditions, but the results also demonstrate the long-term performance of 3M™ VHB™ Tapes. These tests typically demonstrate about 100% bond strength retention in 3M™ VHB™ Tapes after 2 to 5 year 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. The tests are done on bonds to aluminum, glass, stainless steel, PVC and painted metal. Similar results have also been observed in an 11-year outdoor test conducted in Japan.

Moisture and Solvent Resistance

Water can hydrolyze not only the chemical bonds of every polymer backbone but also the bonding of an adhesive to the substrate's surface. This phenomenon may appear even at room temperature and may cause both cohesive and adhesive failure. Adhesion tests have been performed on 3M™ VHB™ Tape 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 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 sealants, which are also recognized for their durability. Drying of the 3M™ VHB™ Tape bond, which occurs in a normal environmental cycle, shows that this effect is reversible and the bond returned to the original dry strength. Detailed investigations showed that even silicones experience a similar change in material properties after a continuous exposure to water. Therefore, efficient draining of the structural joint is essential for structural glazing constructions. Any uncoated glass bonding application of 3M™ VHB™ Structural Glazing Tapes that is subject to moisture or high humidity should always have the glass surface treated with a silane solution as described in the “Surface Preparation of Glass” section of this manual.

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. Some of these solvents may be included in window cleaning solutions. 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.

Structural Performance Tests

3M™ VHB™ Structural Glazing Tapes have been used worldwide in thousands of glazing applications in the construction industry. To further support consideration for structural glazing applications, performance tests were conducted at an independent, accredited 3rd party test facility (Winwall Technology Pte Ltd – Singapore) to evaluate 3M™ VHB™ Structural Glazing Tapes under stresses and environmental conditions that glass panels would typically experience in a glazed curtain wall system.

The glazed panels constructed with 3M™ VHB™ Structural Glazing Tapes provided excellent performance overall compared to control panels glazed with structural silicone sealant. The first test sequence consisted of a PVB laminated glass panel bonded with 3M™ VHB™ Structural Glazing Tape 4972, a double glazed unit (DGU) bonded with 3M™ VHB™ Structural Glazing Tape G23F and a DGU bonded with a one-part structural silicone sealant. No failure was observed with either the 3M™ VHB™ Tape glazed panels or the structural silicone sealant glazed panel in any of the tests including ASTM E 330 wind load structural tests at ambient, cold and hot temperatures (-13°F and 160°F) up to 2.9 kPa (60 psf), corresponding to a wind speed of 155 mph (250 kph). After this, pressures were gradually increased up to 8.4 kPa (175 psf) at ambient temperature conditions. At this point the laminated glass failed and blew out of the chamber. However, glass was still attached and bonded to the 3M™ VHB™ Structural Glazing Tape 4972 around the perimeter of the frame demonstrating the high strength of the tape.

A second test sequence patterned after the first test sequence was run consisting of two single pane tempered glass lites bonded to 3M™ VHB™ Structural Glazing Tape G23F and one-part structural silicone sealant. The DGU panel bonded with 3M™ VHB™ Structural Glazing Tape G23F was also subjected to this second test sequence after surviving the first test sequence. No failure was observed with either the 3M™ VHB™ Structural Glazing Tape glazed panels or the structural silicone sealant glazed panel in any of the tests including ASTM E 330 wind load structural tests up to 10 kPa (210 psf), which corresponds to a sustained wind speed of 290 mph (467 kph). This testing protocol also demonstrated that no air or water leakage can be obtained with proper assembly methods.

The following table summarizes the results of the 3rd party structural performance tests.

Test Sequence	Test Method	Panels in 1st Test Sequence		Panels in 2nd Test Sequence		
		3M™ VHB™ SGT 4972 Laminated Glass	One-Part Structural Silicone DGU	3M™ VHB™ SGT G23F DGU	One-Part Structural Silicone 8mm Tempered	3M™ VHB™ SGT G23F 8mm Tempered
Air Infiltration	ASTM E283 (at +0.3 kPa)	No air leakage from panel	No air leakage from panel	No air leakage from panel	No air leakage from panel	No air leakage from panel
Water Penetration	ASTM E331 (at +0.72 kPa)	No water leakage	No water leakage	No water leakage	No water leakage	No water leakage
Temperature Cycling	20 cycles -25°C to 70°C	For each cycle, temperature is maintained at -25°C for 15 minutes and +70°C for 15 minutes (±2°C)		Subjected to 40 cycles	For each cycle, temperature is maintained at -25°C for 15 minutes and +70°C for 15 minutes (±2°C)	
Air Infiltration	ASTM E283 (at +0.3 kPa)	No air leakage from panel	No air leakage from panel	No air leakage from panel	No air leakage from panel	No air leakage from panel
Water Penetration	ASTM E331 (at +0.72 kPa)	No water leakage	No water leakage	No water leakage	No water leakage	No water leakage
Windload Structural	ASTM E330 -25°C, 32°C, 70°C (hold for 1 minute)	± 2.9 kPa (60psf, 155 mph)		± 2.9 kPa (60psf, 155 mph)	± 2.9 kPa (60psf, 155 mph)	
Air Infiltration	ASTM E283 (at +0.3 kPa)	No air leakage from panel	No air leakage from panel	No air leakage from panel	No air leakage but presence of water condensation seen on spacer tape	No air leakage from panel
Windload Structural Maximum	ASTM E330 32°C (hold for 10 sec.)	± 6 kPa (125psf, 225 mph)	± 6 kPa (125psf, 225 mph)	± 8 kPa (167psf, 260 mph)	± 8 kPa (167psf, 260 mph)	± 8 kPa (167psf, 260 mph)
Windload Structural Destructive	Maximum Pressure (±)	Glass burst at -8.4 kPa (175psf, 265 mph)	>-8.4 kPa 175psf, 265 mph)	>-10 kPa 210psf, 290 mph)	>-10 kPa 210psf, 290 mph)	>-10 kPa 210psf, 290 mph)

 Subject to 2X cycling tests

Note: The limit of the test chamber was 10 kPa. Testing beyond this point was not possible. Panels were designed for a 2.9 kPa windload pressure. Testing beyond this design pressure demonstrates the safety factor used for 3M™ VHB™ Structural Glazing Tapes.

Structural Glazing with 3M™ VHB™ Structural Glazing Tape

Introduction

A 3M™ VHB™ Structural Glazing Tape curtain wall system is based on the tape acting as the main bonding agent between the glass and the structural glazing frame. The windload forces acting on the facade are transferred through the 3M™ VHB™ Structural Glazing Tape to the structure of the building. The 3M™ VHB™ Structural Glazing Tape must maintain its strong bonding performance and strength in order to support the glass panels during windload and other environmental related events. 3M™ VHB™ Structural Glazing Tape is usually only considered for four-sided or two-sided shop glazed structural glazing applications and is the only 3M™ VHB™ Tape suitable for structural glazing applications. The four-sided structurally glazed system is referred to as a “unitized” curtainwall and should only be assembled in a well controlled factory environment. Years of testing and real life applications demonstrate the high performance capability of this tape to meet the demanding requirements of this application. It is important to note that whenever a 3M™ VHB™ Structural Glazing Tape project is initiated a comprehensive process control plan, including review of the project by 3M, adhesion testing, training of the fabricator and in-process audits must be completed to promote a successful project.

Note: specific process and quality control procedures must be followed on all 3M™ VHB™ Structural Glazing Tape projects in order to obtain a 3M™ VHB™ Structural Glazing Tape Application Warranty.

Structural Joint Design

A typical structural glazing section with 3M™ VHB™ Structural Glazing Tape is given in Fig. 1.

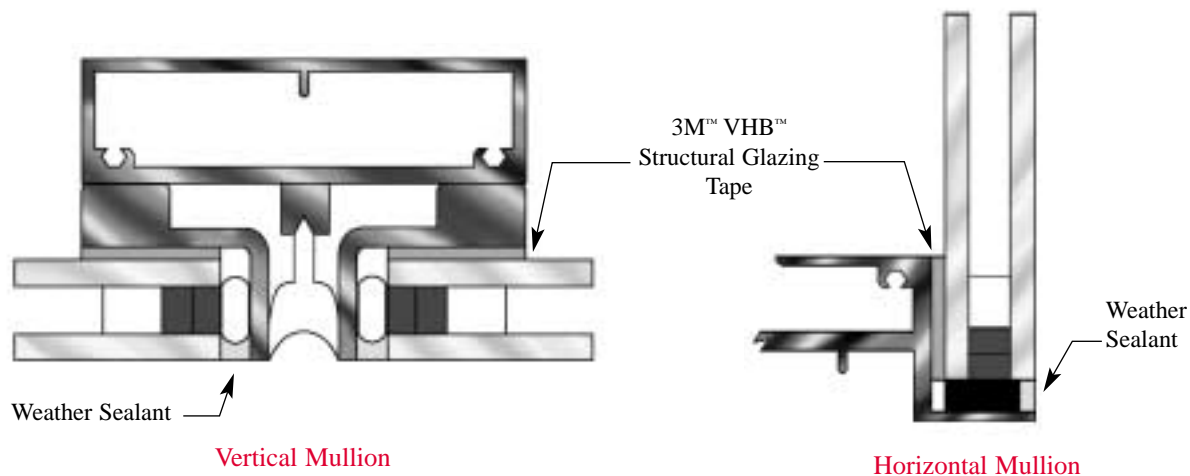


Fig. 1: Glazing sections with 3M™ VHB™ Structural Glazing Tape as the bonding agent

Design Considerations – Adhesion

Adhesion is the molecular force of attraction between unlike materials, similar to a magnetic force. The strength of attraction is determined by the surface energy of the material. The higher the surface energy, the greater the molecular attraction – the lower the surface energy, the weaker the attractive forces. Greater molecular attraction results in increased interfacial contact between an adhesive and a substrate. In other words, on a high surface energy material the adhesive can more easily flow or “wet” the surface to obtain a stronger bond.

