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January 17, 2024

Via Email:
ATTN: MO MADANI
Florida Building Commission
Product Oversight Committee
2601 Blair Stone Road
Tallahassee, Florida 32399
Mo.madani@myfloridalicense.com

Re: ES-SGD2020, FLORIDA PRODUCT APPROVAL NO. 22267 COMPLAINT
ES-8000T, FLORIDA PRODUCT APPROVAL NO. 17897.5 COMPLAINT

Dear Product Oversight Committee,

As you are aware, this firm represents PGT Innovations, Incorporated ("PGTI"). Accordingly, please direct any and all correspondence regarding this matter to the undersigned herein. Further, this correspondence is intended to serve as a formal written reply to the response by E.S. Windows dated January 17, 2024 concerning PGTI's Complaint directed to the Florida Department of Business & Professional Regulation in regards to both the Florida Product Approval No. 22267, ES-SGD2020 (the "SGD Product") and Florida Product Approval No. 17897.5, ES-8000T Jumbo (the "Commercial Window Wall Product") (collectively the "Subject Products").

First and foremost, E.S. Windows' assertions that such allegations contained therein are unverified and lack merit are unfounded and not supported by the record evidence, but, rather, demonstrate a blanket denial and an attempt to confuse the issues highlighted by PGTI therein. Such a position by E.S. Windows is not supported by requisite facts or data and is comprised solely of conclusory statements.

Moreover, PGTI has not now nor ever engaged in unfair trade practices—as alleged by E.S. Windows. Rather, PGTI believes the Subject Products present a very real health and safety risk to the Florida consumer, which necessitated PGTI's obligation to commence the instant action. E.S. Windows' attempt to dissuade action on behalf of this Committee by diminishing the very real concerns regarding its products as mere "competition," is a disservice to the citizens and consumers of this state. Accordingly we would respectfully request this Committee to not be confused by such issues of purported "competition" and instead focus on the facts at hand: (1) E.S. Windows' Subject Products do not comport with the interlayer manufacturer's own product guidance; (2) E.S. Window's Subject Products are an extreme outlier and do not comport with known industry standards and practices; and (3) the tested FPA 22267 specimen, performed by an independent third-party testing entity and witnessed by Florida Professional Engineers, resulted in total failure of the system.

The Subject Products do not comport with the interlayer manufacturers' product guidance or known industry standards

E.S. Windows attempts to equate the PVB interlayer manufacturer's performance guidelines to "marketing materials." Such an assertion is completely inaccurate and deceptive at best. While it is true the interlayer manufacturer's product guidelines do not "prohibit" the implementation of PVB interlayers in dry-glazed systems, it is clear had the same been designed for such a purpose the interlayer manufacturer would have provided product guidance for their design and implementation in fenestration systems. Rather, the opposite is true. The interlayer manufacturer, of the exact PVB interlayer utilized in E.S. Windows' Subject Products, explicitly states: "[o]nly SentryGlas can be used in dry glaze systems because of its high modulus." Accordingly, it is clear not only are the PVB interlayers, utilized by E.S. Windows' Subject Products, ***not designed*** for such purposes—but, further, the interlayer manufacturer believed the PVB Interlayers were ***not fit*** for use in dry glazed systems. Such materials are not mere "marketing materials," as coined by E.S. Windows, but are, in fact, the interlayer manufacturer's guidance concerning the ***actual*** performance capabilities of its products. To ask the Committee to ignore such product guidance would be the equivalent of asking the Committee to turn a blind eye, all because E.S. Windows has chosen to ignore it. The same, is plainly, an illogical course of action.

Importantly, the interlayer manufacturer is not the only entity that believes PVB interlayers are not fit for use in a dry glazed system. In a sample of nearly 100 other Florida Product Approvals, Florida window and door manufacturers align closely with the interlayer manufacturer's design guidelines and pressure capacities. Remarkably, ***no other Florida manufacturer*** approves comparable dry glazed PVB interlayer systems—such as the Subject Products at issue. Accordingly, E.S. Windows' Subject Products depart from known industry standards and represent extreme outliers when evaluating ***all other comparable systems on the market***.

Even further, however, it is not just the PVB interlayer manufacturer or Florida window and door manufacturers that recognize such inherent product limitations of dry glazed systems. The American Society of Civil Engineers ("ASCE") also stresses the dangers of using PVB interlayers in dry glazed systems. The ASCE conducted missile impact testing on varying glazed systems (inclusive of dry glazed systems) and published their results in an article titled *Postbreakage Behavior of Heat Strengthened Laminated Glass under Wind Effects* in the 1993 Journal of Structural Engineering. A true and correct copy of the ASCE Article is attached hereto as **Exhibit A**. Therein the ASCE noted, "[t]he dry glazed specimens with the high velocity (HV) missile impact tests are not included in these results. All of the glass was lost in these tests, i.e. the entire unit was pushed from the frame." *See id.* at p. 463.

<u>An independent third-party testing entity tested the subject SGD Product, which resulted in a sudden and catastrophic failure of the system</u>

PGTI retained the services of an independent third-party testing entity, PRI Construction Materials Technologies LLC ("PRI"), to conduct testing of the SGD Product. The same was tested to TAS 201 (large missile) and TAS 203 test protocols. In each instance, the SGD Product failed to perform at the levels claimed by E.S. Windows. Attached hereto please find testing reports for the FPA 22267 systems, tested by independent third-party testing entity, PRI Construction Materials Technologies LLC ("PRI") as **Exhibit B**.

Therein, PRI noted, in reference to the dry glazed 57x102 systems, that the "samples provided did not achieve the desired performance for basic protection per TAS 201 at the desired differentials per TAS 203 due to deglazing during cyclic wind loading." *See* Exh. B. In reference to the wet glazed 142x120 system PRI noted, "the sample provided did not achieve the desired performance for basic protection per TAS 201 at +80/-85 psf pressure differentials per TAS 203 due to deglazing during positive cyclic wind loading." *See id.*

Additionally find below the test summaries previously provided to the Committee in PGTI's initial complaint of the independent testing of the three (3) separate systems of FPA 22267, inclusive of the PRI summaries illustrating the same.

<u>Dry glazed 57x102, 2 panel SGD, PVB interlayer, level 1 reinforcement</u>

- Units failed during the fifth sequence of TAS 203 testing, as the dry glazed gasket was unable to hold the flexible PVB interlayer within the system's panel.
- Notably this is the smallest qualified option and lowest design pressure in the pressure charts on FPA 22267 and would have had the best chance for success.

Table 2: Specimen 1 - TAS 203 / E1886 Results

Direction	Pressure Differential PSF[1]	Number of Cycles Completed	Max Deflection[2] (inches)	Permanent Set[2] (inches)	Result[3]
Positive	11 to 27	3500	0.24	0.07	Pass
	0 to 32	300	0.27	0.07	Pass
	27 to 42	600	0.39	0.07	Pass
	16 to 53	100	0.48	0.07	Pass
Negative	-20 to -65	50	0.65	-	Fail
	-33 to -52	1050	-	-	-
	0 to -39	50	-	-	-
	-13 to -33	3350	-	-	-

Notes:

1. Tape and polyethylene film were utilized to seal the specimen for excessive air leakage, and in the PRI-CMT witness's opinion did not influence the test results.
2. Deflection and permanent set were captured on the meeting stiles, the unsupported span measured 97-3/4".
3. Upon completion of testing the specimen did not meet the requirements outlined in the Florida Building Code section 1626.2.8. The operable glass lite deglazed at 26 cycles into the sequence.

<u>Dry glazed 57x102, 2 panel SGD, PVB interlayer, level 2 reinforcement</u>

- Units failed during the sixth sequence of TAS 203 testing, as the dry glazed gasket was unable to hold the flexible PVB interlayer within the system's panel.

Table 4: Specimen 2 - TAS 203 / E1886 Results

Direction	Pressure Differential PSF[1]	Number of Cycles Completed	Max Deflection[2] (inches)	Permanent Set[2] (inches)	Result[3]
Positive	11 to 27	3500	0.14	0.03	Pass
	0 to 32	300	0.20	0.01	Pass
	27 to 42	600	0.23	0.02	Pass
	16 to 53	100	0.26	0.01	Pass
Negative	-23 to -78	50	0.53	0.04	Pass
	-39 to -62	1050	-	-	Fail
	0 to -47	50	-	-	-
	-16 to -39	3350	-	-	-

Notes:

1. Tape and polyethylene film were utilized to seal the specimen for excessive air leakage, and in the PRI-CMT witness's opinion did not influence the test results.
2. Deflection and permanent set were captured on the meeting stiles, the unsupported span measured 97-3/4".
3. Upon completion of testing the specimen did not meet the requirements outlined in the Florida Building Code section 1626.2.8. The operable glass lite deglazed at 228 cycles into the sequence. Due to early failure within the cycle no deflections/sets were captured.

<u>Wet glazed 142x120, 2 panel SGD, PVB interlayer level 3 reinforcement</u>

- Unit failed very early in the first sequence of an eight sequence test.
- The inherent physical properties of PVB allow far too much stretch and/or ballooning during cycling at these sizes.

