



Structural Performance Tests of VHB™ Structural Glazing Tapes

Technical Bulletin

September, 2010

Introduction

3M™ VHB™ Acrylic Foam Bonding Tapes have been used worldwide in a variety of 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 Tape under stresses and environmental conditions that glass panels would typically experience in a glazed curtain wall system.

Summary

The glazed panels constructed with 3M™ VHB™ Structural Glazing Tapes provided excellent performance overall compared to a control panel glazed with a one part structural silicone. 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. No failure was observed with either the 3M™ VHB™ Tape or the structural silicone glazed panels in any of the tests including ASTM E330 wind load structural tests at ambient, cold and hot temperatures (-25°C and 70°C) up to 2.9 kPa (60 psf), corresponding to a wind speed of 250 kph (155 mph). 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. An 8.4 kPa pressure load is equivalent to a wind speed of 426 kph (264 mph).

A second test sequence patterned after the first test sequence was run consisting of two single pane tempered glass panels. One was bonded with 3M™ VHB™ Structural Glazing Tape G23F and the other with one part structural silicone. The DGU panels bonded with 3M™ VHB™ Structural Glazing Tape G23F were also subjected to this second test sequence after surviving the first test sequence. No failure was observed with either the 3M™ VHB™ Tape glazed panels or the structural silicone glazed panel in any of the tests including ASTM E330 wind load structural tests up to 10 kPa (210 psf), which corresponds to a sustained wind speed of 290 mph (467 kph).

Conclusions

In the tests conducted, 3M™ VHB™ Structural Glazing Tapes G23F and 4972 fulfilled all the requirements as specified by ASTM E283, ASTM E331 and ASTM E330 test methods.

Their performance exceeded expectations as shown in tests with more stringent conditions such as structural loads at -25°C (-13°F) and at 70°C (158°F) with test method ASTM E330. The conditions set for air infiltration and water leakage were higher than the minimum standards outlined in ASTM E283 and ASTM E331. Furthermore, the destructive structural load performance for the laminated glass frame was exceeded by > 250% (failure due to glass breakage, and > 300% for structures with tempered glass and DGU glass.

Overall, in the tests conducted, there were no observable differences between 3M™ VHB™ Structural Glazing Tapes and structural silicone in terms of performance; all fulfilled and exceeded their basic objectives.

Technical Bulletin

Structural Performance Tests of 3M™ VHB™ Structural Glazing Tapes

The following table briefly summarizes the results of the construction tests. See the descriptions of the three test sequences, and the complete Winwall Technology test report, for more detailed information.

| Test Sequence | Test Method | 3M™ VHB™ Tape 4972 Laminated Glass | One Part Structural Silicone DGU | 3M™ VHB™ Tape G23F DGU | One Part Structural Silicone 8mm Tempered | 3M™ VHB™ Tape 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 maintain at -25°C for 15 minutes and +70°C for 15 minutes (±2°C) | For each cycle, temperature is maintain at -25°C for 15 minutes and +70°C for 15 minutes (±2°C) | Subjected to 40 cycles | For each cycle, temperature is maintain at -25°C for 15 minutes and +70°C for 15 minutes (±2°C) | For each cycle, temperature is maintain 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 (60 psf, 155 mph, 250 kph) | ±2.9 kPa (60 psf, 155 mph, 250 kph) | ±2.9 kPa (60 psf, 155 mph, 250 kph) | ±2.9 kPa (60 psf, 155 mph, 250 kph) | ±2.9 kPa (60 psf, 155 mph, 250 kph) |
| 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 Max. | ASTM E3330 (32°C, hold 10 sec) | ±6 kPa (125 psf, 224 mph, 360 kph) | ±6 kPa (125 psf, 224 mph, 360 kph) | ±8 kPa (167 psf, 258 mph, 416 kph) | ±8 kPa (167 psf, 258 mph, 416 kph) | ±8 kPa (167 psf, 258 mph, 416 kph) |
| Windload Structural Destructive | Maximum Pressure (±) | Glass burst at -8.4 kPa (175 psf, 264 mph, 426 kph) | > -8.4 kPa (175 psf, 264 mph, 426 kph) | > 10 kPa (209 psf, 289 mph, 465 kph) | > 10 kPa (209 psf, 289 mph, 465 kph) | > 10 kPa (209 psf, 289 mph, 465 kph) |