A glass surface is generally considered to be a high energy surface. However, surface coatings such as reflective coatings on the glass can change the surface energy of the glass. Likewise, coatings or paint on metal frames will also change the surface energy of a normally high energy surface like bare aluminum. Thus, it is important to have the 3M Technical Support Center review each 3M™ VHB™ Structural Glazing Tape project and run adhesion tests to determine the appropriate surface preparation method for each structural glazing substrate. This will help to ensure that high bond strength of the 3M™ VHB™ Structural Glazing Tape exists to both bonding surfaces.

Design Considerations – Tape Width

The appropriate tape width is determined based on one or two calculations depending on the design of the structural glazing system. Laminated or insulated glass should always have static (deadload) support as part of the framing system. When the deadload is supported, a dynamic load calculation is required to determine the appropriate tape width for the application. For monolithic – single pane glazing applications, deadload support is still recommended but it is up to local governmental regulations, the fabricator/structural engineer and the 3M Technical Service Representative to allow a nonsupported 3M™ VHB™ Structural Glazing Tape project. In structural glazing systems without deadload support,

the weight of the glass places a constant load on the tape. A static load and dynamic load calculation must be performed for these applications.

Tape Width - Dynamic Loads

The minimum tape width for a structural glazing application is dependent on three factors. The design strength of the bonding agent (3M™ VHB™ Structural Glazing Tape), the design pressure (dynamic wind load) requirement for the building and the size of the glass panel. The tape must be the appropriate width to fasten the glass panel and allow the wind load to be transferred to the building structure.

For dynamic tensile or shear loads (such as windloads), a design strength of 12 psi (8435 kg/m² or 85 kPa) is used for 3M™ VHB™ Structural Glazing Tape. This design strength guideline provides a safety factor of at least 5 and was established based on material property testing as well as ASTM dynamic load testing for curtain wall applications. Years of real-life application success also supports the use of this design guideline for this application.

The Trapezoid Rule is the industry recognized calculation used for determining the appropriate bonding agent width for a structural glazing application. This calculation is also commonly used to determine “structural bite” for structural silicone sealant glazing applications and is also applicable for 3M™ VHB™ Structural Glazing Tape applications. This calculation and examples are shown below:

$$\text{Tape Width (inches)} = \frac{0.5 \times \text{panel short edge length (ft)} \times \text{windload (psf)}}{12 \text{ in./ft.} \times \text{tape design strength (12 lbs./in}^2\text{)}}$$

Example: 4' x 6' lite of glass designed to withstand a 60 psf windload

$$\text{Tape Width (inches)} = \frac{0.5 \times 4 \text{ ft.} \times 60 \text{ lbs./ft}^2}{12 \text{ in./ft.} \times 12 \text{ lbs./in}^2} = 0.83" \blacktriangleright \text{ round up to nearest } 1/4" \blacktriangleright 1.0"$$

Note: Always round up to the nearest 1/4" and never round down.

$$\text{Tape Width (mm)} = \frac{0.5 \times \text{panel short edge length (mm)} \times \text{windload (kg/m}^2\text{)}}{\text{Tape design strength (8435 kg/m}^2\text{)}}$$

Example: 1200 mm x 2400 mm lite of glass exposed to a 295 kg/m² windload

$$\text{Tape Width (mm)} = \frac{0.5 \times 1200 \text{ mm} \times 295 \text{ kg/m}^2}{8435 \text{ kg/m}^2} = 21 \text{ mm} \blacktriangleright \text{ round up } \blacktriangleright 25 \text{ mm}$$

Note: Always round up to the nearest whole number divisible by 5 and never round down for metric (mm) calculations.

$$\text{Tape Width (mm)} = \frac{0.5 \times \text{panel short edge length (mm)} \times \text{windload (kPa)}}{\text{Tape design strength (85 kPa)}}$$

Example: same as previous conditions with a windload of 2.9 kPa

$$\text{Tape Width (mm)} = \frac{0.5 \times 1200 \text{ mm} \times 2.9 \text{ kPa}}{85 \text{ kPa}} = 21 \text{ mm} \blacktriangleright \text{ round up } \blacktriangleright 25 \text{ mm}$$

This dynamic load calculation should be done to determine the appropriate VHB™ Structural Glazing Tape width for each glass panel size in the glazing application. The static load calculation must also be performed if the application is for an unsupported monolithic glass application.

Tape Width - Static Loads (Deadload)

Structural glazing applications utilizing unsupported monolithic glass require a static load calculation to determine the appropriate width of 3M™ VHB™ Structural Glazing Tape. A design strength guideline of 0.25 psi (1.75 x 10⁻⁴ kg/mm²) should be used for static load calculations. This means that 4 sq. in. of 3M™ VHB™ Structural Glazing Tape per 1 lb. (55 sq. cm per 1 kg) should be used to support static loads.

Important: Static load and dynamic load calculations should be performed on unsupported deadload structural glazing applications. The calculation resulting in the wider tape width should be used as the appropriate tape width for the application.

The following static load calculation is used to determine the appropriate tape width.

$$\text{Tape Width (inches)} = \frac{\text{glass panel weight (lbs.)}}{\text{Glass perimeter (in.)} \times \text{tape design strength (0.25 psi)}}$$

Example: 3' x 4' lite of monolithic glass with a weight of 2 lbs./ft²

$$\text{Tape Width (inches)} = \frac{(3 \text{ ft.} \times 4 \text{ ft.}) (2 \text{ lbs./ft}^2)}{168 \text{ in.} \times 0.25 \text{ lbs./in}^2} = 0.57" \blacktriangleright \text{ round up } \blacktriangleright 0.75"$$

Note: Always round up to the nearest 1/4" and never round down.

$$\text{Tape Width (inches)} = \frac{\text{glass panel weight (kg)}}{\text{Glass perimeter (mm)} \times \text{tape design strength (1.75} \times 10^{-4} \text{ kg/mm}^2\text{)}}$$

Example: 1000 mm x 1500mm lite of monolithic glass with a weight of 10k kg/m²

$$\text{Tape Width (inches)} = \frac{(1 \text{ m} \times 1.5 \text{ m}) (10 \text{ kg/m}^2)}{2 (1000 \text{ mm} + 1500 \text{ mm}) (1.75 \times 10^{-4} \text{ kg/mm}^2)} = 17 \text{ mm} \blacktriangleright \text{ round up } \blacktriangleright 20 \text{ mm}$$

Important: A dynamic load calculation should also be performed along with the static load calculation. For example, if the 1000 mm x 1500 mm glass panel above were designed to withstand a 1.4 kPa windload, the following dynamic load calculation should be performed:

$$\text{Tape Width (mm)} = \frac{0.5 \times 1000 \text{ mm} \times 1.4 \text{ kPa}}{85 \text{ kPa}} = 8.2 \text{ mm} \blacktriangleright \text{round up} \blacktriangleright \mathbf{10 \text{ mm}}$$

In this example the static load calculation resulted in wider tape width (20 mm) compared to the dynamic load calculation (10 mm). Thus, to satisfy the static load and dynamic load requirements, the wider tape width of 20 mm should be used for the application.

Design Considerations – Differential Movement

3M™ VHB™ Structural Glazing Tape performs well in applications where two bonded surfaces like glass and an aluminum frame experience movement relative to each other as a result of thermal expansion and contraction. 3M™ VHB™ Structural Glazing Tape can tolerate shear movement up to 3 times its original thickness (300% shear strain). This means the 0.090" (2.3 mm) thick 3M™ VHB™ Structural Glazing Tapes G23F or B23F can safely experience shear strain up to 0.27" (6.9 mm). The 0.080" (2.0 mm) 3M™ VHB™ Structural Glazing Tape 4972 can safely experience strain up to 0.24" (6 mm). The curtain wall system designer should calculate the amount of joint movement and mismatch possible between the glass panel and metal frame and determine if this will result in less than 300% shear strain on the 3M™ VHB™ Structural Glazing Tape. An example of thermal expansion movement and the associated calculation is listed below:

$$\text{Total \% strain} = \sqrt{(\text{panel short edge \% shear strain})^2 + (\text{panel long edge \% shear strain})^2}$$

where

$$\% \text{ shear strain} = \frac{100 \times (\text{frame length}) \times (\text{frame CTE} - \text{glass CTE}) \times (\text{max temp change})}{\text{tape thickness}}$$

The % strain in shear calculation listed above should be calculated for both the short edge and long edge length. The values calculated for each panel edge is then used to calculate the total % strain on the tape. The maximum temperature change should be calculated from the application temperature to the greater temperature extreme – hot or cold.

Example:

1500 mm x 2000 mm glass lite bonded to an aluminum frame. The 3M™ VHB™ Structural Glazing Tape G23F was applied in a factory with a temperature of 21°C. The project building is located in a hot temperature zone where the maximum temperature of the building may reach 85°C. The coefficient of thermal expansion (CTE) for glass is

$9 \times 10^{-6}/^{\circ}\text{C}$ and for aluminum is $24 \times 10^{-6}/^{\circ}\text{C}$. The thickness of the tape is 2.3 mm.

$$\text{Short edge \% strain} = \frac{100 (1500 \text{ mm}) (24 \times 10^{-6}/^{\circ}\text{C} - 9 \times 10^{-6}/^{\circ}\text{C}) (85^{\circ}\text{C} - 21^{\circ}\text{C})}{2.30 \text{ mm}} = 63\%$$

$$\text{Long edge \% strain} = \frac{100 (2000 \text{ mm}) (24 \times 10^{-6}/^{\circ}\text{C} - 9 \times 10^{-6}/^{\circ}\text{C}) (85^{\circ}\text{C} - 21^{\circ}\text{C})}{2.30 \text{ mm}} = 84\%$$

$$\text{Total \% strain} = \sqrt{(63)^2 + (84)^2} = \mathbf{105\%}$$

This value is well within the design limit of 300% for 3M™ VHB™ Structural Glazing Tape. These calculations only account for movement due to thermal changes. Other sources of movement in the glazing system such as building settling, slab deflection, seismic events, mismatch during assembly, etc. should also be considered by the architect/curtain wall designer to verify that they are within the design limit of 300% shear strain.

Materials Involved in Glazing

Structural glazing in general involves bonding of glass to a supporting load bearing metallic frame work, with additional components to aid the building movements and to seal moisture entry. There are a variety of glasses and metallic frames available and used in structural glazing applications.