Table 2: TAS 203 / E1886 Results

Direction	Pressure Differential PSF[1]	Number of Cycles Completed	Max Deflection[2] (inches)	Permanent Set[2] (inches)	Result[3]
Positive	16 to 40	3500	-	-	Fail
	0 to 48	300	-	-	-
	40 to 64	600	-	-	-
	24 to 80	100	-	-	-
Negative	-26 to -85	50	-	-	-
	-43 to -6	1050	-	-	-
	0 to -51	50	-	-	-
	-17 to -43	3350	-	-	-

Notes:

1. Tape and polyethylene film were utilized to seal the specimen for excessive air leakage, and in the PRI-CMT witness's opinion did not influence the test results.
2. Deflection and permanent set were captured on the meeting stiles, the unsupported span measured 116-1/2".
3. Upon completion of testing the specimen did not meet the requirements outlined in the Florida Building Code section 1626.2.8. The IGU deglazed at 450 cycles into the sequence. Due to an early failure no deflections/sets were captured.

Importantly, as previously noted, each of the above tests were witnessed by Florida professional engineers with over thirty (30) years' experience in fenestration testing and in accordance with the methods designated in TAS 201-94 Impact Test Procedures and TAS 203-94 Criteria for Testing Product Subject to Cyclic Wind Pressure Loading. The tests concluded that the SGD Product failed to meet the requirements of sections 1620 and 1626 of the Florida Building Code. A PGTI Florida Professional Engineer has attested to the accuracy of these results in the Affidavit attached hereto as **Exhibit C**.

Such results are not isolated incidents, but rather appear to be the result of a systemic overstatement of performance capability when utilizing dry-glazed systems that simply does not and cannot perform as represented. Moreover, the Commercial Window Wall Product utilizes the exact same PVB interlayer as the SGD Product, also in a dry-glazed system. E.S. Windows claims its Commercial Window Wall Product can perform at levels 90% above the PVB interlayer manufacturer's performance guidance. Accordingly, it suffers the same deficiencies as the SGD Product and PGTI does not believe the Commercial Window Wall Product can actually achieve performance levels at the amounts claimed by E.S. Windows.

In the face of such substantial evidence presented against it, it is E.S. Windows' burden to overcome the same and prove compliance with the Florida Product Approval process. E.S. Windows has failed to do just that and in lieu of facts and evidence has provided mere blanket denials—devoid of any evidence in support.

Accordingly, at this time, PGTI has provided ample evidence in support of its claims against E.S. Windows' SGD Product and Commercial Window Wall Product and strongly refutes any and all baseless claims against it by E.S. Windows.

Should you have any questions regarding the foregoing or need any further documentation, please feel free to contact my office. Thank you in advance for your prompt attention to this matter.

Very truly yours,

/s/ Daniel J. DeLeo

Daniel J. DeLeo, Esq.

DJD/rkp
Enclosures

Postbreakage Behavior of Heat Strengthened Laminated Glass under Wind Effects

By Chris P. Pantelides,[1] Associate Member, ASCE, Amy D. Horst,[2] Associate Member, ASCE, and Joseph E. Minor,[3] Fellow, ASCE

Abstract: Results of a full-scale experimental investigation into the postbreakage behavior of heat-strengthened laminated glass subjected to windstorm effects are presented. Two different interlayer constructions and two different glazing configurations are examined. The two interlayer constructions are a PVB polymer and a PVB/PET/PBV composite polymer. The two glazing configurations are a conventional dry glazed system and an unconventional system with a silicone anchor bead. Two test criteria are established that relate to effects of a severe windstorm. The first criterion addresses impact with windborne debris; the second defines a wind-load spectrum that represents a severe windstorm of a 4-hr duration. Three principal findings are presented. First, the ability of heat strengthened laminated glass to reject small missile impacts with small probabilities of breaking the inner glass ply is established. Second, heat-strengthened laminated glass with the silicone anchor bead performed significantly better than similar glass in a dry-glazed system. Finally, the heat-strengthened laminated glass with the PVB/PET/PVB composite interlayer performs significantly better than similar glass with PVB interlayer.

Introduction

Possible hazards to people from glass particle fallout and a need for protecting interior furnishings and equipment strongly suggest that the selection of glass for tall buildings should involve consideration of postbreakage behavior. Choosing glass type and glass thickness using the design wind pressure only may not be a conservative design methodology. Building size, shape, and location and different areas of the building may require design criteria beyond simply wind pressure. The ability of glass to carry postbreakage wind-induced pressures and the propensity of the glass units to remain in their frames following breakage have become important considerations in the design process.

Test results reported in this paper examine the postbreakage behavior of heat strengthened laminated glass in two glazing configurations with respect to its resistance to small missile impacts and a subsequent dynamic wind-load spectrum. The test conditions simulate a severe windstorm (Pantelides et al. 1991) and may serve as a basis for future design criteria. The paper provides descriptions of the test conditions, the test facility, the types of laminated glass tested, and the glazing configurations evaluated. The test procedure is outlined, and a summary of results is presented.

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[2]Engr., Engrg. Services, City Utilities of Springfield, Springfield, MO 65802.

[3]Thomas Reese Prof. and Chmn., Dept. of Civ. Engrg., Univ. of Missouri-Rolla, Rolla, MO.

Note. Discussion open until July 1, 1993. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on July 19, 1991. This paper is part of the ***Journal of Structural Engineering***, Vol. 119, No. 2, February, 1993. ©ASCE, ISSN 0733-9445/93/0002-0454/$1.00 + $.15 per page. Paper No. 2273.

EXHIBIT
A

Background

The importance of addressing the postbreakage behavior of glass in tall buildings became evident after Hurricane Alicia hit the central business district of Houston, Texas, in 1983, resulting in extensive glass breakage and glass particle fallout. Kareem and Stevens (1984) reported on a survey of glass companies which indicated that more than 80% of the broken glass was caused by windborne debris (Neunlist 1983). This observation was supported by Beason et al. (1984) who concluded that the principal source of the missiles in downtown Houston was a rooftop in the center of the business district. It was known prior to this event that small rocks from gravel surfaced roofs, including single-ply membrane roofs with ballast, could become airborne at wind speeds as low as 18–20 m/s (40–45 mph) (King 1974) and had potential for impacting the glass in taller buildings (Minor et al. 1978). These observations and the fact that the wind velocities that occurred in downtown Houston during Hurricane Alicia 36–38 m/s (80–85 mph) were below those required for design by the Houston building code [nominally 40 m/s (90 mph)] (Vild 1984) strongly suggest that small missile impacts should be a consideration in the design of window glass in hurricane-prone urban areas.

Openings in tall buildings following glass breakage can result in damage to building furnishings and equipment. Falling glass particles produce potential liability resulting from injuries. Both of these effects produce adverse publicity for the building owner and architect. Various proposals have been advanced to address this problem. Fully tempered glass is a possible alternative to annealed or heat strengthened glass because of its breakage characteristics. The smaller particles that result from breakage of fully tempered glass may be less hazardous, although a certain hazard remains. Further, these small particles can damage or break other glass panels. Glass that has been coated with film may tend to stay in the opening following breakage, but subsequent wind gusts may push it out as a unit, or glass particles may separate from the film. A third option, which is the topic of the present paper, is the use of laminated glass. Laminated glass is composed of two glass lites adhered by an interlayer that is commonly a polymer. In this study, two types of interlayers were used with heat strengthened glass.

Laminated glass has been studied theoretically and experimentally, and compared with monolithic glass (Vallabahn et al. 1987; Behr et al., 1985, 1986). Further, tests by Minor and Reznik (1990) indicated that the failure strength of annealed laminated glass is equal, at room temperature, to that of annealed monolithic glass with the same nominal thickness. Discussions of the resistance of laminated glass to small missile impact can be found in Minor et al. (1978) and in manufacturer's literature (*A Guide* 1990).

Test Criteria

Presently, no test criteria exist that address the effects of missile impacts on glass in tall buildings during windstorms. Therefore, test criteria were defined for the research presented herein. The test criteria address both small missile impacts and subsequent cyclic wind pressures. The missile impact portion of the test criteria consists of impacting the outer surface of the glass specimen with a small (2.03 g) missile at 190 points. The missile impact pattern is shown in Fig. 1. This grid is based upon a density of 52 impacts per square meter (five impacts per square foot), which reflects data

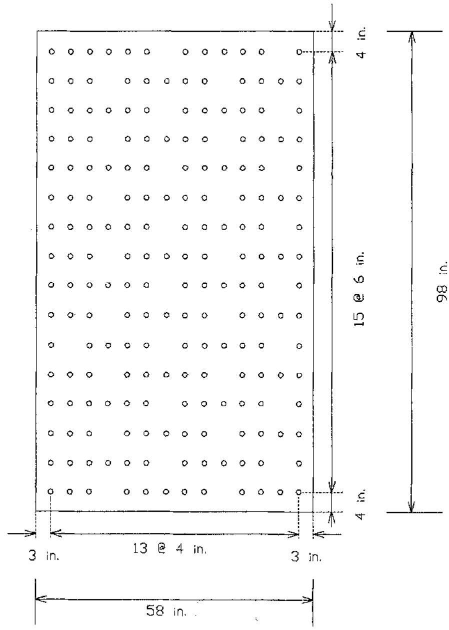

FIG. 1. Missile Impact Pattern (1 in. = 25.4 mm)

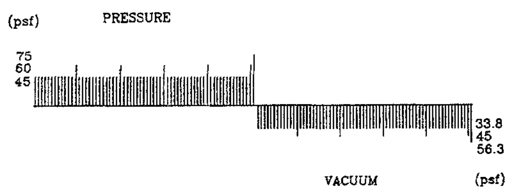

FIG. 2. One of Eight Sets of Pressure/Vacuum Cycles (Test Chamber Pressures/Vacuums) (1 psf = 47.88 Pa)

on glass impact damage from actual windstorm events as reported by Minor and Reznik (1990).