Min ASTM E283 standard is 0.075 kPa

Min ASTM E331 standard is 0.137 kPa

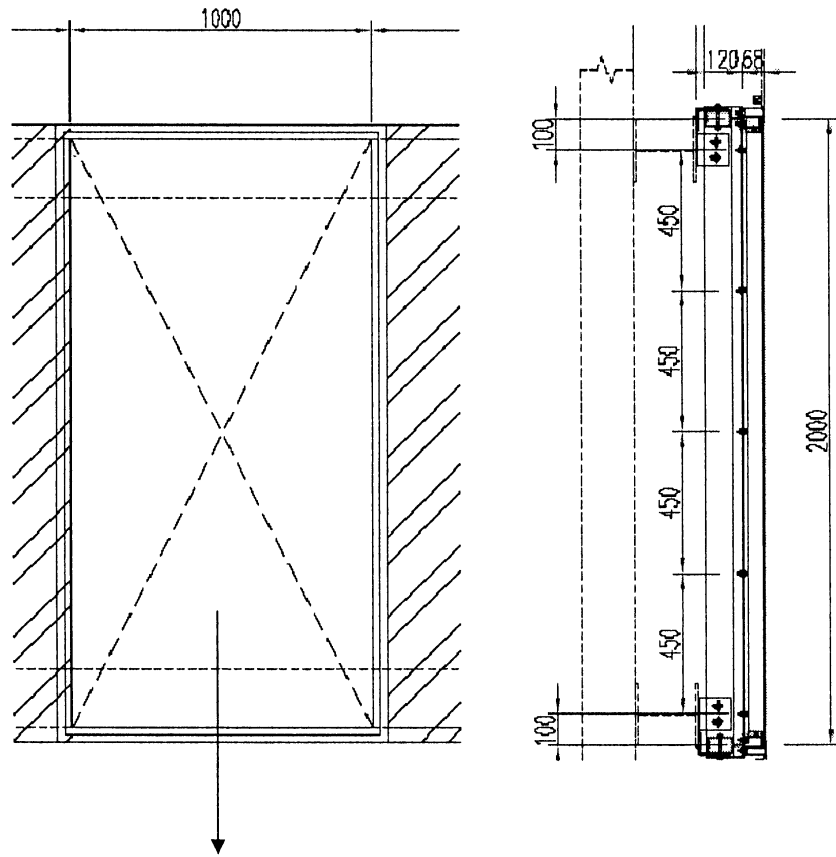
Subjected to 40 temp cycles & 2x structural load at extreme temperature settings

Technical Bulletin

Structural Performance Tests of 3M™ VHB™ Structural Glazing Tapes

Panels

The glazing panels submitted for the construction tests were built at a leading manufacturer of architectural curtain wall panel systems using designs, assembly procedures, and factory conditions typical of the construction industry. The panels measured 1m by 2m and were made of laminated glass, double glazed unit glass (DGU) and single pane tempered glass. Similar units with a common one part structural silicone sealant used in the industry were also fabricated with the exception of the laminated glass construction.



Glass Panel:

1. Single Pane 8mm Tempered
2. Double Glazed Unit (6mm/10mm/6mm)
3. Laminated Glass (4mm/PVB/4mm)

Technical Bulletin

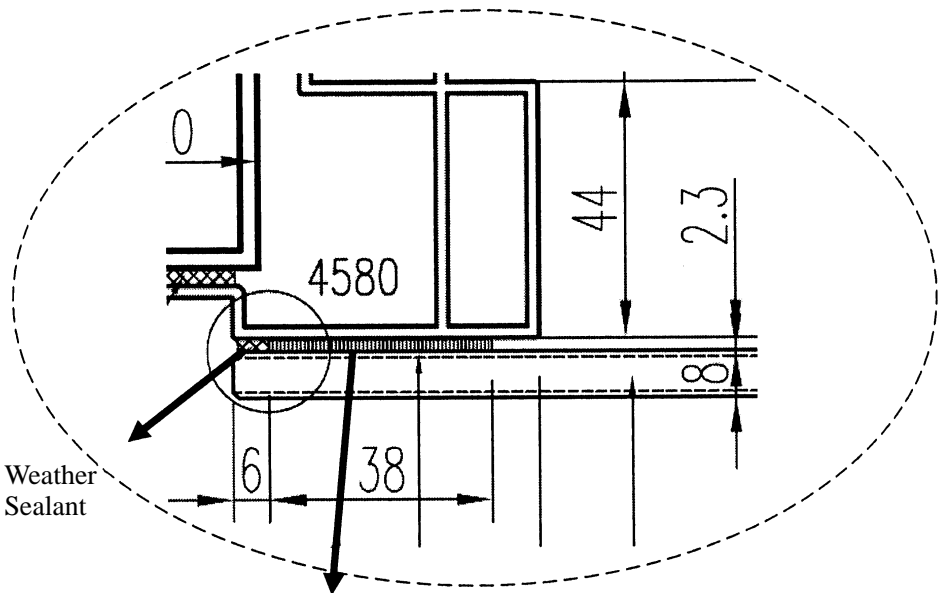
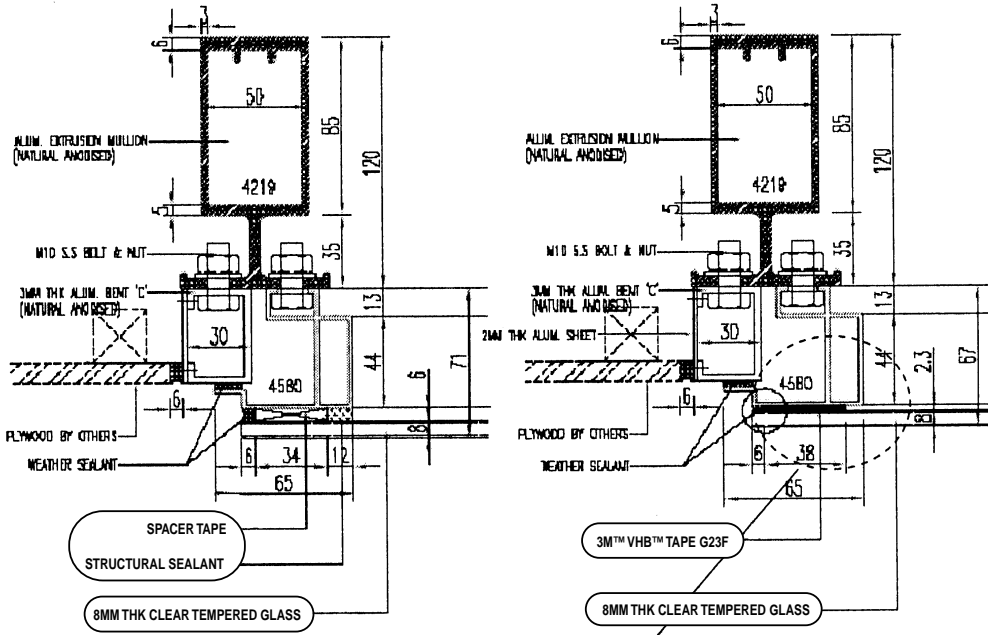
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Panels

8mm Tempered Glass Panel with:

Structural Silicone Sealant

3M™ VHB™ Structural Glazing Tape G23F



3M™ VHB™ Tape G23F

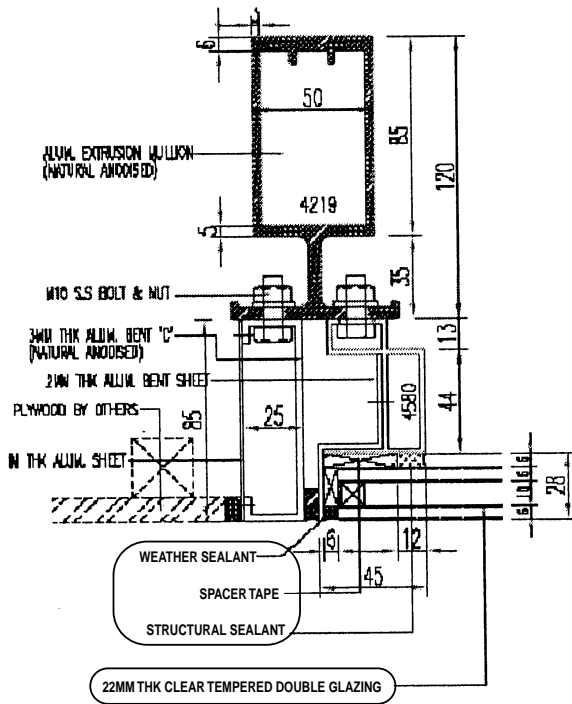
Technical Bulletin

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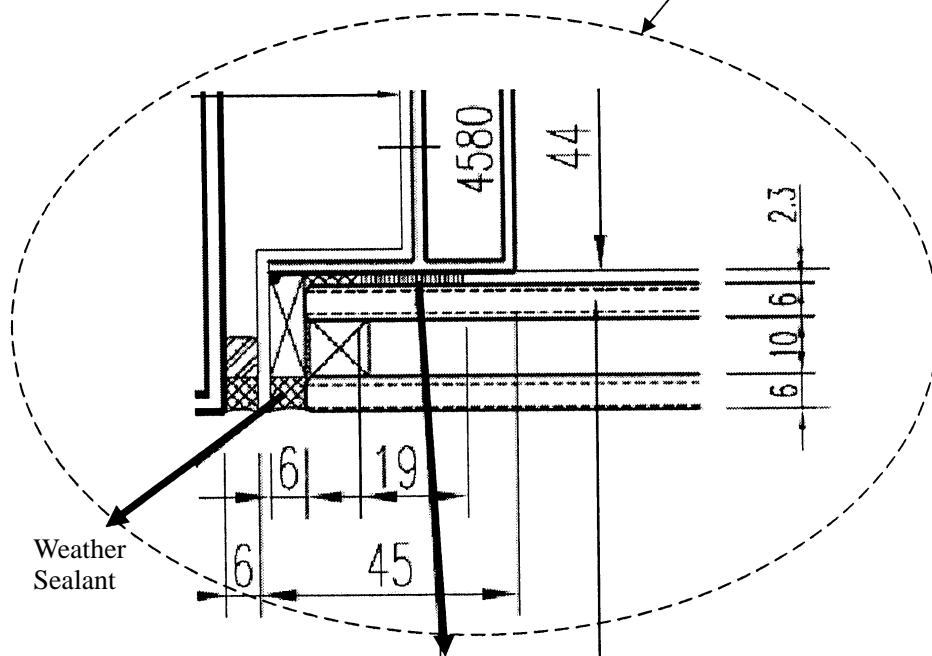
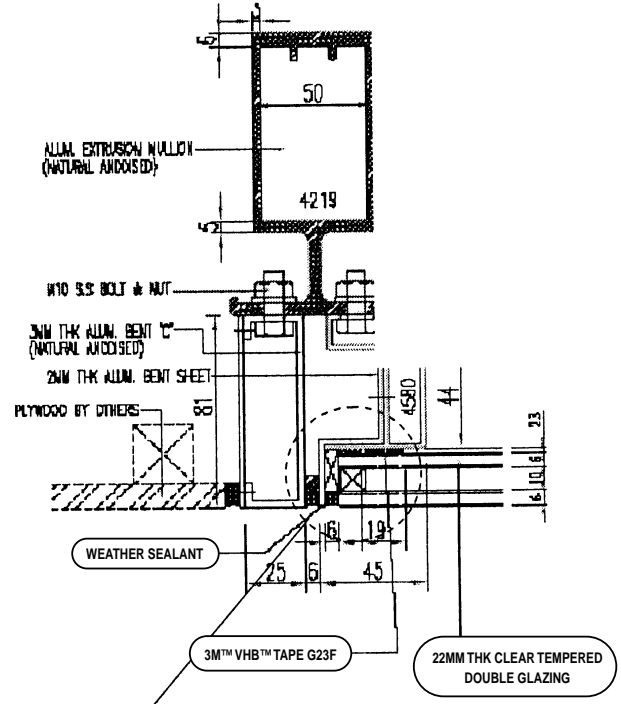
Panels