Substrate Materials – Glass

3M™ VHB™ Structural Glazing Tapes form a durable bond to clear float glass, but a facade has not only a visual effect on the building but also the function of thermal insulation, which is mainly achieved by the use of multifunctional glasses with reflective coatings. Pyrolytic coatings of metal oxides are applied on the float glass just after the float process when the glass is still very hot. This makes the coatings very durable and appropriate for structural glazing. This type of coating is considered a “hard coating”. Alternatively, magnetron or “soft coatings” (coatings applied off-line after glass has cooled) consist of thin layers of noble metals (e.g. silver in low E coatings), which are not resistant to environmental influences like oxygen and acid rain. This causes surface corrosion and a gradual loss of adhesion. A few glass suppliers have made great progress in developing new generations of these soft coatings which are resistant to these influences and may be suitable for structural glazing. But this variety of coatings requires great efforts in adhesion testing. The adhesion of 3M™ VHB™ Structural Glazing Tape on any glass coating must be checked by a 3M Technical Service Representative on each individual project. If possible, it is preferred to apply the 3M™ VHB™ Structural Glazing Tape to the uncoated side of the glass panel.

It is important to avoid excessively warped glass lites when bonding with 3M™ VHB™ Structural Glazing Tape. Quality glass manufacturers typically have far less warpage in their finished product than are specified in ASTM standards for glass flatness. In general, a glass lite should have < 0.072" warpage for every 1 yd. length of glass or < 2 mm for every 1 m length of glass.

Substrate Materials - Metal Frames

The most typical frame material used in structural glazing systems is aluminum. High grade stainless steel (316) is occasionally used in structural glazing systems as well. The different types of structural frames suitable for 3M™ VHB™ Structural Glazing Tape include alodine aluminum, anodized aluminum, thermal set paint/coated aluminum and stainless steel. Mill finish aluminum is typically not used for structural glazing applications. In some cases non-typical surface finishes may be specified for a 3M™ VHB™ Structural Glazing Tape project. Always consult with the 3M Technical Support Center for guidance in these cases.

A flat frame surface void of surface irregularities (along the frame and at the joint seams) is required for 3M™ VHB™ Structural Glazing Tape applications. Mismatch in frame corner joints should be limited to < 0.011" (0.3 mm). If frames are welded, any weld marks in corners on the bonding side must be < 0.011" (0.3 mm). Ideally these should be abrasively removed. Frame profiles should have < 0.025" warpage (non-flatness) for every 1 yd. length of profile or < 0.70 mm for every 1 m length of profile. Laying a metal yard or meter stick on the profile is a good way to measure this. It is also important that the bonding area of the profile is parallel to the glass surface. Some standard structural silicone sealant glazing frames may not be suitable for use with 3M™ VHB™ Structural Glazing Tape.

The width of the flat bonding surface must be adequate to accommodate the calculated minimum tape width required for the glazed panel. It is best to use a frame that will accommodate the tape width yet leave little or no bare glass exposed over the metal frame (see Fig. 1). The frame profile should also allow for the application of a perimeter weather sealant.

3M's testing protocol will verify the adhesion characteristics of the 3M™ VHB™ Structural Glazing Tape to the substrate but do not in any way confirm the durability of the substrate. Please contact a 3M Sales or Technical Service Representative for further information.

Project Review and Warranty Obtainment

3M™ VHB™ Structural Glazing Tape Sales, Marketing and Technical Service Specialists are available to assist the customer to determine the suitability of 3M™ VHB™ Structural Glazing Tape for structural glazing applications. All 3M™ VHB™ Structural Glazing Tape projects must be reviewed on a project-specific basis by a 3M Technical Service Representative to begin the 3M™ VHB™ Structural Glazing Tape application process. The project review and associated adhesion testing must be successfully completed along with fabricator training and process control and audit documentation before 3M will issue a 3M™ VHB™ Tape Structural Glazing Tape Application Limited Warranty. A warranty application form is included in the back of this

manual. Additional forms are available from a 3M™ VHB™ Structural Glazing Tape Sales, Marketing or Technical Service Specialist. It is important to complete the entire warranty application form to ensure that 3M will be able to accurately assess the 3M™ VHB™ Structural Glazing Tape project. Required information in this form includes design windload values for the building, glass dimensions and the structural details related to the glazing system.

3M will provide bonding performance information of 3M™ VHB™ Structural Glazing Tape to the substrates and will also provide training to the fabricator personnel in application procedures to maximize tape bonding performance. The warranty program is for those projects handled by approved 3M customers who strictly adhere to and follow 3M specifications & instructions, and is subject to certain conditions. The warranty application and project review process is listed below:

Warranty Application/ Project Review Process

1. Structural glazing customer inquires about utilizing 3M™ VHB™ Structural Glazing Tape and the associated Limited Warranty. A 3M Sales, Marketing or Technical Service Representative works with the customer to fill out the Customer Warranty Request Form which begins the 3M™ VHB™ Structural Glazing Tape application process. Customer submits designs and drawings to 3M for project review.
2. 3M Technical Service and Marketing Representatives perform initial project assessment to determine general suitability of 3M™ VHB™ Structural Glazing Tape for the specific project.
3. If initial project review is acceptable, substrate materials (glass and frame) must be submitted to perform a complete technical evaluation of the project including adhesion testing. The 3M Sales Representative requests and obtains adequate samples of all appropriate substrate materials and submits a Technical Service Request (TSR) to the 3M Technical Service Representative.

Samples to be submitted:

Samples of all the substrates (frame and glass) that will be joined with 3M™ VHB™ Structural Glazing Tape should be submitted to the 3M Sales or Technical Service Representative upon request to conduct all the necessary adhesion and surface preparation analysis. The number of samples required and dimensions are given below. Be sure to identify the bonding surface of each substrate. If the application utilizes insulated glass, it is acceptable to provide samples of the bonding sheet of glass only with the bonding side clearly marked.

Glass panel samples: 12" x 12" (300 mm x 300 mm) – 2 pieces
Frame extrusions: 12" (300 mm) length – 8 pieces

4. The 3M Technical Service Representative performs appropriate adhesion testing of actual materials to measure

performance and provide requirements for surface preparation of the substrates. This may take up to four weeks from receipt of drawings and samples.

5. Technical service and marketing fill out Warranty application documents and requirements using results from the technical review. The warranty documents are reviewed by the 3M legal department.
6. The customer reviews the Warranty documents and requirements and agrees to terms including training, fabrication requirements and process auditing.
7. The 3M Technical Service Representative develops training materials with specific 3M™ VHB™ Structural Glazing Tape application techniques plus any project-specific instructions. 3M local Sales, Technical Service or Marketing delivers on-site training before project begins and fills out Application Training Document. A mock-up may also be built at this point in the process.
8. Once production begins, a local 3M Sales, Technical Service or Marketing Representative conducts periodic on-site audits of actual assembly process and fills out Audit Document.
9. Upon project completion, the customer fills out the Warranty Application Document which states that everything about the project was completed as described and nothing significant about the design or materials used in the project were modified. The warranty period begins upon signing by the customer and 3M.

Additional Testing Requirements

Additional, non-standard testing may be required depending on the wishes of the customer or the demands of the project. Please consult your 3M Sales or Technical Service Representative at the beginning of the project to determine if 3M is capable of such testing services. 3M may charge a service fee for non-standard testing outside of 3M internal testing capabilities.

Any statement made on behalf of 3M relating to an architectural drawing, product formulation, engineering design, end-use specification or similar document is limited to the knowledge of product properties as determined by laboratory testing of material produced by 3M. Any comments relating to any subject other than such product properties are offered only to call to the attention of the engineer, architect, formulator, end-user or other person considerations that may be relevant in his/her independent evaluation and determination of the appropriateness of such design, drawing, specifications, document or formula.

3M ASSUMES NO RESPONSIBILITY FOR AND SHALL NOT BE LIABLE FOR THE ADEQUACY OR PROPRIETY OF ANY MATERIALS USED FOR A PROJECT OR THE PROJECT ITSELF, OR FOR ANY STRUCTURAL DESIGN ELEMENTS IN THE PRINTS/SPECIFICATIONS PROVIDED BY CUSTOMER FOR THE PROJECT, AND 3M EXPRESSLY DISCLAIMS ANY WARRANTY OR RESPONSIBILITY WHATSOEVER FOR SUCH MATERIALS, PROJECT OR STRUCTURAL DESIGN ELEMENTS.

Application Procedure for 3M™ VHB™ Structural Glazing Tape

Factory Glazing

Factory or “shop” glazed curtainwalls are assembled as individual units (glass and frame bonded panels) in a controlled environment where proper surface preparation and tape application procedures can be maintained and quality process control programs can be implemented and documented. This is referred to as a unitized curtainwall system and is usually the only glazing system approved for 3M™ VHB™ Structural Glazing Tape projects. A key benefit of a unitized 3M™ VHB™ Structural Glazing Tape system is the ability to assemble and handle the glazed panels in the same day. This is due to the immediate handling strength of a 3M™ VHB™ Structural Glazing Tape fabricated panel. If the outdoor temperature is below 50°F (10°C) it is required that the assembled panels be kept in the warmer, controlled environment of the factory shop for 24 hours before exposing to the colder temperatures.

Site Glazing

Site or “field” glazing is a method where the glass lites are bonded to the metal frames at the construction site. This fabrication technique is not recommended for 3M™ VHB™ Structural Glazing Tape projects. Please consult a 3M

representative if site glazing is to be considered for a 3M™ VHB™ Structural Glazing Tape project.

