

Inspection / Evaluation of 3M VHB Structural Glazing Tape for Structural Integrity after Years of Service

CLIENT: 3M INDUSTRIAL ADHESIVES & TAPES DIVISION

CDC PROJECT #: F00892

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SUBMITTED ON: JANUARY 11, 2011

Background:

CDC was contacted by 3M to perform testing on the structural integrity of 3M VHB Structural Glazing Tape (SGT) 4972 and record the data based on its use as a structural adhesive holding the glass to the aluminum framing on the exterior façade in South America. 3M VHB SGT 4972 is an 0.080 inch (2.0 mm) thick acrylic foam adhesive tape and according to 3M is compositionally the same as 3M VHB SGT G23F which is 0.090 inch (2.3 mm) thick. Three buildings were chosen by 3M based on the various service life of the VHB SGT. CDC chose the individual test locations on each building based on the following criteria:

- Access available to 3M and CDC.
- Areas that have experienced the highest negative wind pressures (usually toward the top, and at the extreme corners of the building)
- Areas of the most intense ultraviolet exposure (generally from the North and the West in South America)

The existing conditions were noted and the results of each test were recorded.

Test Objective:

The objective was to test the 3M VHB SGT 4972 in a negative windload direction by a sustained “pulling” action and provide 3M with independent test data for each location tested. Test data included tensile capacity at design load and 150% overload of the SGT with a minimum 5 year service life.

Conclusion / Test Results:

1. 3M Brazil CTC (approximately 5 years old, constructed in 2005): While testing was performed mainly to check the apparatus; testing was completed at two locations with no evident signs of failure.
2. Dallas Tower (approximately 10 years old, constructed in 2000): Testing was completed on 5 locations of various installed configurations with no evident signs of failure (see the recorded test data listed in this report).
3. Glass Tower (approximately 16 years old, constructed in 1994): Testing was completed on 12 locations of various installed configurations with no evident signs of failure (see the recorded test data listed in this report).

Test Method:

The test method used for evaluating the integrity of VHB SGT is a modified version of ASTM C 1392 "Standard Guide for Evaluating Failure of Structural Sealant Glazing". The modification is that the difference between test areas and failed areas was not determined. This was due to the fact that removal of the tape to simulate a failed area was not acceptable on the projects.

This was a non-destructive test procedure that was used also to replicate imposed loads using Test Method ASTM E 330 "Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Uniform Static Air Pressure Difference".

Using a tripod apparatus that braced against the face of glass at the interior framing members, the center 12" (305mm) long vacuum pad is aligned at the edge of glass, at the VHB SGT on the interior. The apparatus was equipped with a vacuum pump connected to an air compressor to hold the center pad securely in place while slowly pulling the pad / glass outward using a hydraulic cylinder connected to a hydraulic pump. The pulling action replicated negative wind pressures and thereby testing the tensile stress capacity of the VHB SGT. Prior to testing, the distance from the inside face of glass to a surface on the aluminum framing is measured (if possible) in its original state of rest using calipers. During each test, the displacement of the glass relative to the aluminum framing is also measured and recorded.

(See Photos #001-004 for test apparatus)