Double Glazed Unit with:

Structural Silicone Sealant



3M™ VHB™ Structural Glazing Tape G23F

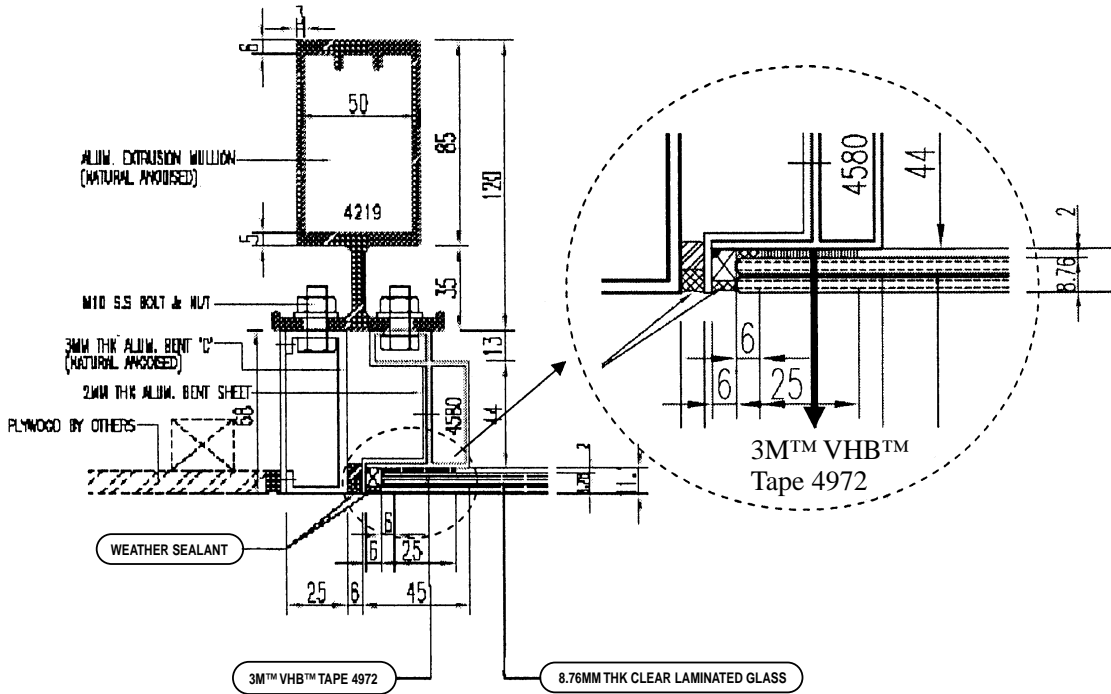


Technical Bulletin

Structural Performance Tests of 3M™ VHB™ Structural Glazing Tapes

Panels

Laminated Glass with 3M™ VHB™ Structural Glazing Tape 4972



3M™ VHB™ Structural Glazing Tapes

3M™ VHB™ Structural Glazing Tapes G23F and 4972 have been selected for curtain wall glazing applications due to their acrylic foam tape performance properties which are suitable for bonding glass to metal frame assemblies. The performance of 3M™ VHB™ Structural Glazing Tapes has also been proven with over 15 years of successful curtain wall applications for glass panels around the world.

| Product Number | Adhesive/Foam Type | Thickness | Tape Color | Liner Type |
|----------------|---------------------|----------------|------------|------------------|
| G23F | Acrylic/Conformable | 2.3mm (0.090") | Grey | Red film liner |
| B23F | Acrylic/Conformable | 2.3mm (0.090") | Black | Red film liner |
| 4972 | Acrylic/Conformable | 2.0mm (0.080") | Grey | Green film liner |

A most common proven structural silicone sealant from a well known manufacturer was used in this study to compare the performance of 3M™ VHB™ Structural Glazing Tapes in similarly designed curtain wall panels.

| Product | Description | Type |
|--------------------|------------------------|---------------------|
| Structural Sealant | One part, neutral cure | Architectural grade |

The same weather sealant was used in all the designs. It is also a one part, neutral cure silicone material.