Application Techniques

This application procedure outlines general process requirements for fabricating 3M™ VHB™ Structural Glazing Tape glass panel units. It is important to follow these fabrication techniques along with the recommendations in the project specific 3M™ VHB™ Structural Glazing Tape technical report from 3M to ensure good bonding performance. Fabrication will only start after production personnel have been properly trained by an appropriate 3M representative. The procedures in this document are not intended to be a complete and comprehensive quality assurance program as project situations may vary from job to job. The basic steps involved in a 3M™ VHB™ Structural Glazing Tape process are:

1. Establishment of appropriate work area
2. Surface preparation – glass and metal frame
3. Tape application
4. Pressure application
5. Weather sealant application

The Work Environment

It is important to establish an appropriate work area before assembly of the structurally glazed glass panels. The workplace should be free from excessive dust, dirt and other airborne contaminants. The 3M™ VHB™ Structural Glazing Tape will bond strongly to the surface it contacts. Should this be a layer of dust, dirt, grease, oils, etc., then an inadequate bond will be made to the component surface.

The workplace should be at a minimum temperature of 60°F (15°C) and free from sources of wide temperature variations such as open loading doors. All substrates for bonding and the 3M™ VHB™ Structural Glazing Tape should be conditioned at 60°F (15°C) minimum temperature in covered, weatherproof conditions for a minimum of 12 hours or until it is verified that the substrate is at or above the minimum temperature requirement. 3M™ VHB™ Structural Glazing Tape is a viscoelastic adhesive, which forms a bond by "wetting" (making intimate contact with) the surfaces to which it is

applied. When temperatures are low, this wetting process is slower, and it takes more time to reach full bond strength with complete wetting-out of the surface. If the temperature of the 3M™ VHB™ Structural Glazing Tape roll or the components is below 60°F (15°C), then the initial wetting may be so low that full bond strength may not develop before the panel is erected, and therefore put under load. Similarly, once the initial bond is made, then the 60°F (15°C) minimum is still required, so that the adhesive can continue to flow until full bond strength is achieved. Approximately 90% of full bond strength is achieved when the fabricated panels are held overnight at 60°F (15°C) or above.

Rapid variations in temperature in the workplace should also be avoided; many workshops have end-doors or roller shutters to allow vehicle entry for deliveries, etc., and opening these can cause a major change in both temperature and humidity which may have a negative impact on the bonding process.

The Workbench

The workbench for bonding should be of an appropriate size to accommodate the largest glass panel component to be constructed as a single assembly. The workbench should be stable, of a convenient height and should offer an even, flat surface over the entire area. If several benches are used together under a large frame, it is important that they all be of equal height and stability and that the operator can reach and apply pressure to all parts of the frame where a bond is required to be made. Several benches of variable height and construction brought together are not acceptable. When benches are at different heights the frame/glass will not rest squarely on the bench or be completely supported by the table surface. Application pressure applied at one end of the frame/glass may "bow" the panel, or create an opposing separation force at the other end of the frame/glass, thus breaking the previously made bond. Fig. 2 is an example of a simple work bench.

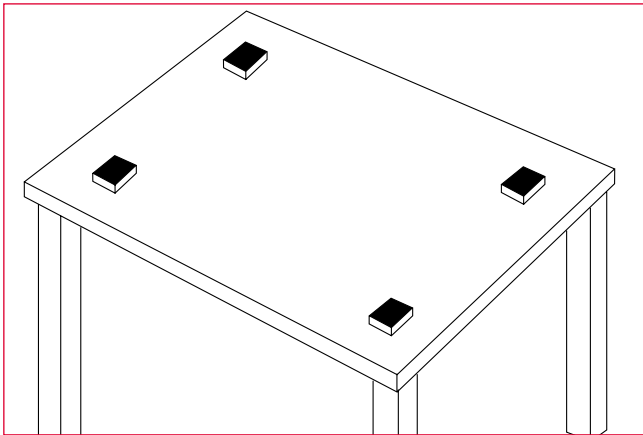


Fig. 2: Workbench with support blocks for glass placement

The workbench should be covered with a material which will not damage or contaminate the frame and the glass. The workbench should be kept clean of dust, dirt, oils, silicones and other contaminants. If possible it should be used solely as a 3M™ VHB™ Structural Glazing Tape application area. Support blocks may be used to elevate the glass. Wood or another non-damaging material may be used for supporting the glass.

Surface Preparation

Proper surface preparation is the critical first step in the fabrication process. Proper preparation of a surface prior to the application of a pressure sensitive tape is a key factor in ensuring maximum bond strength. Contaminants act as a barrier between the adhesive and substrate. Even a fingerprint on an otherwise clean surface may impair adhesion. Care must also be taken to examine surfaces for moisture, particularly during periods of high humidity as it is possible for an invisible film of water to be present.

Each project reviewed and approved by 3M will involve adhesion testing of the actual project substrates (glass and frame). A technical report will summarize this testing and will require a specific surface preparation method for each substrate. The fabricator must refer to this report for proper guidelines on how to prepare the substrate surface to achieve acceptable bonding performance. The procedures listed below for glass and metal frame substrates provide more detail related to proper surface preparation.

Surface Preparation of Glass

Be sure to remove any loose debris from the glass surface before starting this glass preparation procedure.

Silane Treatment of Uncoated Glass:

Uncoated glass is a hydrophilic (water loving) material and in high humidity or frequent water contact applications the 3M™ VHB™ Structural Glazing Tape adhesive bond can be "undercut" by moisture getting between the adhesive and the glass surface. This causes bond weakening and can lead to adhesive failures from the glass. To prevent this and to change the hydrophilic nature of glass it is necessary to treat an uncoated glass surface in the bonding area. This is done using 3M™ Silane Glass Treatment AP115. Please note the 'USE BY' date on the bottle to assure 3M™ Silane Glass Treatment AP115 is not beyond its expiration date. Glass treatment is best achieved utilizing the following method.

Clean the bonding area of the glass surface, the area around the perimeter, with a 50% solution of isopropyl alcohol (IPA) in water. Important: IPA is a flammable solvent and all appropriate safety procedures advised by the manufacturer should be followed when working with this cleaning agent.

1. Use a clean, soft absorbent, lint-free cloth moistened with the IPA/water mixture. Pour this solution onto the cloth. Do not dip the cloth into the cleaning solution as this will contaminate the cleaning agent. Alternatively, the IPA/water solution may be sprayed onto the surface and wiped with the clean cloth.
2. Wipe the glass vigorously in one direction moving around the perimeter making sure the whole bonding area is wiped clean. A white cloth works best for this cleaning procedure as the removed contaminants will be visible on the cloth. Continue this procedure until no contaminants are visible on the cloth demonstrating the glass has been thoroughly cleaned. Once the wipe has been used, it should be immediately discarded into a flameproof bin. This is a basic safety practice and also serves to keep the work area clear and clean.
3. Immediately wipe the cleaned area with a fresh, clean and dry cloth. Wipe around the perimeter in one direction until the surface is completely dry.

After the surface has been thoroughly cleaned, follow with the application of the 3M™ Silane Glass Treatment AP115.

1. Moisten a clean, soft absorbent, lint-free cloth with the silane solution and vigorously wipe over the area to be bonded in one direction. Do not dip the cloth into the silane solution as this will contaminate it. Alternatively, 3M™ Silane Glass Treatment AP115 may be sprayed onto the surface and vigorously wiped with the clean cloth around the perimeter of the glass. Experience has shown that only a very thin layer (monolayer) of 3M™ Silane Glass Treatment AP115 gives the best and most consistent results.
2. In an effort to achieve a monolayer, the primed area should be re-wiped (in one direction) with a fresh, clean, lint free, dry cloth immediately after initial application. The glass should appear clear with no visible residue, wetness or streakiness.

This procedure is commonly known as the "two cloth" cleaning method. Fig. 3 shows an example of treating the glass with the silane solution.

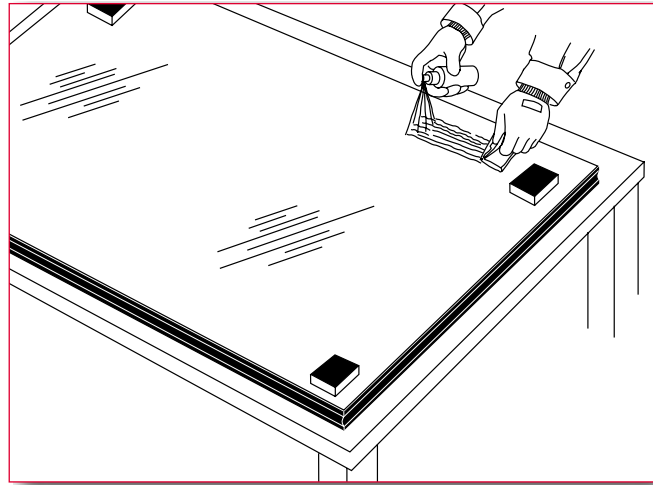


Fig. 3: Treatment of glass with silane solution

3M™ Silane Glass Treatment AP115 is clear and should not cloud or discolor glass. If clouding occurs it is due to excessive solution being applied to the glass. If this happens it is best to wipe aggressively over the treated area with a dry, clean cloth to remove the residue. This must be done prior to tape application.

Silicone contamination around the perimeter of glass is also possible especially with insulated glass units. Silicone contamination must be removed prior to the application of 3M™ Silane Glass Treatment AP115 to the glass and application of 3M™ VHB™ Structural Glazing Tape. Refer to the silicone manufacturers instructions for proper removal of silicone contamination.

Surface treatment of coated glass will vary due to the different types of materials and processes used for coating glass. The fabricator will need to refer to the project specific 3M technical report for the appropriate surface preparation of a coated glass surface.

Surface Preparation of Metal Frames

Aluminum is the most commonly used frame material for structural glazing systems although high grade stainless steel is occasionally used. The variability in metal finishes (anodization type, paint type and color) necessitates the testing of this substrate to determine the appropriate surface preparation method. The fabricator should refer to the project specific 3M technical report for proper guidelines on how to prepare the metal substrate surface to achieve acceptable bonding performance. The basic surface preparation process for metal frames is listed below but this does not replace surface preparation requirements in the project specific technical report.