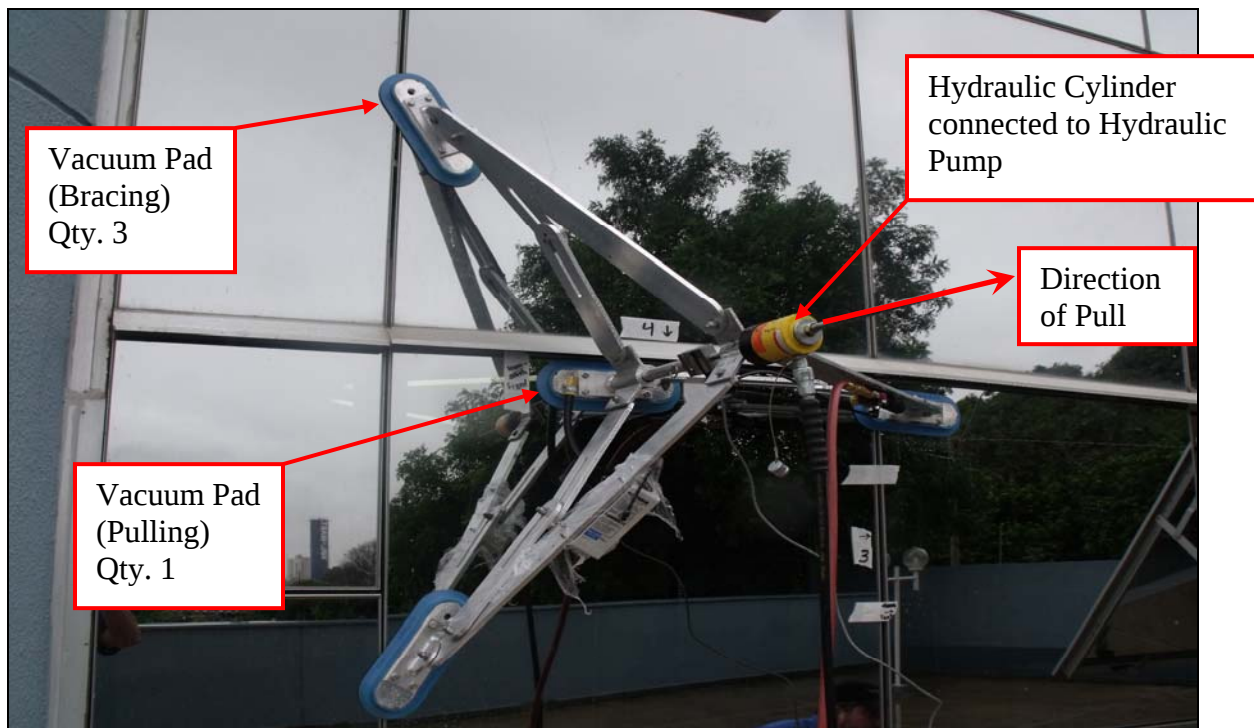


Photo #001: Testing apparatus in position on the wall. Pulling vacuum pad is close to the center of the length of tape to be tested. Bracing vacuum pads are positioned at interior aluminum framing members.