The cyclic wind pressure portion of the test criteria is defined by a wind load spectrum which consists of 1,056 cycles of pressure and suction which represents pressures and suctions which may be experienced on a tall building. The wind spectrum represents pressures at a specific point on a specific tall building in a midwestern (North America) city as predicted by a wind tunnel evaluation. The wind spectrum is associated with a 100-year mean recurrence interval windstorm in a midwestern city of approximately 4 h duration. The spectrum was implemented in the experiments within a frequency range varying from 0.05 to 0.2 Hz. These cycles are broken down to eight sets of the following sequences: 60 low (L) suction cycles at 2.15 kPa (45 psf), five medium (M) suction cycles at 2.87 kPa (60 psf), 1 high (H) suction cycle at 3.59 kPa (75 psf), followed by 60 low (L) pressure cycles at 1.62 kPa (33.8 psf), five medium (M) pressure cycles at 2.15 kPa (45 psf), and one high (H) pressure cycle at 2.70 kPa (56.3 psf). A graphic representation of one of the eight sets is shown in Fig. 2. The terms *vacuum* and *pressure* in Fig. 2 refer to the actual conditions inside the test chamber. To relate these conditions to suctions and pressures that exist on the exterior of the building, vacuum relates to wind pressures and pressure relates to suction pressures on the building face (Fig. 2).

TEST FACILITY

A facility was constructed at the University of Missouri-Rolla to perform the testing discussed in this paper (Horst 1991) (Fig. 3). The facility consists of a testing table that holds the specimen and forms the pressure chamber, two 1,892 L (500 gal.) pressure/vacuum accumulation tanks, a compressed air cannon, and a computer control and data acquisition center. The 3.05 × 3.05 m (10 × 10 ft) holding table was designed to rotate through 90° from vertical to horizontal positions for ease of mounting the test specimens and maintenance/modification operations. The pressure chamber is composed of the front side of the testing table, four C10 × 15.3 channels, and the glass that is mounted in its aluminum frame, on the channels. The pressure chamber was designed according to *ASTM E997-84* ("Standard Test" 1984) for a maximum pressure of 27.6 kPa (4 psi).

A compressed air cannon was used to propel the 2.03-g missiles representing windborne debris at the glass specimens, at consistent velocities (Fig. 4). The air cannon can be loaded and fired remotely. Two sensors, spaced 0.305-m (1-ft) apart, were used to measure the velocity of the missiles with very good accuracy. Computer-operated valves were used to apply

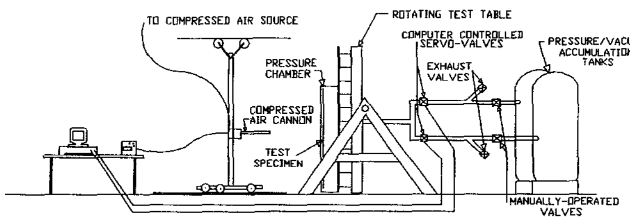

FIG. 3. Glass Test Facility

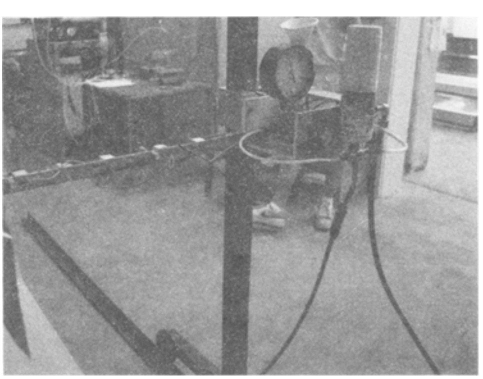

FIG. 4. Compressed Air Cannon

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pressure/vacuum cycles, representing the prescribed wind load spectrum, to the glass specimens.

Test Specimens and Glazing Configurations

The test specimens consisted of heat strengthened laminated glass with two interlayer constructions. The size of the specimens were 1,473 × 2,489 mm (58 × 98 in.) as shown in Fig. 1 and the nominal thickness of each of the two lites in all specimens was 5 mm (3/16 in.). The first interlayer construction was a 1.52 mm (0.060 in.) layer of polyvinyl butyral (PVB). The second interlayer construction was a combination of two 0.38 mm (0.015 in.) layers of PVB sandwiching a 0.08-mm (0.003-in.) layer of polyethylene terepthalate (PET). Both configurations are shown in Fig. 5. PVB interlayers were Saflex® and PVB/PET/PVB interlayers were Solarflex®, both manufactured by Monsanto Chemical Co.

Specimens were glazed using two different glazing configurations. The first configuration was a conventional dry-glazed detail. In this case, the glass was simply held in the frame by neoprene gaskets. A preset gasket was first placed into the frame [Fig. 6(*a*)], the glass was then inserted into the frame and, finally, a neoprene wedge gasket [Fig. 6(*b*)] was installed around the perimeter. The other configuration was unconventional. It was composed of a dry-glazed system augmented by a bead of structural silicone sealant between the glass and a batten attached to the inside of the window frame. Two variations of this configuration were tested. The first was a "large anchor" detail [Fig. 7(*a*)] that has a 19 mm (3/4 in.) silicone bead,

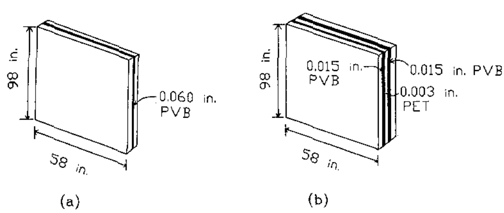

FIG. 5. Interlayers of Heat-Strengthened Laminated Glass: (*a*) PVB; and (*b*) PVB/PET/PVB (1 in. = 25.4 mm)

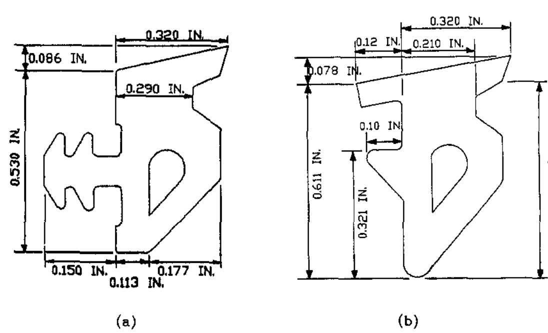

FIG. 6. Conventional Dry Glazed System: (*a*) Preset Gasket; and (*b*) Wedge Gasket (1 in. = 25.4 mm)

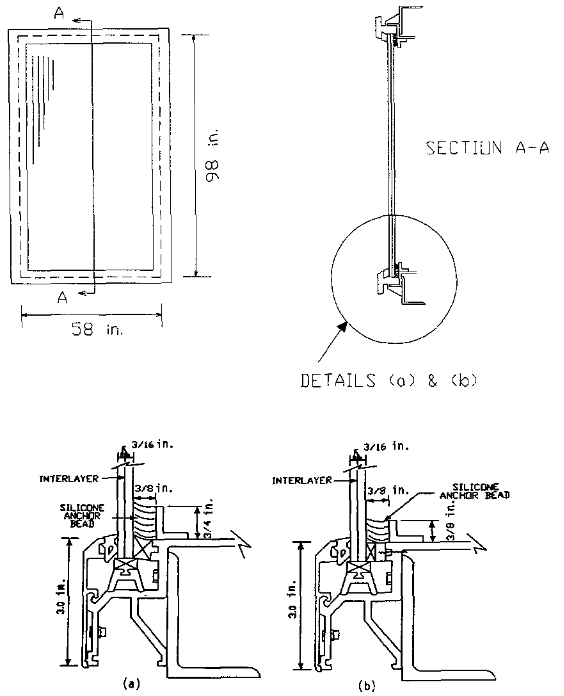

FIG. 7. Unconventional Glazed System: (*a*) Large Anchor Detail; and (*b*) Small Anchor Detail (1 in. = 25.4 mm)

and the second was a "small anchor" detail [Fig. 7(*b*)] that has a 9 mm (3/8 in.) anchor bead.