1. Abrasion: (if required per the 3M technical report)

If the frame is powder coated or enamel coated, the painted surface may need to be lightly abraded in the bonding area with a Scotch-Brite™ Hand Pad. When abrading, it is important to have a finely abraded surface. Very small scratches in the surface, generated with a multi-directional motion rather than straight-line motion, are most desirable. A surface with many micro-scratches can have up to 40% additional surface area, translating to higher ultimate strength and greater initial adhesion. Scotch-Brite™ General Purpose Hand Pad 7447 (green or maroon) are good for achieving the right level of abrasion. Tools such as a random orbit, hand or power palm sander will assist on large jobs. Avoid grinding a surface with coarse abrasive materials, since they may create too rough of a texture for the adhesive to adequately flow onto the surface. When using abrasive paper, the grit value should be finer (higher number) than 320 grit. Abrasion is only needed in the area of the frame where the 3M™ VHB™ Structural Glazing Tape will make contact – the bonding area. After abrasion, always clean the surface with the IPA/water solution described below in the Surface Cleaning section and be certain that all loose particles are removed prior to tape application.

2. Surface Cleaning:

The bonding area of the structural glazing frame must always be cleaned before tape application. On surfaces where there appears to be little or no contamination, a light oily film or other light contamination may be present. Use the 50:50 blend of IPA/water for surface cleaning. Use a “two cloth” cleaning procedure when cleaning the bonding area of the metal frame with the IPA/water solution. Once the part is clean and dry, tape bonding should begin shortly after to minimize the potential for recontamination. The only exception to this is if a primer is required per the project specific requirements in the 3M technical report. Priming of the frame will follow the IPA/water cleaning step.

Where heavy oils or grease are present, a “degreasing” solvent such as 3M™ Prep Solvent 70 or 3M™ Adhesive Remover (Citrus Base) are suggested to cut the oil. This should always be followed by the “two cloth” IPA/water cleaning procedure to help ensure that any solvent residue or film is removed.

Note: These cleaner solutions contain greater than 250 g/l of volatile organic compounds (VOC). Please consult your local Air Quality Regulations to be sure the cleaner is compliant. When using solvents, be sure to follow the manufacturer’s precautions and directions for use when handling such materials.

3. Priming: (if required per the 3M technical report)

Priming a surface can significantly improve initial and ultimate adhesion to many materials such as painted metal surfaces or coated glass because of their low surface energy or the additives they may contain. A primer creates a new, higher energy surface to adhere to with the 3M™ VHB™ Structural Glazing Tape. The project specific 3M technical report will state if a primer is required for adequate bonding performance of the 3M™ VHB™ Structural Glazing Tape.

3M™ Primer 94 can be applied either with a brush, clean cloth or dauber bottle. A thin single coat is sufficient. Avoid applying excess primer where “puddling” may occur. The primer should be allowed to dry leaving a tack free film. Once dry, tape bonding should be started to minimize the potential for recontamination.

3M™ Adhesion Promoter 111 should be applied to a clean cloth and then applied to the frame bonding surface. The “two cloth” cleaning method should be employed with this adhesion promoter. It is important not to leave a pool of this adhesion promoter solution on the substrate surface. There should be no visible residue left on the surface after the proper application of 3M™ Adhesion Promoter 111. Once dry, tape bonding should be started to minimize the potential for recontamination. Fig. 4 shows an example of this primer being applied to a frame profile.

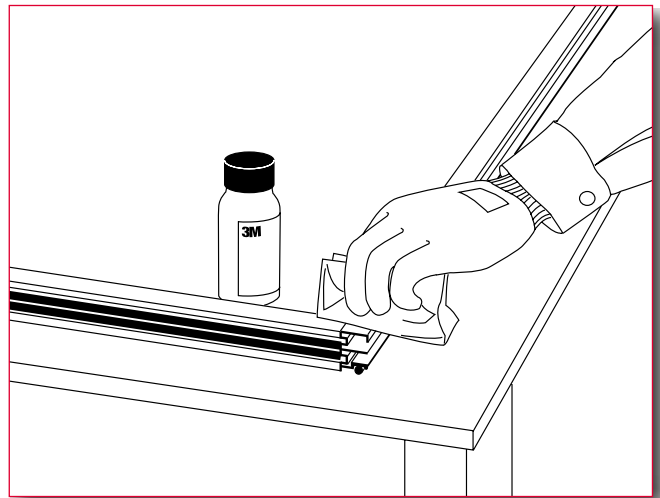


Fig. 4: Application of adhesion promoter

Note: 3M™ Primer 94 and 3M™ Adhesion Promoter 111 contain greater than 250 g/l of volatile organic compounds (VOC). Please consult your local Air Quality Regulations to be sure the primer is compliant. When using solvents, be sure to follow the manufacturer’s precautions and directions for use when handling such materials.

3M™ VHB™ Structural Glazing Tape Application

The 3M™ VHB™ Structural Glazing Tape may be applied to either the glass or frame surface first. It is best to apply the tape to the glass if a clean sight line (minimal or no visible air entrapment – bubbles) is desired. However, applying the tape to the frame first may bring additional process benefits. A reflective glazing application may be suitable for this since the tape will not be visible behind the glass. Application of the tape should occur very shortly after the two bonding surfaces have been prepared as outlined in the Surface Preparation section of this technical guide. Your 3M Sales or Technical Service Representative will help you determine the best tape application method based on the project specific requirements. This guide will discuss the application of the tape to the glass first.

1. Tape Application to Glass and Pressure Application:

The tape should be handled at the edges or by the protective liner with effort made to avoid contact with the exposed and tacky bonding surface. Excessive contact with the bonding surface may contaminate the tape and reduce bonding performance. Apply the tape to the glass surface aligned with the edge starting in one corner working down the entire length of the glass lite. Leave a small amount of tape extending over the edge of the glass on both ends (Fig. 8). Repeat this procedure along the entire periphery of the glass. It is best to apply light pressure to the tape as it makes first contact with the glass to avoid air entrapment (bubbles) between the tape and the glass. A small roller, squeegee or even fingers may be used for this step. The tape can be “butt” jointed at the corners or overlapped and cut at a 45° angle for a cleaner look. The graphic below (Fig. 5 and 6) illustrates proper application of 3M™ VHB™ Structural Glazing Tape by hand or with a tape applicator.

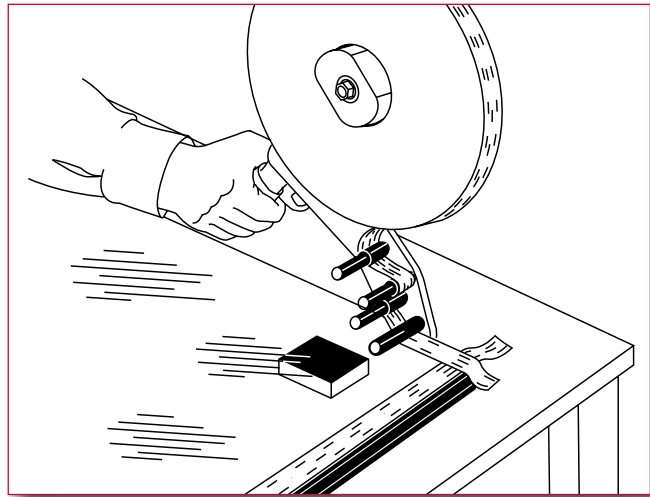


Fig. 6: Tape applicator

After application of the tape, pressure is applied to the tape around the entire periphery with a squeegee, manual or automatic rubber roller to ensure proper surface contact (Fig. 7).

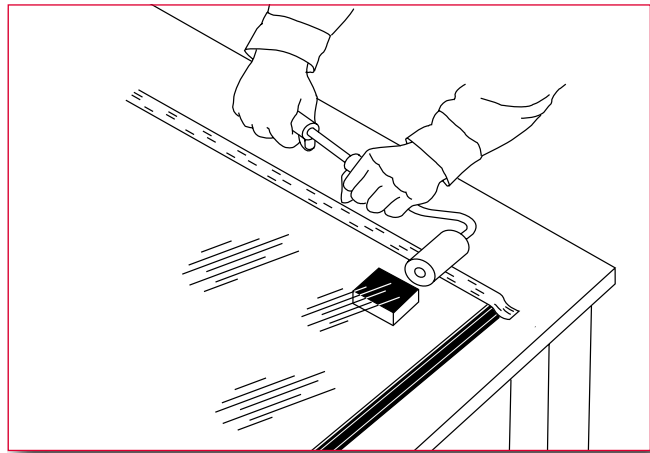


Fig. 7: Initial pressure application

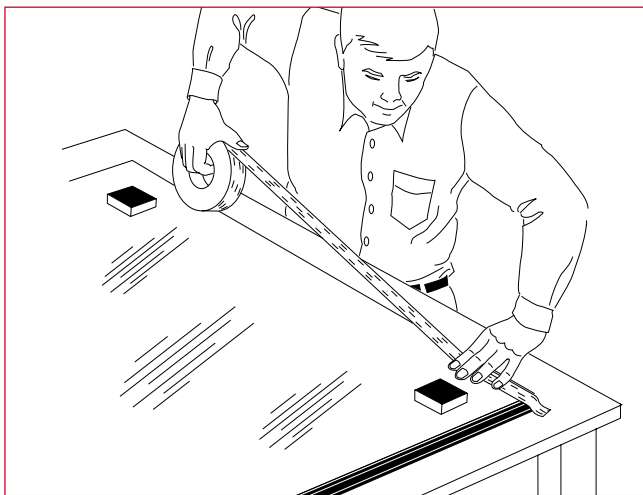


Fig. 5: Hand tape application

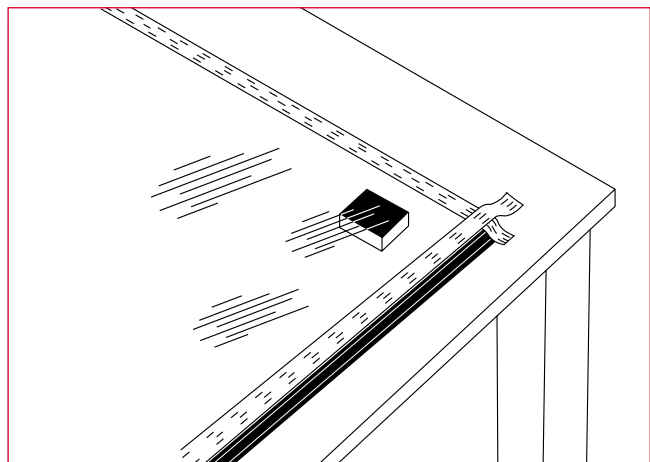


Fig. 8: Taped corner

2. Tape Cutting and Splicing

3M™ VHB™ Structural Glazing Tape should be cut using a proper utility knife with a stable and sharp blade. Retractable knives with long cutting edge blades work well for tape cutting. Tape corners can be finished utilizing a simple miter cutting procedure (Fig. 9, 10 and 11). A simple miter cutting tool can be fabricated or may be available from 3M. After cutting through both layers of tape carefully remove the excess pieces left over the edge (Fig. 10). Take care again to only contact the edge of the tape that will remain bonded to the glass. Once the excess is removed carefully align the two miter (45°) cut edges so they make contact. Then apply finger and roller pressure to the tape in the direction from the middle of the tape length moving towards the tape seam (Fig. 11).