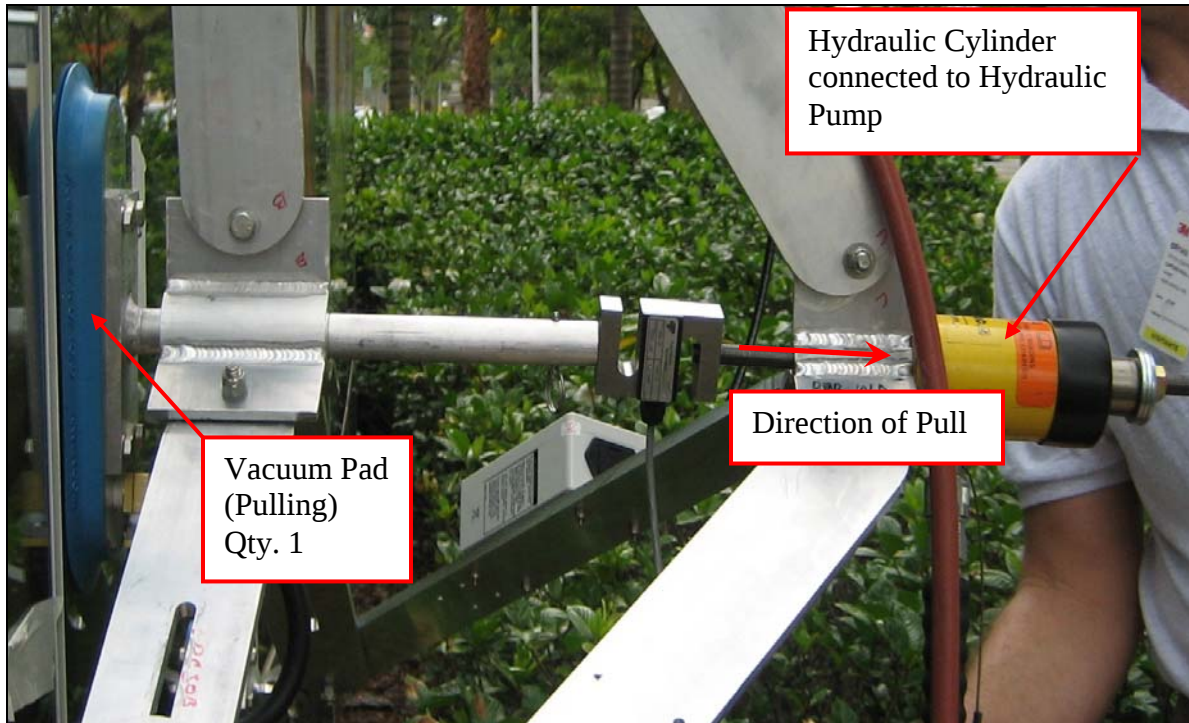


Photo #002: Enlarged view of the apparatus where the hydraulic cylinder pulls the vacuum pad; load cell measuring the amount of force is connected to a pressure meter (Photo #004) which recorded the pressure readings.



Photo #003: Hydraulic pump which is connected to the hydraulic cylinder on the test apparatus. The pump operator monitored the pressure meter, keeping it at the desired load.



Photo #004: The pressure meter connected to the load cell was monitored, keeping the desired force being pulled on the vacuum pad. "S"-Type Load Cell & Pressure Meter were calibrated by RECAL on 11/29/2010 (See Certificate of Calibration attached to this report).

Test Equation:

The equation used to determine what load was required at each test location (Pulling vacuum pad) is: **Tape width X Tape length X PSI = lbs. (load)**. The width of the VHB SGT 4972 at two of the three buildings is 1.181 inches (30 mm); however, each test location was measured in case installation adjustments were made. The length of the side of the vacuum pad aligned over the tape is 11.75 inches (298 mm).

Test Parameters:

Each location was tested to 12 psi (85 kPa) tensile design strength (provided by 3M) as well as a 150% overload of 18 psi (124 kPa). An inline "S"-Type load cell measured the amount of force being applied.

Test Sequence @ Each Location:

Design Load Cycle (100% Design Load)

The glass was pulled to the appropriate design load of 12 psi (85 kPa), held for 10 seconds, and then released back to its original state. The 10 second design load cycle was repeated two more times at the same location with a minimum of 1 minute between each test (Per ASTM E 330).

After a 3 to 5 minute recovery period, the glass was then pulled at the same location to the appropriate design load of 12 psi (85 kPa), held for 60 seconds, and then released back to its original state.

Overload Cycle (150% Design Load)

After a 3 to 5 minute recovery period at original state, the glass was then pulled again at the same location to 150% overload of 18 psi (124 kPa), held for 60 seconds, and then released back to its original state. At 45 seconds into this test, talcum powder was blown into the back surface to reveal any delaminating that might have occurred between the glass and the VHB-SGT.

Each test location was listed as pass / fail.

Pass / Fail Determination:

Each test was determined as passed if:

- The VHB-SGT remained completely adhered to both the aluminum framing and the glass (no adhesion failure was permitted).
- The VHB-SGT did not shear within itself (no cohesion failure was permitted).

Each test was determined as failed if:

- Loss of adhesion between the VHB-SGT and glass / aluminum framing occurred.
- Cohesion failure of the tape within itself.



Photo #005: Prior to testing, the distance from the inside face of glass to a surface on the aluminum framing is measured (if possible) in its original state of rest using calipers. During each test, the displacement of the glass relative to the aluminum framing is also measured and recorded.



Photo #006: Talcum powder was applied at the interior 45 seconds into the overload test to determine if there was evidence of adhesion failure of the VHB SGT to the glass. If adhesion failure occurred, powder would fall into the detached area or void, producing an uneven line of powder when viewed from the exterior (See Photo #007 for exterior view).



Photo #007: Exterior view looking through the glass at the talcum powder. A clean, straight line indicates no visible adhesion failure between the VHB-SGT and glass.

Test Locations:

Test #1 – 3M Brazil CTC



Photo #008: Test Location #1-3M Brazil CTC

3M Brazil CTC Information:

The 3M Facility is approximately 5 years old (constructed in 2005), located at Rod. Anhanguera, km 110, Sumare, Sao Paulo, Brazil.

Locations 1 and 2 were located at Ground Level, facing West.

The glass make-up is: 4mm Tinted/6mm Resin Fill/4mm Clear.