Test Plan

The test plan was comprised of nine test series. Each series contained three specimens; hence, a total of 27 specimens of heat strengthened laminated glass were tested. The only exceptions to the three specimens per test scheme was series 5, in which only two specimens were tested, and series 6, in which four specimens were tested. Three specimens were tested in each series in order to provide more data on behavior and to assess consistency in the patterns of performance. This approach is important because of the inherent variability of glass strength and the complexities of the glazing systems. The nine test series are defined in Table 1. It would have been prohibitively expensive to conduct enough tests to establish statistically significant results. As will be seen in the presentation of results, the "three specimens per test scheme" proved adequate in that, with few exceptions, consistency of performance was established through similar behavior in each specimen within a test series.

Two missile impact categories were planned. The first category was the damage threshold (DT) category, in which it was desired to induce the minimum amount of surface damage that could be detected visually at arms length in good light. To achieve the DT missile impact velocity, the missiles were first fired at a low velocity that was not expected to produce damage.

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TABLE 1. Test Plan

Test series (1)	Interlayer (2)	Glazing configuration (3)	Missile impact (4)
1[a]	PVB	Dry	DT
2	PVB	Dry	HV
3	PVB	Small anchor[b]	DT, BT
4	PVB	Small anchor	HV
5	PVB/PET/PVB	Small anchor	DT
6	PVB/PET/PVB	Small anchor	HV
7	PVB	Large anchor[c]	DT, BT
8	PVB	Large anchor	HV
9	PVB/PET/PVB	Large anchor	HV

[a]All tests series comprised of three heat-strengthened laminated-glass specimens with 5 mm (3/16 in.) plies (except series 5 and 6; see Table 2).

[b]See Fig. 7(b).

[c]See Fig. 7(a).

Note: DT = damage threshold missile impact velocity; BT = breakage threshold missile impact velocity; HV = high missile impact velocity [36 m/s (80 mph)]; PVB = polyvinyl butyral (PVB) polymer of 1.52-mm (0.060-in.) thickness; PVB/PET/PVB = two layers of 0.38 mm (0.015 in.) PVB, sandwiching a polyethylene terepthalate (PET) polymer of 0.08 mm (0.003 in.) thickness.

The velocity of the missiles was then gradually increased by small increments until damage was sustained. The second category was the high velocity (HV) test. The HV missile impact velocity was preset at 36 m/s (80 mph) and represents the maximum missile velocity that could be achieved for the windstorm conditions that were simulated, i.e., missile impact velocities were assumed to equal the design windspeed.

In the process of conducting the tests it was found to be important to define an additional missile impact velocity, the breakage threshold (BT) velocity. The BT missile impact velocity was defined as the velocity at which the impact of the missile causes a crack or fracture that extends through the glass thickness of the outer ply of laminated glass. The BT tests were conducted by impacting specimens that had already been subjected to and survived the DT test with the following application of the wind load spectrum. Two specimens from series 5 and two from series 7 were subjected to BT tests. In both DT and BT tests the missile impact velocity was increased by as little as 0.305 m/s (1 ft/sec) until damage or breakage occurred.

Test Procedure

The full-scale testing consisted of two operations: (1) The missile impact portion of the test criteria; and (2) application of the wind-load spectrum. The missile impact portion of the test consisted of impacting the grid of 190 impact locations (Fig. 1) under one of the three impact categories (DT, BT, or HV). After a specimen had been impacted using the DT or HV tests, it was subjected to the wind-load spectrum that simulates wind-induced pressures on a building in a 4-hr duration, severe windstorm.

During the testing, the behavior of the specimens, interlayer laminate, silicone seal, and gaskets was observed and recorded photographically. The amount of glass lost from the specimens during testing was measured at

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regular intervals, and the condition of specimens following test termination was fully documented.

Test Results

The test results are presented by first describing the missile impact portion of the test, followed by descriptions of the wind load spectrum portion. Table 2 shows the results of the missile impact tests on all specimens. The specimen designation used is as follows: [Series No.—Specimen No.], where the series no. refers to the series defined in Table 1. The missile impact test results are shown for each specimen after impacting the 190 locations as described in Fig. 1. Simple statistical calculations were performed to obtain the mean minimum damage threshold (MMDT) velocity, and the mean

TABLE 2. Missile Impact Test Results

		MMDT velocity[b]		MMBT velocity[c]			
Specimen[a] (1)	Missile impact (2)	(ft/sec) (3)	(m/s) (4)	(ft/sec) (5)	(m/s) (6)	Number of inner ply breaks (7)	Percent of impacts that produced inner ply breaks (8)
1-1	DT	37.5	11.43	—	—	—	—
1-2	DT	29.0	8.84	—	—	—	—
1-3	DT	28.4	8.66	—	—	—	—
2-1	HV[d]	—	—	—	—	10	5.3
2-2	HV	—	—	—	—	9	4.7
2-3	HV	—	—	—	—	11	5.8
3-1	DT, BT	28.9	8.81	45.8	13.96	—	—
3-2	DT, BT	22.1	6.74	53.3	16.25	—	—
3-3	DT	22.5	6.86	—	—	—	—
4-1	HV	—	—	—	—	11	5.8
4-2	HV	—	—	—	—	2	1.1
4-3	HV	—	—	—	—	64	33.7
5-1	DT	19.3	5.88	—	—	—	—
5-2	DT	19.8	6.04	—	—	—	—
6-1	HV	—	—	—	—	78	41.1
6-2	HV	—	—	—	—	88	46.3
6-3	HV	—	—	—	—	112	58.9
6-4	HV	—	—	—	—	92	48.4
7-1	DT, BT	32.5	9.91	52.4	15.97	—	—
7-2	DT	21.7	6.61	—	—	—	—
7-3	DT, BT	26.1	7.96	54.2	16.52	—	—
8-1	HV	—	—	—	—	18	9.5
8-2	HV	—	—	—	—	0	0.0
8-3	HV	—	—	—	—	2	1.1
9-1	HV	—	—	—	—	105	55.3
9-2	HV	—	—	—	—	112	58.9
9-3	HV	—	—	—	—	131	68.9

[a]See Table 1 for specimen descriptions and definitions of DT and BT.
[b]MMDT = Mean minimum damage threshold velocity.
[c]MMBT = Mean minimum breakage threshold velocity.
[d]HV = 36 m/s (80 mph).

minimum breakage threshold (MMBT) velocity. Standard deviations and coefficients of variation were also computed. In the case of high velocity (HV) tests the number of inner ply breaks are shown, and the ratio of inner ply breaks to the total number of impacts on a specimen is reported as a percentage.

In the missile impact portion of the testing, the property of the glass surface being impacted was defined in terms of its being an "air" side or "tin" side. The tin side is the side of a glass plate that contacts the molten tin during the manufacturing process; the air side is the surface exposed to the air. An ultraviolet lamp was used to identify the property (air or tin) of the surface of the glass that was impacted. This identification allowed determination as to whether or not the MMDT and MMBT velocities were any different for the air and tin side. It was concluded that the MMDT and MMBT velocities for air and tin side impacts were not different, statistically. The MMDT and MMBT velocities reported in Table 2 are the average velocities over the 190 missile impacts. The reason for calculating averages relates to the inherent variability of glass strength. The coefficient of variation for all MMDT velocities was 14.6%, while that for all MMBT velocities was 7.5%. The average of all MMDT velocities in Table 2 is 7.98 m/s (26.2 ft/sec) and that of MMBT velocities 15.67 m/s (51.4 ft/sec). Thus, it appears for this missile size (2.03 g) and glass type [9 mm (3/8 in.) heat strengthened laminated], the MMBT velocity is approximately twice the MMDT velocity.

The postbreakage behavior of the specimens was evaluated according to their overall ability to withstand the wind-load spectrum. The desired result was a specimen that would survive the wind-load spectrum following the 190 missile impacts. For specimens not surviving the entire spectrum, larger percentages of pressure/vacuum cycles survived before failure occurred indicate better performance. Failure is defined as the point where the building envelope is not intact anymore. In the present tests it represents a condition where the system has failed to such a degree that it is not possible to apply any pressure or vacuum to the glass.

Table 3 shows the observed behavior of all specimens with respect to the percentage of cycles completed and the failure mode. As can be observed from Table 3, all of the damage threshold (DT) specimens completed the entire pressure/vacuum sequence. Since the heat-strengthened inner ply was not damaged and the outer ply did not break, the unit was able to sustain the wind spectrum without failure. Of the specimens subjected to high velocity (HV) impacts, the highest survival rate was achieved by the heat strengthened laminated glass units with the PVB/PET/PVB interlayer glazed in the large anchor detail.

A primary concern in studies of postbreakage behavior of glass is the risk created by broken glass particles falling from a broken window in a tall building. Glass fragments falling from a tall building facade can become missiles themselves and cause a chain reaction that results in additional glass breakage. This broken glass will fall to the ground, and may injure people or damage property, and the openings created will leave the building contents exposed to wind and water.