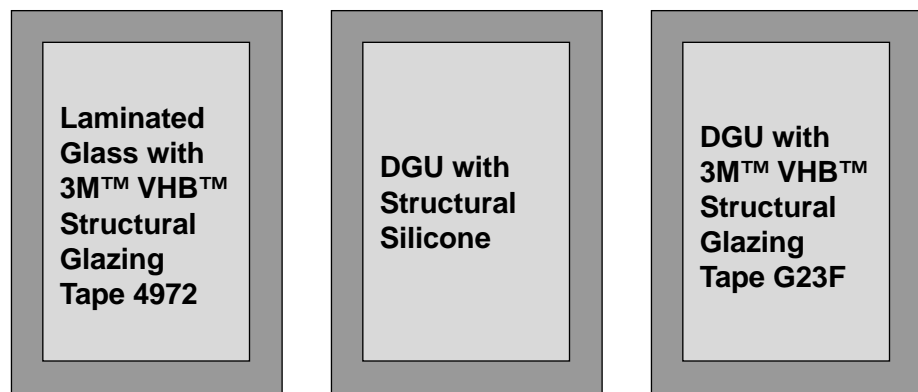
Technical Bulletin

Structural Performance Tests of 3M™ VHB™ Structural Glazing Tapes

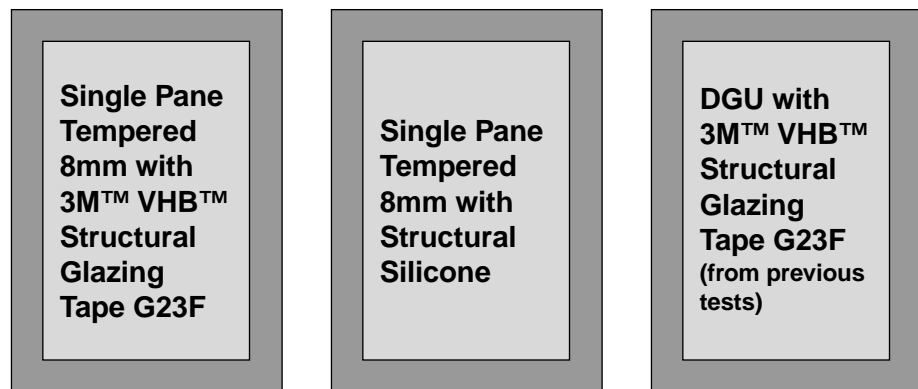
Testing

2 sets of panels were subjected to the following test sequences to evaluate their performance. The first set of panels consisted of laminated glass (with 3M™ VHB™ Tape 4972) and double glazed units (one with 3M™ VHB™ Tape G23F and one with one part structural silicone sealant). The second set of panels consisted of 8mm tempered glass. One constructed with one part structural silicone sealant and one with 3M™ VHB™ Tape G23F. Also included in this second set of panels was the DGU constructed with 3M™ VHB™ Tape G23F from the first set of tests. Summaries of the test methods, observations, and official results are provided on the following pages. While curtain wall systems can incorporate many different designs and materials, the testing of these “typical” panels demonstrate the high performance level of 3M™ VHB™ Tapes in these demanding applications.