The measured tape width was 1.17 inches (29.72 mm).

Design Load = **1.17" X 11.75" X 12 psi = 165 lbs. (75 kg)**

Overload = **1.17" X 11.75" X 18 psi = 247.5 lbs. (112 kg)**

Testing performed at the 3M Facility was primarily for the purpose of setting up and testing the apparatus before going to the other buildings; no displacement measurements were recorded.

Both locations passed, with no evident adhesion or cohesion failure.

Test #2 – Dallas Tower

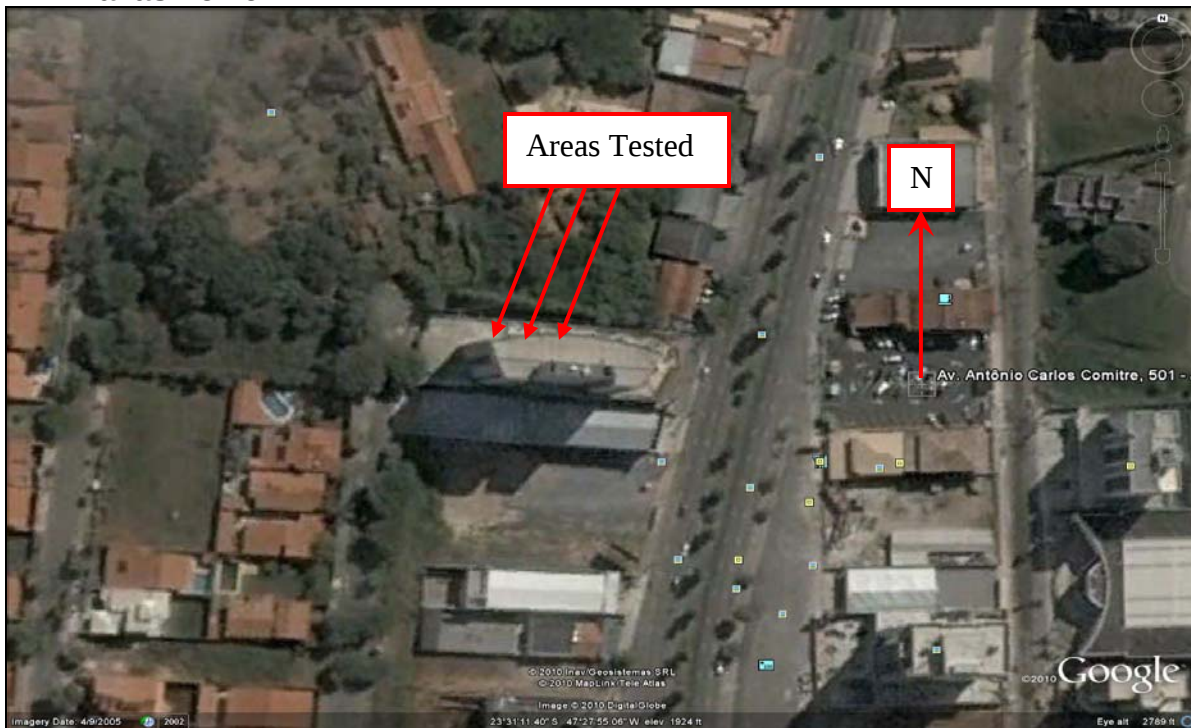


Photo #009: Aerial View of Test Location #2-Dallas Tower

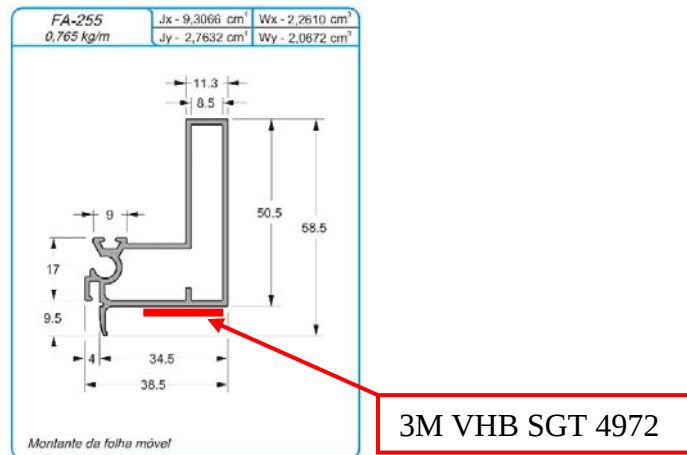


Photo #010: Test Location #2-Dallas Tower

Dallas Tower Information:

The Dallas Tower is approximately 10 years old (constructed in 2000), located at 510 Avenida Antonio Carlos Comitre, Sorocaba, Sao Paulo, Brazil.