The average weight of most of the pieces of glass that fell off during testing was less than 15 g. Two exceptions occurred when large pieces were dislodged due to laminate tearing. Overall, the largest percentage of glass fallout was 1.5%. The dry glazed specimens with the high velocity (HV) missile impact tests are not included in these results. All of the glass was

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TABLE 3. Specimen Behavior with Respect to Wind-Load Spectrum

Specimen[a] (1)	Missile impact (2)	Percentage of total cycles completed (3)	Glass fallout (Percentage of glass lite weight) (4)	Failure mode (5)
1-1	DT	100.0	0.0	None
1-2	DT	100.0	0.0	None
1-3	DT	100.0	0.0	None
2-1	HV	0.3	100.0	Dry glazed system
2-2	HV	0.4	100.0	Dry glazed system
2-3	HV	0.6	100.0	Dry glazed system
3-1	DT, BT	100	0.0	None
3-2	DT, BT	100	0.0	None
3-3	DT	100	0.0	None
4-1	HV	9.6	0.3	Laminate tearing
4-2	HV	17.3	3.1	Silicone adhesion
4-3	HV	7.7	—	Silicone adhesion
5-1	DT	100.0	0.0	None
5-2	DT	100.0	0.0	None
6-1	HV	9.0	0.2	(Silicone out of date)
6-2	HV	44.8	0.8	Silicone adhesion
6-3	HV	43.8	0.5	Silicone adhesion
6-4	HV	33.8	0.4	Silicone adhesion
7-1	DT, BT	100.0	0.0	None
7-2	DT	100.0	0.0	None
7-3	DT, BT	100.0	0.0	None
8-1	HV	18.8	7.7	Laminate tearing
8-2	HV	100.0	0.0	None
8-3	HV	12.1	0.3	Laminate tearing
9-1	HV	100.0	0.6	None
9-2	HV	84.1	—	Laminate tearing
9-3	HV	87.5	—	Laminate tearing

[a]See Table 1 for specimen descriptions.
Note: DT = damage threshold velocity impact; BT = breakage threshold velocity impact; HV = 36 m/s (80 mph).

lost in these tests, i.e., the entire unit was pushed from the frame. Particle fallout from the specimens was closely examined. Table 3 shows that the percentage of glass particle fallout compared to the total lite weight of 823 N (185 lb) is not significant.

A major discovery was that regardless of the condition of the outer ply of the heat strengthened laminated glass unit, if the inner ply remained undamaged, the specimen would survive the entire pressure/vacuum spectrum. It is desirable, therefore, to use a product with a small probability of inner ply breakage. Results of high velocity (HV) missile impact tests showed that interlayer thickness plays a vital role in protecting the inner ply from breakage. The specimens with a 1.52-mm (0.060-in.) PVB interlayer had, on average, a 7% inner ply breakage rate. Specimens with the 0.84-mm (0.033-in.) PVB/PET/PVB interlayer had a higher inner-ply breakage rate average of 54%. These data are presented in Table 2. It is reasonable to

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conclude that thicker interlayers provide additional resistance against breakage of the inner ply under conditions of small missile impact.

Laminate tearing was one of the forerunners of specimen failure. Tears were measured relative to the total number of cycles that had been completed, during the experiments in the course of the pressure/vacuum cycling. It was concluded that tears in the PVB interlayer propagated quicker than tears in the PVB/PET/PVB interlayer. Table 4 shows the extent to which laminate tears propagated during the testing of the specimens.

The heat strengthened laminated glass specimens with the PVB interlayer

TABLE 4. Laminate Tearing vs. Number of Cycles (Note: All Specimens from HV Impact Tests)

Specimen[a] (1)	Interlayer (2)	Number of vacuum cycles (3)	Number of pressure cycles (4)	Length of laminate tears (in.) (5)	Length of laminate tears (mm) (6)
4-1	PVB	60L/5M/1H	12L/1M	6.0	152
		60L/5M/1H	26L/2M	100.0	2,540
4-2	PVB	60L/5M/1H	36L/3M	8.0	203
		60L/5M/1H	48L/4M	13.5	343
		60L/5M/1H	60L/5M/1H	51.0	1,295
		72L/6M/1H	60L/5M/1H	55.0	1,397
		120L/6M/2H	64L/5H/1H	135.0	3,429
6-2	PVB/PET/PVB	141L/11M/2H	120L/10M/2H	2.5	64
		156L/12M/2H	120L/10M/2H	3.0	76
		180L/15M/3H	175L/13M/2H	6.0	152
		216L/17M/3H	180L/15M/3H	6.3	160
6-4	PVB/PET/PVB	120L/10M/2H	95L/7M/1H	2.0	51
		190L/10M/2H	108L/8M/1H	3.0	76
		120L/10M/2H	113L/9M/1H	6.0	152
		180L/15M/3H	129L/10M/2H	24.0	610
		180L/15M/3H	144L/12M/2H	36.0	914
8-3	PVB	60L/5M/1H	17L/1M	0.3	8
		60L/5M/1H	23L/1M	0.5	13
		60L/5M/1H	24L/2M	12.5	318
		60L/5M/1H	36L/3M	18.0	457
		60L/5M/1H	48L/4M	41.0	1,041
		60L/5M/1H	57L/4M	93.0	2,362
		60L/5M/1H	58L/4M	98.0	2,489
9-1	PVB/PET/PVB	288L/24M/4H	240L/20M/4H	0.1	3
		420L/35M/7H	454L/37M/7H	1.5	38
9-2	PVB/PET/PVB	346L/28M/5H	300L/25M/5H	6.0	152
		360L/30M/6H	307L/25M/5H	12.0	305
		360L/30M/6H	315L/26M/5H	15.0	381
		360L/30M/6H	360L/30M/5H	24.0	610
		360L/30M/6H	360L/30M/6H	30.0	762
		409L/34M/6H	360L/30M/6H	33.0	838
		420L/34M/6H	384L/32M/6H	67.0	1,702
		420L/35M/7H	385L/32M/6H	71.0	1,803
		421L/35M/7H	420L/35M/7H	74.0	1,880

[a]See Table 1 for specimen descriptions.

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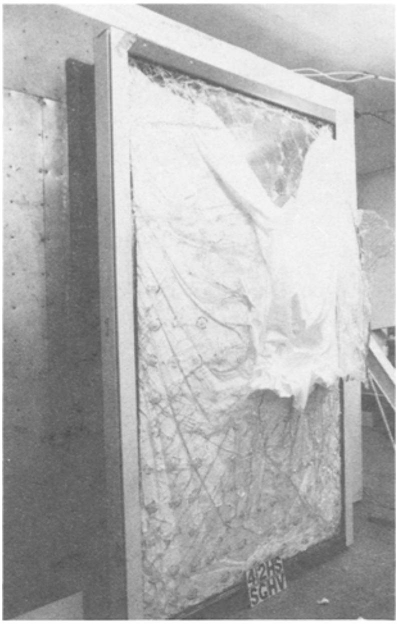

FIG. 8. Tearing of Laminate for Heat-Strengthened Laminated Glass

FIG. 9. Failure of Silicone Anchor Bead for Unconventionally Glazed System

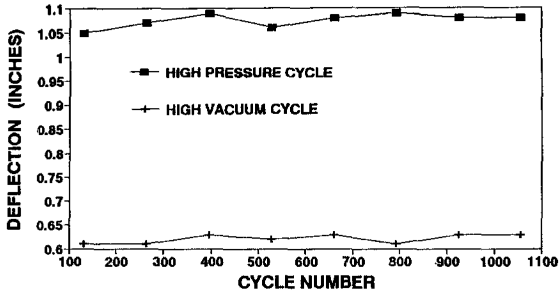

FIG. 10. Midspan Deflection of Damage Threshold Specimens (1 in. = 25.4 mm)

and anchored with the silicone seal subjected to the high-velocity missiles (series 4 and 8), all seemed to fail in one of two modes, or a combination of the two modes. The first mode, laminate tearing, was a common phenomenon and often resulted in tears several feet long. These laminate tears opened as much as 0.61 m (2 ft) in one pressure cycle, as shown in Fig. 8. Eventually, these tears would result in failure of the specimen. The second mode of failure was the failure of the silicone anchor bead, as shown in Fig. 9. Once an anchor bead failure occurred on one of the sides, it normally propagated quickly resulting in failure of the system. Clearly, the 19-mm (¾-in) anchor bead performed better than the 9-mm (⅜-in.) anchor bead.

Deflections at the centers of the specimens were measured for damage threshold (DT) specimens. None of these specimens experienced breakage of the inner ply during the missile impact portion of the test, and the outer plies did not break during pressure/vacuum cycling. It was found that even though the specimens with the PVB/PET/PVB interlayer have a much stiffer and thinner interlayer than those with PVB, this does not appear to influence the amount of deflection experienced by the specimens. High-velocity (HV) impact specimens (which experienced breakage in both plies) yielded much larger deflections, averaging more than 152 mm (6 in.), before failure. Fig. 10 is a typical graph of the magnitude of center of specimen deflection versus number of cycles for DT specimens. The magnitude of the deflection remained consistent throughout the wind load spectrum for these specimens.