First set of panels



Second set of panels

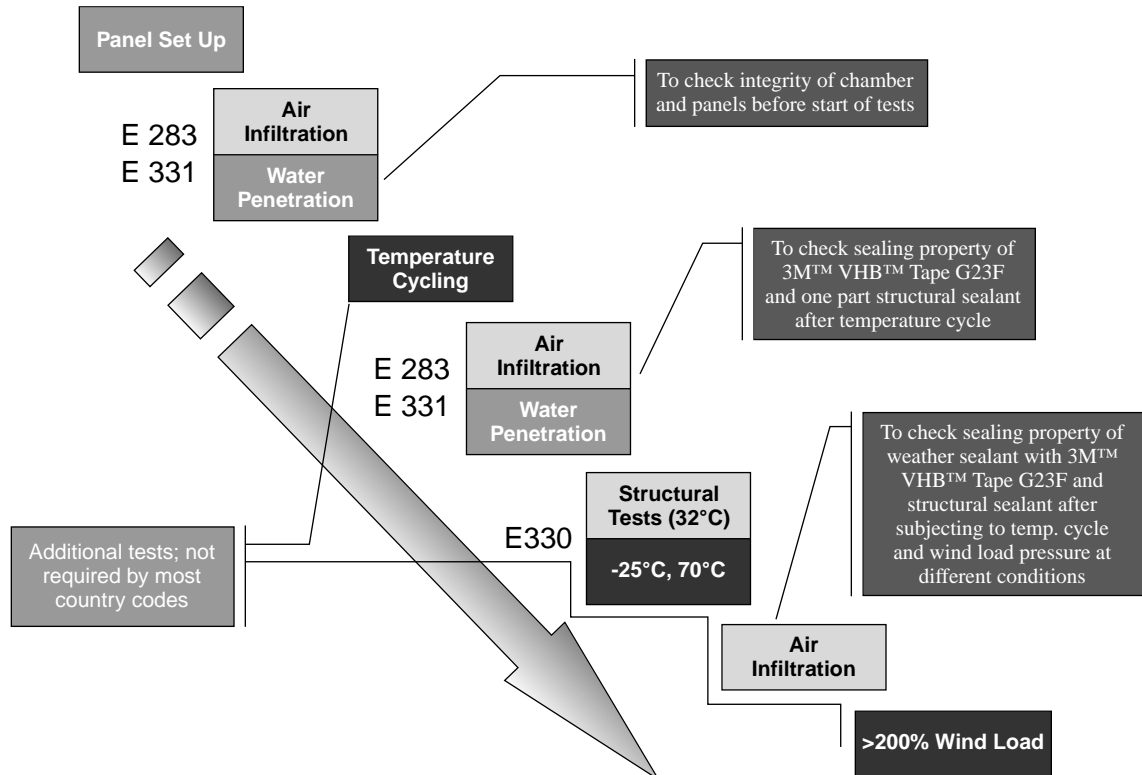


Technical Bulletin

Structural Performance Tests of 3M™ VHB™ Structural Glazing Tapes

Test Sequence

The test sequences (shown in the flow chart below) consisted of measuring the air leakage, water penetration, thermal cycling, air infiltration, water leakage and wind load structural performance at ambient conditions, -25°C (13°F) and elevated temperatures at 70°C (158°F). The air infiltration was done again to confirm the integrity of seal/adhesion properties of both 3M™ VHB™ Tapes and the one part structural silicone sealant. At the end of the test sequence, the uniform static pressure was then increased to more than 200% of the designed wind load in both directions (± pressure).



Thermal Aging

A set of three panels, with each panel assembled using 3M™ VHB™ Structural Glazing Tapes, were given 20 thermal cycles from -25°C to 70°C (-13°F to 158°F) with the temperature extremes held for a minimum of 15 minutes. The cycles subjected the 3M™ VHB™ Tapes to thermal aging and stresses due to thermal expansion and contraction of the bonded parts. The 3M™ VHB™ Structural Glazing Tapes retained complete contact throughout the thermal cycles, with no loss of adhesion.

Technical Bulletin

Structural Performance Tests of 3M™ VHB™ Structural Glazing Tapes

Air Leakage

The air infiltration test was conducted in accordance with ASTM E283 “Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors under Specified Pressure Differences across the Specimen” with a static pressure of 0.3 kPa (6.24 psf), corresponding to an 80 kph (50 mph) wind load. This test was repeated again at the end of the structural wind load test at elevated temperature. There was no measurable air leakage through the 3M™ VHB™ Tapes and the one part structural silicone sealant bonding the frames around the perimeter of the panels.

Water Penetration

The water penetration test was performed in accordance with ASTM E331 “Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference” with a high pressure water spray under a static pressure of 0.72 kPa (15 psf) for 15 minutes. The panels assembled with 3M™ VHB™ Tapes G23F and 4972 had no water leakage through the tape. Performance was comparable to that of the one part structural silicone sealant.