The window system was primarily operable window frames installed within a structural aluminum grid. Below is the extrusion which the glass was attached to with 3M VHB SGT 4972:



Locations 3 through 7 were located on Level 4, facing North.

The glass make-up is: 4mm Reflective/PVB/4mm Clear.

The measured tape width was 1.17 inches (29.72 mm).

Design Load = **1.17" X 11.75" X 12 psi = 165 lbs. (75 kg)**

Overload = **1.17" X 11.75" X 18 psi = 247.5 lbs. (112 kg)**

Test Results for Dallas Tower:

Readings for the locations listed below were taken from the sub-frame members.

Location #	Rest	10 Sec. @ 100%	Rest	10 Sec. @ 100%	Rest	10 Sec. @ 100%	Rest	1 Min. @ 100%	Rest	1 Min. @ 150%
3 Vert. @ Operable	41.6 mm	41.55 mm	-	41.75 mm	-	-	-	41.75 mm	-	41.72 mm
4 Horiz. @ Operable	41.88 mm	41.92 mm	-	41.98 mm	-	-	-	42.05 mm	-	42.06 mm
5 Horiz. @ Fixed	41.70 mm	41.78 mm	-	41.82 mm	-	-	41.72 mm	41.88 mm	41.71 mm	42.02 mm

6 Vert. @ Door	31.47 mm	31.49 mm	-	31.72 mm	-	31.55 mm	31.41 mm	31.57 mm	31.43 mm	31.91 mm
7 Vert. @ Operable	41.30 mm	41.36 mm	-	41.41 mm	-	41.53 mm	41.32 mm	41.52 mm	41.35 mm	41.72 mm

Each location passed, with no evident adhesion or cohesion failure.