CONCLUSIONS

Several significant findings resulted from the missile impact portion of the tests. The inner plies of heat-strengthened, laminated-glass specimens did not fracture during the damage threshold (DT) and breakage threshold (BT) missile impact tests. The mean minimum breakage threshold (MMBT) velocity for heat-strengthened laminated glass is approximately twice the mean minimum damage treshold (MMDT) velocity. Interlayer thickness is critical in determining the amount of inner-ply breakage that occurred in a high-velocity missile impact test. The percentage of inner ply breakage was seven times higher for the 0.84-mm (0.033-in.) interlayer as compared to the 1.52-mm (0.060-in.) interlayer. Therefore, the thicker interlayer protected the inner ply more effectively.

The highest survival rate among specimens subjected to high-velocity missile impacts and the wind-load spectrum was achieved by the PVB/PET/PVB specimens with the large anchor silicone detail. The largest amount of glass lost from a heat strengthened laminated glass unit that remained in

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the frame was 7.7%. Test specimens subjected to high-velocity missile impact experienced various degrees of laminate tearing during application of the pressure/vacuum cycles. Units with the PVB/PET/PVB interlayer resisted tear propagation more effectively than units with the PVB interlayer. The glazing configurations with the anchor beads performed much better than the dry-glazed glazing configuration. In addition, specimens with the 19-mm (¾-in.) anchor bead performed better than specimens with the 9-mm (⅜ in.) anchor bead. A major discovery was that regardless of the condition of the outer ply of a heat-strengthened laminated glass unit, if the inner ply remained undamaged after the missile impact portion of the test, the specimen would survive the entire pressure/vacuum spectrum.

Acknowledgment

The writers acknowledge financial support provided through the Missouri Research Assistance Act and by the Saflex® unit of Monsanto Chemical Co. The writers also acknowledge technical support provided by Cupples Product Division, a part of H. H. Robertson Company. Assistances by Jeff Bradshaw of the Department of Civil Engineering at University of Missouri-Rolla (UMR), and Steve Starrett, formerly a graduate student at UMR are also gratefully acknowledged.

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Test Status Update

To: Brett Henson
Shumaker, Loop & Kendrick, LLP
240 South Pineapple Avenue, Suite 1000
Sarasota, FL 34236

From: Tim Efaw
Subject: Test Status Update TAS 201/203 - for ES-SGD 2020 Series 2-Lite SPD 142" x 120"
Project No. 2636T0001
Date(s) Tested October 20th & 31st, 2023

Brett,
Attached are the impact/cyclic results for the ES-SGD 2020 Series 2-Lite Sliding Patio Door 142"x120". As you will find the sample provided did not achieve the desired performance for basic protection per TAS 201 at +80 / -85psf pressure differentials per TAS 203 due to deglazing during positive cyclic wind loading.

2020 Series 2-Lite (XX) Sliding Patio Door System (142" x 120")	
Test Method Description	**Summary of Results**
TAS 201-94 Monolithic Infill (Large Missile Impact):	Pass No Penetration (2 Impacts)
TAS 201-94 IGU Infill (Large Missile Impact):	Pass No Penetration (2 Impacts)
TAS 203-94 (Positive Test Pressure P_{max} +80psf):	Fail: 1st loading Sequence
TAS 203-94 (Negative Test Pressure P_{max} -85psf):	*Not Tested*

Test Methods Testing was completed as described in Testing Application Standard (TAS) 201-94 Impact Test Procedures, and Testing Application Standard (TAS) 203-94 Criteria for Testing Products Subject to Cyclic Wind Pressure Loading. Test methods assigned or referenced include, ASTM E1996 Standard Specification for Performance of Exterior, Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes, and ASTM E1886 Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials.

Report Date: 11/08/2023	**Test Record Retention Date:** 11/08/2033

2636T0001

EXHIBIT
B

Sampling: The test specimen panels, and frame kite was provided by Structural Engineering and Inspections, Inc via drop off on October 6th, 2023. All dimensional data reported was verified by PRI-CMT, all glazing data was reported via glass labels and/or actual measurements. PRI-CMT personnel completed all assembly and installation of the test specimen.

I. Product Manufacturer & Location ES Windows LLC
Miami, FL

II. Accredited Testing Laboratory PRI-Construction Materials Technologies, LLC
6412 Badger Drive
Tampa, FL 33610

II.1.1. Testing Location: Testing was conducted at PRI-CMT located in Tampa, FL. Verification of testing instrumentation was performed by either an ISO accredited calibration laboratory or by an PRI-CMT representative in compliance with PRI-CMT In-House quality control program governed by ISO/IEC 17025-17.

III. Product Type Bronze Aluminum 2-Lite Sliding Door Assembly (XX)

IV. Product Series/Model ES-SGD 2020 Series

V. Test Specimen Details

V.1. Sizes

V.1.1. Overall Unit Size: 142” x 120” (3607 x 3048mm) 118.3ft^2 (11.0m^2)
V.1.2. Left Panel Size (IGU): 70-3/4” x 117-1/2” (1797 x 2985mm) (OSLI)
V.1.3. Right Panel Size (Mono): 70-7/8” x 117-1/2” (1800 x 2985mm) (OSLI)

V.2. Glazing

Glazing Description	Exterior Lite	Spacer Type	Laminate Lite	Glazing Method
Left Operable Sash (Out Side Looking In)				
Dual Glaze 1-1/16” (27mm)	3/16” (5mm) Tempered	3/8” (10mm) MA Black Spacer (Air Filled Cavity)	3/16” (5mm) Heat Strengthen 0.090” PVB 1/4” (6mm) Heat Strengthen	The glass set by the manufacturer by placing the door panel framing around the glass and then back filling with sealant.
Right Operable Sash (Out Side Looking In)				
Monolithic	N/A	N/A	1/4” (6mm) Heat Strengthen 0.090” PVB 1/4” (6mm) Heat Strengthen	The glass set by the manufacturer by placing the door panel framing around the glass and then back filling with sealant.

Continued on the next page…

V.3. Daylight Opening

Location	Size		Total Area		Quantity
	mm	inches	m^2	ft^2	
Left Operable Sash (Out Side Looking In)	1651 x 2813	65 x 110-3/4	4.6	50.0	1
Right Operable Sash (Out Side Looking In)	1653 x 2813	65-1/16 x 110-3/4	4.7	50.0	1

V.4. Installation

The test specimen was installed into a Southern Yellow Pine wooden test buck. The rough opening maintained a clearance of approximately 3/16” (5mm) around the perimeter of test specimen. Sealant complying with AAMA 800 was utilized to seal the exterior frame perimeters to the test buck.

<table>
<tr><th>Frame Member</th><th>Dimensional Location on Member</th><th>Anchor Description</th><th>Quantity</th></tr>
<tr><td>Head/Sill</td><td>5” O.C. from each end; then paired 20-1/2” from the ends and 14” O.C. thereafter. Paired centerline of meeting stiles and 3”, 6”, and 9” on each side of centerline. All fasteners located in the exterior track pocket. (Paired anchors spaced 3” apart)</td><td rowspan="2">1/4”x 2-3/4” UltraCon Hex Head</td><td>22 per member (44 total)</td></tr>
<tr><td>Jambs</td><td>Paired 6” O.C. from each end; then paired approximately 11-1/2” O.C. thereafter. All fasteners located in the corresponding operable panel track. (Paired anchors spaced 3” apart)</td><td>22 per member (44 total)</td></tr>
</table>

Continued on the next page…

VI. Test Results: Conditions at the beginning of testing were 23°C (73°F) with 50% Rh.

Table 1: TAS 201 / ASTM E1886 E1996

Impact[1]	Missile Weight	Missile Length	Missile Velocity	Location of Impact[2]	Observation	Result[3]
1	8.8lbs	102"	49.1 fps	Left Operable Panel Center of Infill	Shattered exterior lite, Fractured interior laminate	Pass
2	8.8lbs	102"	49.7 fps	Left Operable Panel Upper Right Corner of Infill	Refractured interior laminate	Pass
3	8.8lbs	102"	49.6 fps	Right Operable Panel Center of Infill	Fractured laminate lite	Pass
4	8.8lbs	102"	49.4 fps	Right Operable Panel Upper Right Corner of Infill	Refractured laminate lite	Pass

Notes:

1. The end of the cannon barrel was located 5.2 m (17’) from the exterior surface of the test specimen.
2. Missile impact was within 5° of horizontal.
3. Upon completion of testing the specimens met the passing requirements outlined in the Florida Building Code section 1626.