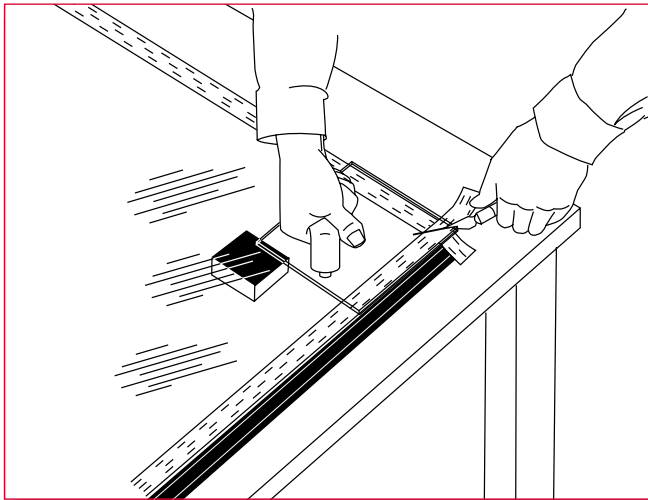


Fig. 9: Miter cutting procedure with miter cutting tool

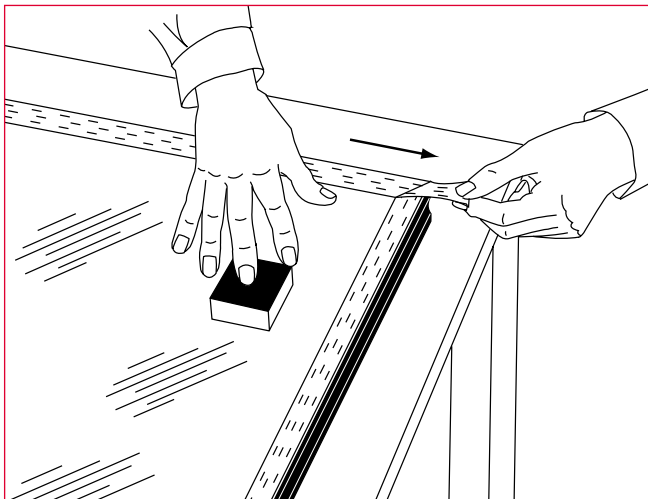


Fig. 10: Tape waste removal

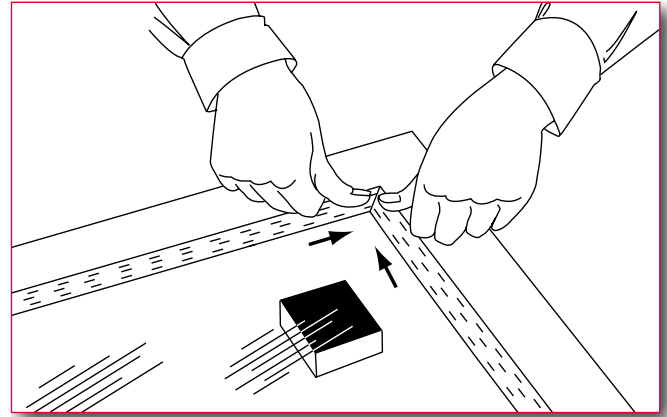


Fig 11. Corner finishing

To achieve a good quality result it is recommended to replace the knife blade frequently. A dull blade may tear the tape and result in less than desirable looking joint seams. Take care not to press the knife blade excessively hard through the tape onto the glass as this could result in scratching of the glass surface.

When the 3M™ VHB™ Structural Glazing Tape roll ends in the middle of a glass edge or frame the same general procedure is used as than shown in Fig. 9 and 10. The tape is overlapped and then cut accordingly with the waste removed. However use a 90° cut instead of a 45° cut for this procedure. Take care to only touch the edges of the tape that will remain bonded to the glass. Carefully bring the cut edges of the tape together in proper alignment forming a “butt” splice. Apply finger or roller pressure moving towards the splice from both sides of the seam.

3. Joining of Parts and Final Pressure Application:

The graphic below (Fig. 12) shows a possible way to stage the structural glazing frame and glass on the workbench. The structural glazing metal frame is placed first on the table with the previously prepared bonding surface up.

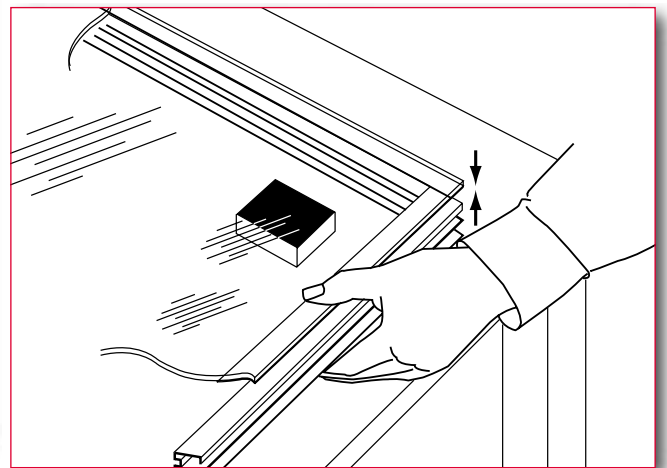


Fig. 12: Lifting frame to contact tape on glass

The glass support blocks are placed inside the perimeter of the frame. Next, the glass is placed on the support blocks with the tape (inside surface) facing down. The liner is then removed and the frame is lifted up to make contact with the exposed, tacky tape surface.

The glass should be sized such that when it is bonded to the frame there is a gap between the edge of the glass and the deadload support fin of the structural glazing frame around the entire perimeter of the glass. This will leave a space to fill with an appropriate sealant to form a weather seal for the assembled unit. Four 90° spacers with a thickness of 1.5-2.0 mm placed in the frame corners prior to joining the parts together can help to provide this uniform gap around the perimeter of the glass for the weather sealant. The spacers should be taller than the glass is thick to allow it to be removed easily from the assembly once the parts are joined together. Spacers are useful for glazing systems that have a lip extending around the entire perimeter edge of the glass.

If spacers are not available or an alternative frame style is used a technique known as “pig-tailing” may be used to properly align the glass with the frame (Fig 13 and 14). This technique involves removing about a 4” (10 cm) long section of the tape release liner from each corner of the glass in both directions. This section of liner is then folded inward or outward – like a loose “pig-tail”. The frame is then positioned to make contact with the tape/glass. Alignment will still be possible because most of the tape is still covered by the protective liner. Once proper alignment is achieved, apply light pressure to the corners where the release liner has been removed from the tape. The frame should remain in place after the light pressure application. The loose “pig-tail” of liner can then be grasped to remove the remainder of the liner by carefully pulling it from under the frame.

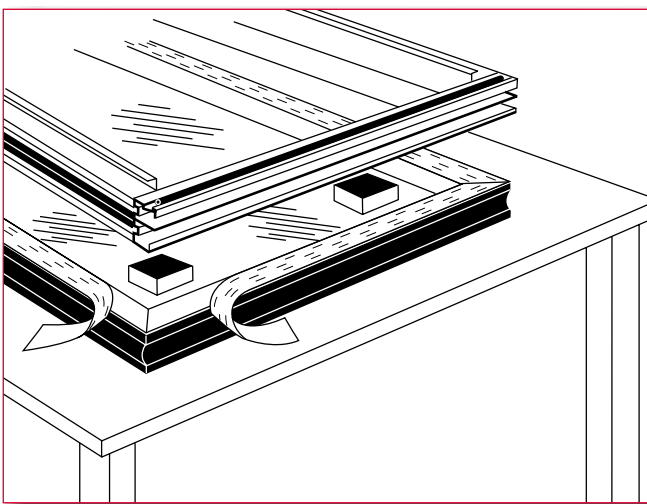


Fig. 13: “Pig-tailing” technique

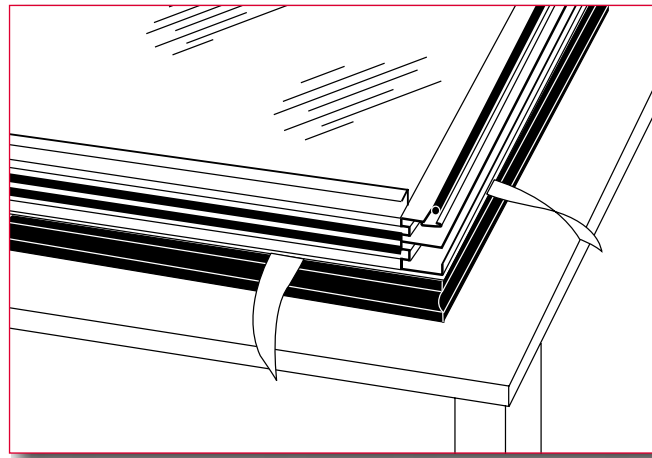


Fig. 14: Frame set on glass and liner

Once the glass and frame are bonded together using either of the techniques described above, final application pressure must be applied around the entire perimeter of the glass and frame – over the entire bonding area. There are several ways to accomplish this. One way is to remove the support blocks so the frame is resting on the table with the glass up. The hand held roller can then be used to apply roll down pressure of at least 15 psi (1 kg/cm²). The roller of the hand held roller should be made of a non-damaging material. An alternative way to apply final application pressure is to use a locking pliers type tool with roller ends. The rollers are placed over the glass and frame and locked in place applying “pinching” pressure to the assembly. The pliers are then pulled around the perimeter. The pliers must be checked to make sure a minimum of 15 psi (1 kg/cm²) of pressure is being applied to the assembled parts.