Wind Load Structural At ambient 32°C (90°F), -25°C (13°F) and 70°C (158°F)

The wind load structural test was performed in accordance with ASTM E330 “Standard Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference”. The panels were subjected to both positive wind loads (inward acting force) and negative wind loads (outward acting force – the most severe direction for frame attachment). The panels were first subjected to loads of 0.5, 1.0, 1.9 and 2.9 kPa (10, 20, 40 and 60 psf) in each direction with the peak pressure held for 1 minute. The 2.9 kPa (60 psf) level represents the basic design pressure for a typical high-rise building or a sustained wind speed of 250 kph (155 mph). The glass panels were visually inspected after the loads. All glass panels showed no sign of any visual defects. The heating and cooling chamber was then set up in front of the glass panels simulating the external side of the curtain wall. Temperature was lowered to -25°C (-13°F). Then the panels were subject to loads of 0.5, 1.0, 1.9 and 2.9 kPa (10, 20, 40, and 60 psf) in each direction and held for 1 minute at each pressure load. Then temperature was increased to 70°C (158°F) and similar sequences of wind load pressure cycling were conducted. After the structural wind load tests at these temperature settings, the heating/cooling chamber was removed. The panels were inspected visually for any sign of delamination or defects. All glass panels showed no sign of any visual defects. It was noted that there was visible moisture condensation on the spacer tape of the 8 mm tempered glass glazed unit constructed with the one part structural silicone sealant after the structural wind load tests at various temperature settings.

Air Leakage

The air infiltration test was conducted in accordance with ASTM E283 “Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors under Specified Pressure Differences across the Specimen” with a static pressure of 0.3 kPa (6.24 psf), corresponding to an 80 kph (50 mph) wind load. There was no measurable air leakage for both sets of glass panels demonstrating that 3M™ VHB™ Structural Glazing Tape can withstand the severe test conditions (thermal aging and structural load at extreme temperature settings).

Wind Load Structural At ambient 32°C (90°F)

The wind load structural test was again performed in accordance with ASTM E330 “Standard Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference”. The panels were then subject to loads of 4 kPa and held for 10 seconds at ambient temperature conditions. Then pressure was reversed and increased up to a suction of 4 kPa and held for 10 seconds. For the first set of panels, this procedure was repeated at 5 kPa (104 psf) and 6 kPa (125 psf) which is 200% of the design pressure load. All the glass panels passed this test successfully.

Technical Bulletin

Structural Performance Tests of 3M™ VHB™ Structural Glazing Tapes

Wind Load Structural Destructive at ambient, 32°C (90°F)

The wind load structural test was performed in accordance with ASTM E330 “Standard Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference”. The panels were subjected to an increase in negative pressure (glass panels were being pushed away from frame) until failure occurred. It was noted that at -8.4 kPa, the laminated glass construction with 3M™ VHB™ Structural Glazing Tape 4972 failed. After observing the video clip, it appeared that the laminated glass started breaking from the center of the glass panel due to deflection beyond the capability of the laminated glass. Even though the majority of glass blew out, the 3M™ VHB™ Tape 4972 held the glass in place around the perimeter demonstrating the capability of the tape to act as an effective bonding agent at this extreme pressure. No delamination or any visual defect was seen on the DGU panels with either 3M™ VHB™ Tape G23F or one part structural silicone sealant.

The second set of panels constructed with 8 mm tempered glass, (one with 3M™ VHB™ Tape G23F and the other with one part structural silicone sealant) together with the 3M™ VHB™ Tape G23F DGU panel from the first set of tests, were again subjected to similar wind loads however, the peak pressure recorded was ± 8 kPa and held for 10 seconds. 8 kPa corresponds to a wind speed of 416 kph (258 mph). Pressure was then increased up to the limit of the blower. In this case, the chamber managed to achieve up to ± 10 kPa without failure, which corresponds to a wind speed of 467 kph (290 mph). Tempered glass panels constructed with both one part structural silicone sealant or 3M™ VHB™ Structural Glazing Tape G23F showed no sign of failure after the 10 kPa pressure load. The DGU panel constructed with 3M™ VHB™ Tape G23F also withstood the ± 10 kPa load without failure, even though it has been subjected to 40 cycles of thermal aging and 2x the structural wind loads at the extreme temperature settings.

Technical Information

The technical information, recommendations and other statements contained in this document are based upon tests or experience that 3M believes are reliable, but the accuracy or completeness of such information is not guaranteed.

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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.

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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 negligence, warranty, or strict liability.



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