Table 2: TAS 203 / E1886 Results

Direction	Pressure Differential PSF[1]	Number of Cycles Completed	Max Deflection[2] (inches)	Permanent Set[2] (inches)	Result[3]
Positive	16 to 40	3500	-	-	Fail
	0 to 48	300	-	-	-
	40 to 64	600	-	-	-
	24 to 80	100	-	-	-
Negative	-26 to -85	50	-	-	-
	-43 to -6	1050	-	-	-
	0 to -51	50	-	-	-
	-17 to -43	3350	-	-	-

Notes:

1. Tape and polyethylene film were utilized to seal the specimen for excessive air leakage, and in the PRI-CMT witness’s opinion did not influence the test results.
2. Deflection and permanent set were captured on the meeting stiles, the unsupported span measured 116-1/2”.
3. Upon completion of testing the specimen did not meet the requirements outlined in the Florida Building Code section 1626.2.8. The IGU deglazed at 450 cycles into the sequence. Due to an early failure no deflections/sets were captured.

Continued on the next page…

Table 3: TAS 203 / E1886 Results (Client Request to Isolate Failed Panel and Continue with Cycling)

Direction	Pressure Differential PSF[1]	Number of Cycles Completed	Max Deflection[2] (inches)	Permanent Set[2] (inches)	Result[3]
Positive	16 to 40	3500	-	-	**Fail**
	0 to 48	300	-	-	-
	40 to 64	600	-	-	-
	24 to 80	100	-	-	-
Negative	-26 to -85	50	-	-	-
	-43 to -6	1050	-	-	-
	0 to -51	50	-	-	-
	-17 to -43	3350	-	-	-

Notes:

1. Tape and polyethylene film were utilized to seal the specimen for excessive air leakage, and in the PRI-CMT witness’s opinion did not influence the test results.
2. Deflection and permanent set were captured on the meeting stiles, the unsupported span measured 116-1/2”.
3. Upon completion of testing the specimen did not meet the requirements outlined in the Florida Building Code section 1626.2.8. The monolithic lite deglazed at 3050 cycles into the sequence. Due to early failure of the previous panel no deflections/sets were captured.

Statement of Attestation:

Testing was conducted in accordance with the methods designated in Testing Application Standard (TAS) 201-94 Impact Test Procedures and Testing Application Standard (TAS) 203-94 Criteria for Testing Products Subject to Cyclic Wind Pressure Loading. Upon completion of testing, the test specimen supplied did not meet the requirements of sections 1620 and 1626 of The Florida Building Code. The laboratory test results presented in this report are representative of the specimen supplied. This report does not constitute certification of this product which may only be granted by the certification program administrator.

Issue History:

Issue #	Date	Pages	Revision Description (if applicable)
Original	11/08/2023	13	N/A

Appendix Follows…

Photographs:

Test Assembly Prior to Testing

Left Panel (OSLI) - IGU **Right Panel (OSLI) – Monolithic Laminate**

Continued on the Next Page…

Test Assembly After Impacts

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Test Assembly During Cyclic Wind Loading

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Test Assembly (Left Panel – IGU) After 450 Cycles FAILURE DUE TO DEGLAZING

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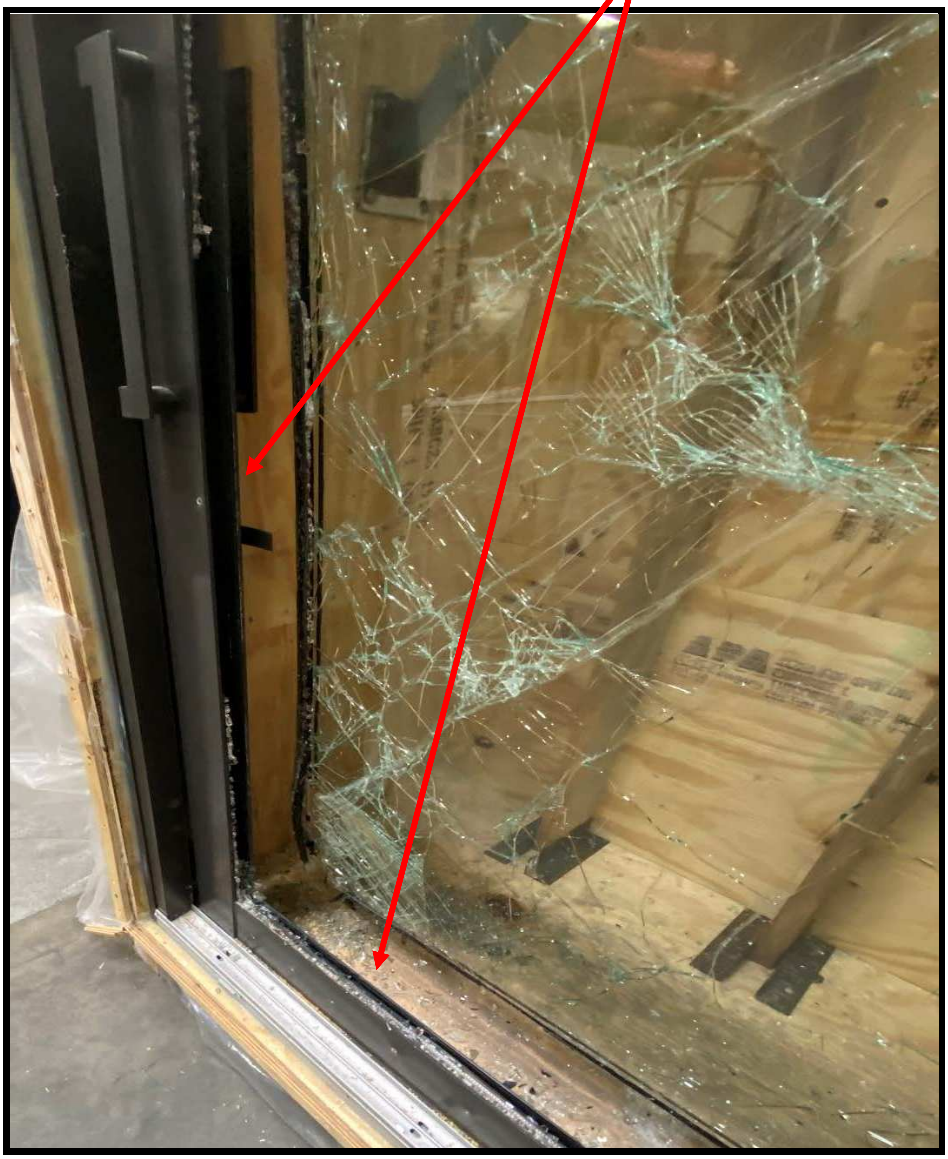
Test Assembly (Left Panel – IGU) After 450 Cycles FAILURE DUE TO DEGLAZING



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Test Assembly Isolation of Failed Panel

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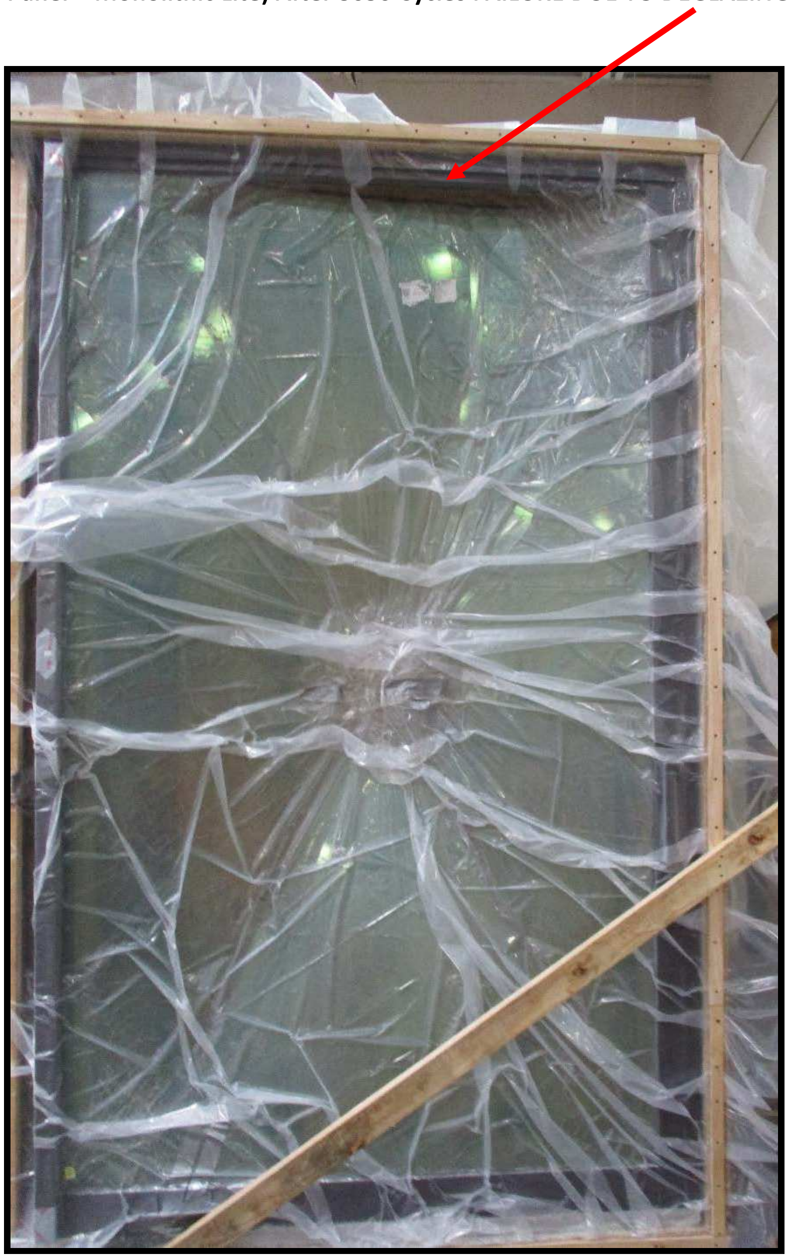
Test Assembly (Right Panel – Monolithic Lite) After 3050 Cycles FAILURE DUE TO DEGLAZING