Test #3 – Glass Tower

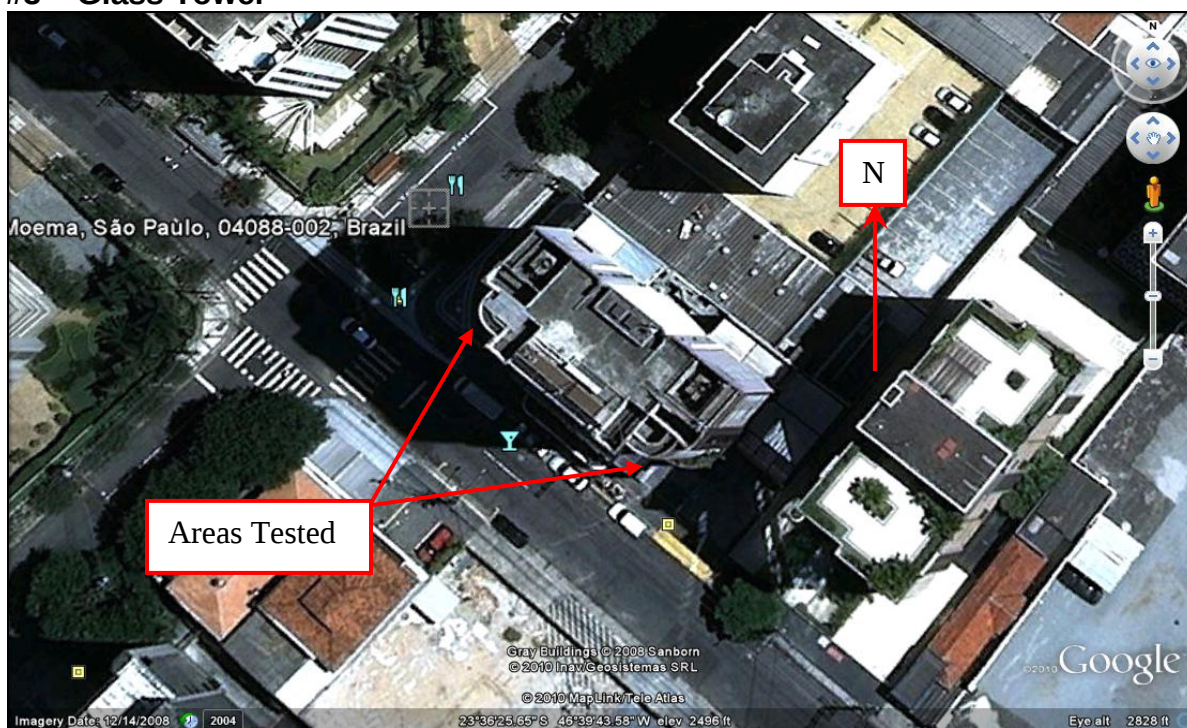


Photo #011: Aerial View of Test Location #3-Glass Tower



Photo #012: Test Location #3-Glass Tower



Photo #013: Test Location #3-Glass Tower (Interior View)

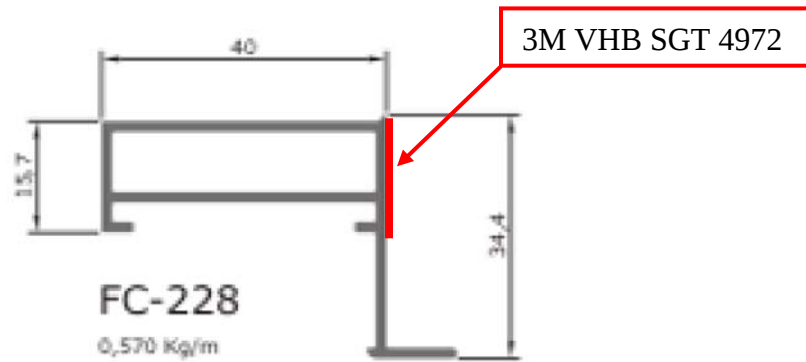


Photo #014: Test Location #3-Glass Tower (Interior View)

Glass Tower Information:

The Glass Tower is approximately 16 years old (constructed in 1994), located at 941 Alameda Dos Jurupis, Sao Paulo, Brazil.

The window system was fixed window frames installed within a structural aluminum grid. Below is the extrusion which the glass was attached to with 3M VHB SGT 4972:



Locations 8 through 13 were located on Level 16, facing West.
Locations 14 through 19 were located on Level 16, facing South.
All glass was fixed (not operable).

The glass make-up is: 4mm Reflective/PVB/4mm Clear.

The measured tape width was 1.0945 inches (27.80 mm).

Design Load = **1.0945" X 11.75" X 12 psi = 154.3 lbs. (70 kg)**

Overload = **1.0945" X 11.75" X 18 psi = 231.5 lbs. (105 kg)**

Test Results for Glass Tower:

Readings for locations 12, 13, & 15 were taken from the sub-frame members.

Readings for locations 8, 9, 10, & 18 were taken from the main framing members which could include some displacement of the sub-frame from the main framing members.

Location #	Rest	10 Sec. @ 100%	Rest	10 Sec. @ 100%	Rest	10 Sec. @ 100%	Rest	1 Min. @ 100%	Rest	1 Min. @ 150%
8 Horiz.	55.84 mm	56.83 mm	-	56.76 mm	-	56.07 mm	55.43 mm	56.77 mm	55.55 mm	57.07 mm
9 Horiz.	56.85 mm	57.60 mm	-	56.99 mm	-	57.64 mm	56.70 mm	57.56 mm	56.90 mm	58.10 mm
10 Horiz.	54.37 mm	55.09 mm	-	55.03 mm	-	55.20 mm	54.34 mm	55.26 mm	54.30 mm	55.91 mm
11 Vert.	-	-	-	-	-	-	-	-	-	-

12 Vert.	42.09 mm	42.11 mm	-	42.31 mm	-	42.29 mm	42.09 mm	42.32 mm	42.05 mm	42.14 mm
13 Vert.	42.04 mm	42.26 mm	-	42.16 mm	-	42.25 mm	41.98 mm	42.18 mm	41.90 mm	42.05 mm
14 Vert.	-	-	-	-	-	-	-	-	-	-
15 Vert.	41.83 mm	41.94 mm	-	42.16 mm	-	41.93 mm	41.75 mm	42.26 mm	41.86 mm	42.01 mm
*16 Vert.	-	-	-	-	-	-	-	-	-	-
17 Horiz.	-	-	-	-	-	-	-	-	-	-
18 Horiz.	54.57 mm	55.44 mm	-	56.66 mm	-	55.21 mm	56.84 mm	56.84 mm	55.12 mm	57.27 mm
**19 Horiz.	-	-	-	-	-	-	-	-	-	-

Each location passed, with no evident adhesion or cohesion failure.