The methods described above for tape and pressure application are fairly simple methods for panel fabrication with 3M™ VHB™ Structural Glazing Tapes. Equipment is also available that can be used to automate or semi-automate the application of tape and the application of pressure. Please consult a 3M Sales, Marketing or Technical Service Representative for more information on automation of the 3M™ VHB™ Structural Glazing Tape bonding process.

Weather Sealant Application

A neutral-curing (non-acidic) silicone sealant should be applied around the entire perimeter of the glass once it's bonded to the structural glazing frame (Fig. 15 and 16). This will act as a weather sealant and help to protect the 3M™ VHB™ Structural Glazing Tape from potentially aggressive glass cleaning agents and should be done while the glazed units are still in the shop if possible. Sealant may be applied immediately after final pressure application to the assembled units. Use an appropriate sealant that has the required performance and durability for the application. It is important to apply the sealant around the entire perimeter of the glass to establish a proper seal. Acid curing silicone sealants are known as “acetoxycure” silicone sealants and should be avoided.

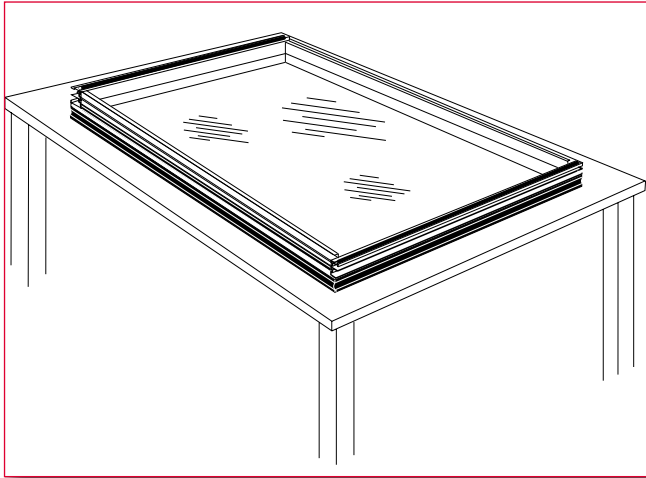


Fig. 15: Frame bonded to glass

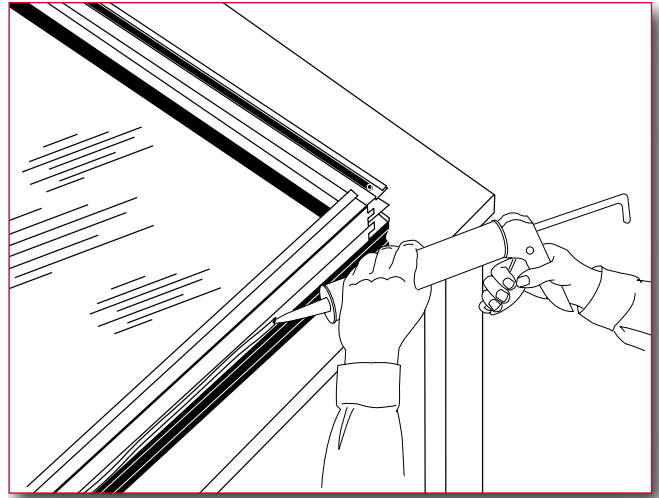


Fig. 16: Weather sealant application

A backer rod may be placed in the weather sealant gap prior to filling with silicone sealant. The backer rod is typically a size (diameter) approximately 25% greater than the joint cavity and must be placed as deep as possible into the weather sealant gap. This is to ensure that the majority of the glass edge has weather sealant between it and the metal frame. Consult first with a 3M Technical Service Representative if considering the use of a backer rod.

Masking tape may be used on the glass face and the outside edge of the metal frame to keep excess weather sealant from contacting these areas to ensure an aesthetically pleasing finished product. Remove the masking tape before the sealant skins over (within about 15 minutes after application of the sealant).

Important: When using silicone sealants, be careful to avoid contaminating other pre-bonded parts or works areas where 3M™ VHB™ Structural Glazing Tapes will be applied. It is best to have the silicone sealant applied in an area away from where tape is being applied and surfaces are being cleaned. It should also be done by someone who is not involved in surface cleaning or tape application activities.

Bond Build Rate

After proper application of the tape as described above, the bond strength will increase as the adhesive flows onto the surface making more intimate contact. There is no curing reaction taking place. At room temperature (70° F/21°C), approximately 50% of the ultimate strength will be achieved in 0 to 20 minutes after pressure application, 75% after approximately 1 hour, 90% after 24 hours and 100% after 72 hours. In some cases, bond strength can be increased and ultimate bond strength can be achieved more quickly by exposure of the bond to elevated temperatures (e.g. 150°F) or when the surfaces are either abraded or primed. In these cases ultimate bond strength may be achieved in as little as one hour. After assembly the glazed units can be handled and stacked for storage or shipment. They should remain in an environment at a minimum temperature of 60° F (15°C) for 24 hours before the assembled units have significant forces acting on the 3M™ VHB™ Structural Glazing Tape joint. The assembled units can be stacked horizontally immediately after pressure application. Be sure to use appropriate spacers between each glazed unit when stacking horizontally. The units can also be placed vertically but there must be deadload support for the glass.

Sloped Glazing

Sloped glazing is a type of structural glazing used for non-vertical applications. An example of this is for skylight applications. The calculations for a sloped glazing application will vary slightly from the conventional calculations listed earlier in this technical guide. Please contact a 3M representative to help determine the suitability of 3M™ VHB™ Structural Glazing Tape for a sloped glazing application. Local building codes may also influence the design and testing requirements of a sloped glazing system.

Protective Glazing

3M™ VHB™ Structural Glazing Tape has been tested for use in protective glazing systems including missile impact and hurricane pressure cycling. 3M™ VHB™ Structural Glazing Tape is only one component of a system that includes the framing system, glass and laminate. Bomb blast systems also involve intricate systems to absorb and dissipate the high energies associated with that type of event. The unique energy absorbing/stress relaxation characteristics of viscoelastic 3M™ VHB™ Structural Glazing Tape demonstrates the potential to consider it for these types of applications. 3M does not provide “approval” for these types of systems as the system designer is usually required to test their unique design. 3M Technical Service Representatives are available to offer consultation if a protective glazing system utilizing 3M™ VHB™ Structural Glazing Tape is being considered for an application.

Glass Replacement and Remedial Glazing

Glass breakage may occur during any phase of a construction project or after the project has been completed. It is important to consider how the system will be replaced or re-glazed in the event of glass breakage. This may vary from project to project dependent on the design of the glazing system. Always contact your 3M representative for specific advice on this process. Listed below are some general guidelines on the replacement or re-glazing of a 3M™ VHB™ Structural Glazing Tape structurally glazed unit.

Replacement Glazing Due to Glass Breakage

The following procedure is specific for a 3M™ VHB™ Structural Glazing Tape structurally glazed system. The application should be verified as a 3M™ VHB™ Structural Glazing Tape project and the original project specific 3M technical report should be available for reference. Contact your 3M representative if this information is not available. Prior to deglazing an assessment must be made by a 3M representative along with other building and contractor representatives to determine the cause of failure. A written record of this inspection should be retained by all appropriate parties.

It is recommended to replace the entire frame and glass panel unit, if possible, with a newly fabricated unit. If this is not possible, follow the deglazing procedure described below.

1. Cutting through the 3M™ VHB™ Structural Glazing Tape bondline is the most effective way of separating the glass lite from the structural frame. This will require special tools such as piano wire (Fig. 17), an automatic sealant cutter (Fig. 18) or a sharp blade to cut through the 3M™ VHB™ Structural Glazing Tape. Use a lubricant such as liquid soap to quicken cutting through the tape. Care should be exercised to avoid damaging of the frame surface or the glass if they are to be used in the re-glazed unit.

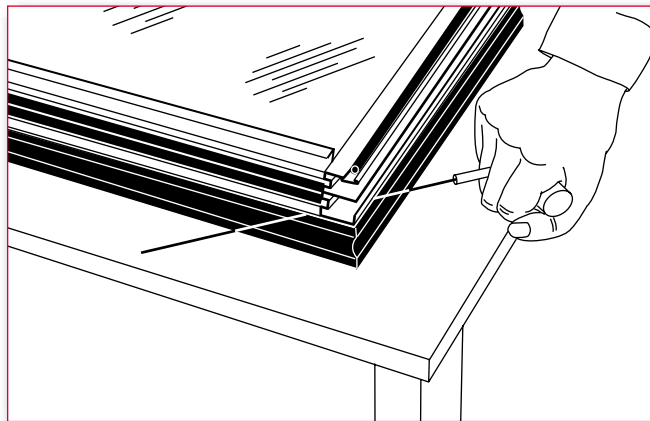


Fig. 17: Cutting through tape with “Piano Wire”

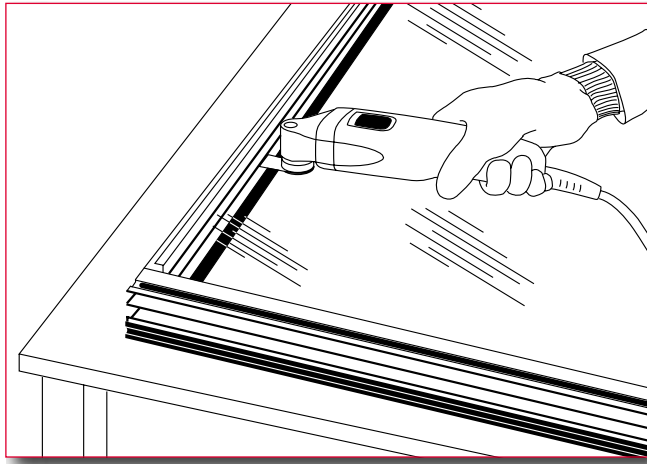


Fig. 18: Automatic sealant cutter

2. Residue removal – The 3M™ Stripe Off Wheel (part # 07498) is a special rubber disk which mounts to a 3/8" electric drill and can be used to remove the adhesive residue from the glass panel and metal frame. When the rotating disk is brought in contact with the adhesive residue, it lifts and removes the adhesive from the surface. The wheel will not damage the surfaces if used properly. It may help to remove the bulk of the adhesive residue with a razor or sharp knife before using the Stripe Off Wheel. Another alternative is to grasp a portion of the adhesive residue and attempt to stretch and release the tape from the frame or glass. This should be attempted before cutting the adhesive residue and often results in a complete and clean removal.