***Window sub-frame began to disengage from the main framing members; therefore measurements could not be obtained.**

****Testing was stopped due to disengagement of glass/sub-frame to main framing members.**

Additional Testing Photos:



Photo #015: Air compressors connected in-line to provide sustained air during the test procedure.



Photo #016: Pulling vacuum pad testing VHB SGT 4972 viewed from the exterior.



Photo #017: Pulling vacuum pad testing VHB SGT 4972 viewed from the interior.



Photo #018: Testing being performed, monitored, and results being recorded.



Photo #019: Testing being performed. Note the amount of offset at the adjacent glass / framing.



Photo #020: Blow-up photo of glass / framing offset due to testing (pulling action) being performed.



Photo #021: During each test, the displacement of the glass relative to the aluminum framing is measured and recorded.

CALIBRATION
Certification No.: 1426.01**CERTIFICATE OF CALIBRATION**

McEuen Enterprises, Inc. • 1003A Cresthaven Drive • Euless, TX 76040 • Phone: 817-540-0011 • Fax: 817-283-5107 • Web: recalcalibration.com

COMPANY:

Name: Construction Testing Sciences, LLC.
Address: 4609 S. Shiloh Road
Garland TX 75041
Phone: (972) 437-4200

REPORT:

Report #: 1-31291
Calibration Date: 11/29/2010
Recalibration Date: 11/29/2011
Job Site Recal Lab

EQUIPMENT CALIBRATED:

Machine Type: Load Cell Location: Portable
Manufacturer: Transducer Techniques Directions: Portable
Model: SBO-2K Maximum: 2,000 Pounds
Serial #: 158773 Minimum: 50 Pounds

MACHINE READING POUNDS	RUN 1 Temperature: 78			RUN 2 Temperature: 78			ALGEBRAIC DIFFERENCE	CEL CODE
	LOAD CELL READING	MACHINE ERROR		LOAD CELL READING	MACHINE ERROR			
		Lbs.	%		Lbs.	%		
50	49.9	0.1	0.20	49.9	0.1	0.20	0.00	DW
100	99.9	0.1	0.10	99.8	0.2	0.20	0.10	2.5K
200	199.8	0.2	0.10	199.7	0.3	0.15	0.05	2.5K
500	499.4	0.6	0.12	499.3	0.7	0.14	0.02	2.5K
1,000	998.5	1.5	0.15	998.5	1.5	0.15	0.00	2.5K
1,500	1,497.2	2.8	0.19	1,497.2	2.8	0.19	0.00	2.5K
2,000	1,995.9	4.1	0.21	1,995.7	4.3	0.22	0.01	2.5K

"As Found" condition was within the required tolerance, unless otherwise noted.
Calibrated in accordance with ASTM E4-09, producing the above values traceable to NIST.
Indicator resolution is 0.1 lbf
Indicator returned to zero
Lo In= 000.46, Lo Rd= .000, Hi In= 037.68, Hi Rd= 2000
Measurement Uncertainty: 0.05% Full Scale.

CALIBRATION APPARATUS USED: Load Cell

Method Used: ASTM E-74

Manufacturer	Serial #	Cell Code	Max Capacity	Class A Limit	NIST ID	Cal Lab	Date Calibrated
Fairbanks	None	DW	325	5.0	169838	Aldinger	9/21/2010
BLH(3)	975060	2.5K	2,500	54.7	43688-1	Tovey	11/4/2010

Q.A. Manager: Kara McEuen-Powell

Technician: Warner E. Powell

The values of the above document are traceable to NIST.
Uncertainty expressed at 95% confidence using a coverage of k=2
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