The graphic below (Fig. 19) depicts the use of the 3M™ Stripe Off Wheel.

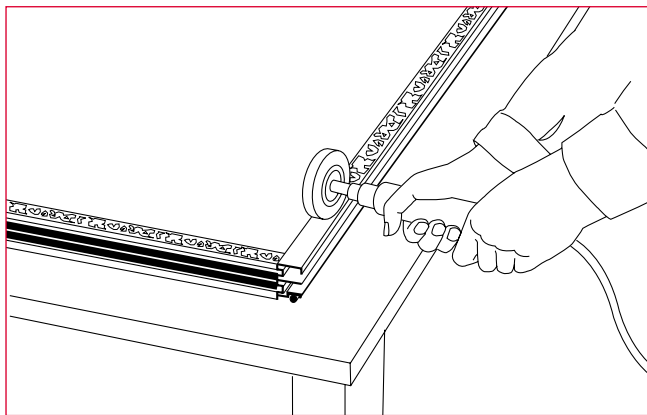


Fig. 19: 3M™ Stripe Off Wheel

Note: Follow manufacturer's safety instructions and precautions for tool operation and use. 3M™ Adhesive Remover (Citrus Base) can be utilized to remove the last residue. Follow solvent manufacturer's precautions and directions for using cleaners.

3. Clean the glass and frame surface with the "two cloth" cleaning procedure utilizing the IPA/ water solution described earlier in this technical guide. The original project specific technical report should also be referenced to determine if priming or abrasion is required for maximum bonding performance. Be sure that all the adhesive residue and sealant residue are removed before re-glazing.
4. Apply 3M™ VHB™ Structural Glazing Tape to the glass as described in the 3M™ VHB™ Structural Glazing Tape Application section of this document. Be sure to use the correct width of tape based on the appropriate structural calculations for the application.
5. Place the glass into the structural glazing frame. It is probably best to use the "pig-tailing" method described earlier in this document. A temporary and removable spacer should be put along the deadload support fin of the structural glazing frame to assure that a consistent gap is maintained between the edge of the glass and frame for application of silicone weather sealant.
6. Application of pressure – apply a minimum of 15 psi roll down pressure along the entire perimeter of the re-glazed unit to ensure that the tape has made good contact with both the glass and frame surfaces. The glass lite should fit properly into the structural frame without forcing. There should be no evidence of excessive visible gaps or distortions. If this cannot be accomplished, the structural frame will need to be removed and replaced with a new, structurally sound frame.
7. Temporary fasteners should be used to hold the re-glazed glass lite in place for a minimum of 24 hours assuming a minimum temperature of 60°F (15°C) at the tape bondline.
8. Remove the temporary fasteners and temporary spacers along the bottom edge of the glass. Apply a bead of silicone weather sealant around the entire edge of the glass as described earlier in the Weather Sealant Application section of this technical guide.

Replacement Glazing Due to System Failure

Please consult a 3M representative if the re-glazing project includes a major remedial operation to help determine the cause of the system failure. It is important to document dates and project specific details related to the system failure to determine the best remedial solution.

Quality Assurance and Warranty Documentation

The 3M™ VHB™ Structural Glazing Tape project checklist and an initial blank warranty request form is provided on the following pages. Adhesion test results and application specific guidelines and instructions are generated by 3M for each 3M™ VHB™ Structural Glazing Tape project. Training and audit documents are also provided by 3M and must be available from the contractor, fabricator or owner in the event of a warranty claim or inspection for review by 3M and/or the local building official.

The customer should retain these documents for the length of the warranty period. Contact your 3M Sales Representative for questions related to these documents or the quality control process. 3M is available to assist in the implementation of a quality control program.

3M™ VHB™ Structural Glazing Tape Project Checklist

The following checklist activities must be completed for 3M™ VHB™ Structural Glazing Tape projects. Check off on each item below by filling in a date of completion for each activity.

Copy the document and submit to 3M representatives. Retain the original document for the life of the warranty.

1. Project Initiation

	Initial contact and project review with 3M Sales Representative
	Fill out Customer Warranty Request Form 1.1
	Submit project drawing and Warranty Request Form to 3M for review
	Initial project assessment completed by 3M

4. Fabrication Training

	3M representative provides project specific training to fabrication personal
	Training Application Document Form 1.2 signed by fabrication personal

2. Technical Assessment

	Materials submitted for adhesion testing (jobsite representative glass and frame)
	3M Technical Service Representative completes project specific technical report
	3M fills out project specific warranty documents: Schedule A – Required Application Procedures, Schedule B – Application Description and Materials List

5. Quality Assurance and Production Control

	Customer performs daily quality and process control procedures and documents on a production control sheet
	3M representative conducts production audits and documents in Audit Form 1.3

3. Project Approval

	3M submits warranty documents and recommendations to customer
	Customer reviews and agrees to project specific warranty and recommendations
	Signs Customer Agreement Form

6. Project Completion

	Project glazing is complete and 3M and customer sign off on Warranty Application Document Form 1.4. – warranty period begins
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For additional information on 3M™ VHB™ Structural Glazing Tapes and associated applications please visit www.3m.com/vhb/structuralglazing.

3M™ VHB™ Structural Glazing Tape Application

Customer Warranty Request Form 1.1

Warranty Request Form to be completed by 3M Sales, Marketing, or Technical Service Representative, and Customer. Document returned to 3M to initiate Initial Project Assessment.

Date of Request _____ 3M Contact (Initiator): _____
 Field Location: _____ Phone Number: _____
 Customer (Fabricator) Name: _____
 Customer Contact: _____ Customer Phone: _____
 Customer Address: _____
 Building (Project) Name: _____
 Building Address: _____
 Building Height: _____ Number of Floors: _____
 General Contractor (if relevant): _____
 Consultant/Control Office (if relevant): _____
 Architect and Firm (if relevant): _____

Project Materials

Glass Type: Insulated (IG) Laminated Monolithic Stepped Glass: Yes No

Glass Finish: Uncoated Coated – Coating Type: _____

Glass Bonding Side: Coated Side Uncoated Side

Glass Manufacturer: _____

Frame Type (model): _____ Frame Manufacturer: _____

Frame Material: Aluminum Stainless Steel

Frame Finish: Anodized – Color: _____
 Painted – Color and Type: _____
 Bare

Does the frame provide deadload support? Yes No

Note: The frame must provide deadload support for insulated glass (IG) lites as well as other glass types depending on the thickness/weight.

Project Specific Design Parameters

Design Required Windload (Design Pressure): _____ Hurricane Area? Yes No

Glass Lite Dimensions

Glass Lite #	Width (in.)	Height (in.)	Quantity/Project	Vision or Spandrel	Thickness (include both lites and space if IG)	Weight of Glass Lite
1						
2						
3						
4						
5						
6						
7						

Estimated Project Volume (total length of tape): Lineal ft. _____ Lineal yds. _____

Note: width of tape will be determined by project specific calculations

Other Considerations (seismic region, etc.): _____

Has the customer/fabricator previously been trained for 3M™ VHB™ Structural Glazing Tape projects? Yes No

NOTE: Customer assumes responsibility for meeting local business codes

Global 3M Contact
Information for 3M™ VHB™
3M™ VHB™ Structural
Glazing Tape:

**For unlisted countries please contact
Mark Jennings at 651-736-6076**

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Marketing – Mark Jennings 651-736-6076

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Germany +49-2131-14 3465
Gulf +971-4265 212
Italy +39-02-70352526
Netherlands +31-55 540 2323
Poland +48 22 739 60 10
Pakistan +92-21-111-225536 Ext. 350
Russia +7 (095) 784-74-74
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Sweden +46 8 92 23 42
Switzerland + 41 1 724 91 91
Norway +46 8 92 23 42
Israel +972 9 9615032
United Kingdom,
& Ireland +44-1344 857841

For unlisted Latin American countries please contact:

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Brazil, Pedro Terzi 55-019-38387295
Colombia, Julian Pardo 57-1-4108555 or
57-1-4161666
El Salvador,
Maria Eugeniade Tomasino (503) 2210-0833
El Salvador, Mario Gonzalez (503)2210-0832
Guatemala, Carlos Lemus (502) 2379-3636, ext. 3620
Jamaica, Fernando A. Johnson (876) 920-1787
México, Roberto González (55) 52-70-20-48

Certification/Recognition

MSDS: 3M is not required to prepare an 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.

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.

Limited Warranty

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, 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™ VHB™ Tape due to misuse, workmanship in application, or application or storage not in accordance with 3M recommended procedures. AN APPLICATION WARRANTY EXPRESSLY APPROVED AND ISSUED BY 3M IS AN EXCEPTION. THE CUSTOMER MUST APPLY FOR A SPECIFIC APPLICATION WARRANTY AND MEET ALL WARRANTY AND PROCESS REQUIREMENTS TO OBTAIN AN APPLICATION WARRANTY. CONTACT 3M FOR MORE INFORMATION ON APPLICATION WARRANTY TERMS AND CONDITIONS.

Limitation of Remedies and Liability

If the 3M™ VHB™ Tape is proved to be defective within the warranty period stated above. THE EXCLUSIVE REMEDY, AT 3M'S OPTION, SHALL BE TO REFUND THE PURCHASE PRICE OF OR TO REPAIR OR REPLACE THE DEFECTIVE 3M™ VHB™ TAPE. 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 tort, contract, negligence, warranty, or strict liability.



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