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Test Assembly (Right Panel – Monolithic Lite) After 3050 Cycles FAILURE DUE TO DEGLAZING

END OF UPDATE

PRI Construction Materials Technologies LLC
6412 Badger Drive
Tampa, FL 33610
813.621.5777
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Test Status Update

To:	Brett Henson Shumaker, Loop & Kendrick, LLP 240 South Pineapple Avenue, Suite 1000 Sarasota, FL 34236
From:	Tim Efaw
Subject:	Test Status Update TAS 201/203 - for ES-SGD 2020 Series 2-Lite SPD 57-1/2" x 102" Level 1 & 2 Doors
Project No.	2636T0002
Date(s) Tested	October 31st – November 2nd, 2023

Brett,
Attached are the impact/cyclic results for the ES-SGD 2020 Series 2-Lite Sliding Patio Door 57-1/2"x102" Level 1 & Level 2 products. As you will find the samples provided did not achieve the desired performance for basic protection per TAS 201 at the desired pressure differentials per TAS 203 due to deglazing during cyclic wind loading.

2020 Series 2-Lite (OX) Sliding Patio Door System (57-1/2" x 102")	
Test Method Description	**Summary of Results**
TAS 201-94 Level 1 (Large Missile Impact):	Pass No Penetration (2 Impacts)
TAS 201-94 Level 2 (Large Missile Impact):	Pass No Penetration (2 Impacts)
TAS 203-94 Level 1 (Positive Test Pressure P_{max} +53 / -65psf):	Fail: 1st Negative loading Sequence
TAS 203-94 Level 2 (Positive Test Pressure P_{max} +53 / -78psf):	Fail: 2nd Negative loading Sequence

Test Methods Testing was completed as described in Testing Application Standard (TAS) 201-94 Impact Test Procedures, and Testing Application Standard (TAS) 203-94 Criteria for Testing Products Subject to Cyclic Wind Pressure Loading. Test methods assigned or referenced include, ASTM E1996 Standard Specification for Performance of Exterior, Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes, and ASTM E1886 Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials.

Report Date: 11/08/2023	**Test Record Retention Date:** 11/08/2033

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Sampling: The test specimen panels, and frame kite was provided by Structural Engineering and Inspections, Inc via drop off on October 30th, 2023. All dimensional data reported was verified by PRI-CMT, all glazing data was reported via glass labels and/or actual measurements. PRI-CMT personnel completed all assembly and installation of the test specimen.

I. Product Manufacturer & Location ES Windows LLC
Miami, FL

II. Accredited Testing Laboratory PRI-Construction Materials Technologies, LLC
6412 Badger Drive
Tampa, FL 33610

II.1.1. Testing Location: Testing was conducted at PRI-CMT located in Tampa, FL. Verification of testing instrumentation was performed by either an ISO accredited calibration laboratory or by an PRI-CMT representative in compliance with PRI-CMT In-House quality control program governed by ISO/IEC 17025-17.

III. Product Type White Aluminum 2-Lite Sliding Door Assembly (OX)

IV. Product Series/Model ES-SGD 2020 Series

V. Test Specimen Details

V.1. Sizes – All Specimens
V.1.1. Overall Unit Size: 57-1/2” x 102” (1461 x 2591mm) 40.7ft^2 (3.78m^2)
V.1.2. Fixed Panel Size: 27-1/4” x 99-3/8” (692 x 2524mm)
V.1.3. Operable Panel Size: 29-15/16” x 99-5/16” (760 x 2523mm)

V.2. Glazing – All Specimens

Glazing Description	Exterior Lite	Spacer Type	Laminate Lite	Glazing Method
Left Operable Sash (Out Side Looking In)				
Monolithic	N/A	N/A	1/4” (6mm) Heat Strengthen 0.090” PVB 1/4” (6mm) Heat Strengthen	The glass was set by the manufacturer by placing the door panel framing around the glass. An EPDM gasket was placed around the perimeter of the glass before assembling.
Right Operable Sash (Out Side Looking In)				
Monolithic	N/A	N/A	1/4” (6mm) Heat Strengthen 0.090” PVB 1/4” (6mm) Heat Strengthen	The glass was set by the manufacturer by placing the door panel framing around the glass. An EPDM gasket was placed around the perimeter of the glass before assembling.

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V.3. Daylight Opening – All Specimens

Location	Size		Total Area		Quantity
	mm	inches	m^2	ft^2	
Fixed Panel	603 x 2350	23-3/4 x 92-1/2	1.4	15.3	1
Operable Panel	603 x 2350	23-3/4 x 92-1/2	1.4	15.3	1

V.4. Reinforcement Level

V.4.1. Specimen 1: Level 1

V.4.2. Specimen 2: Level 2

V.5. Installation – All Specimens

The test specimen was installed into a Southern Yellow Pine wooden test buck. The rough opening maintained a clearance of approximately 3/16” (5mm) around the perimeter of test specimen. Sealant complying with AAMA 800 was utilized to seal the exterior frame perimeters to the test buck.

Frame Member	Dimensional Location on Member	Anchor Description	Quantity
Head/Sill	5” O.C. from each end; centerline of meeting stiles and 3”, 6”, and 9” on each side of centerline. All fasteners located in the exterior track pocket.	1/4”x 2-3/4” UltraCon Hex Head	9 per member (18 total)
Jambs	Paired 7-1/2” O.C. from each end; then paired approximately 11-1/2” O.C. thereafter. All fasteners located in the corresponding panel track pocket. (Paired anchors spaced 3” apart)		18 per member (36 total)

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VI. Test Results: Conditions at the beginning of testing were 23°C (73°F) with 50% Rh.

Table 1: Specimen 1 - TAS 201 / ASTM E1886 E1996

Impact[1]	Missile Weight	Missile Length	Missile Velocity	Location of Impact[2]	Observation	Result[3]
1	8.8lbs	102"	49.5 fps	Operable Panel Center of Infill	Fractured laminate lite	Pass
2	8.8lbs	102"	50.4 fps	Operable Panel Lower Left Corner of Infill	Refractured laminate lite	Pass

Notes:

1. The end of the cannon barrel was located 5.2 m (17') from the exterior surface of the test specimen.
2. Missile impact was within 5° of horizontal.
3. Upon completion of testing the specimens met the passing requirements outlined in the Florida Building Code section 1626.

Table 2: Specimen 1 - TAS 203 / E1886 Results

Direction	Pressure Differential PSF[1]	Number of Cycles Completed	Max Deflection[2] (inches)	Permanent Set[2] (inches)	Result[3]
Positive	11 to 27	3500	0.24	0.07	Pass
	0 to 32	300	0.27	0.07	Pass
	27 to 42	600	0.39	0.07	Pass
	16 to 53	100	0.48	0.07	Pass
Negative	-20 to -65	50	0.65	-	**Fail**
	-33 to -52	1050	-	-	-
	0 to -39	50	-	-	-
	-13 to -33	3350	-	-	-

Notes:

1. Tape and polyethylene film were utilized to seal the specimen for excessive air leakage, and in the PRI-CMT witness's opinion did not influence the test results.
2. Deflection and permanent set were captured on the meeting stiles, the unsupported span measured 97-3/4".
3. Upon completion of testing the specimen did not meet the requirements outlined in the Florida Building Code section 1626.2.8. The operable glass lite deglazed at 26 cycles into the sequence.

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Table 3: Specimen 2 - TAS 201 / ASTM E1886 E1996

Impact[1]	Missile Weight	Missile Length	Missile Velocity	Location of Impact[2]	Observation	Result[3]
1	8.8lbs	102"	50.0 fps	Operable Panel Center of Infill	No Damage	Pass
2	8.8lbs	102"	49.5 fps	Operable Panel Lower Left Corner of Infill	Fractured laminate lite	Pass

Notes:

1. The end of the cannon barrel was located 5.2 m (17’) from the exterior surface of the test specimen.
2. Missile impact was within 5° of horizontal.
3. Upon completion of testing the specimens met the passing requirements outlined in the Florida Building Code section 1626.

Table 4: Specimen 2 - TAS 203 / E1886 Results

Direction	Pressure Differential PSF[1]	Number of Cycles Completed	Max Deflection[2] (inches)	Permanent Set[2] (inches)	Result[3]
Positive	11 to 27	3500	0.14	0.03	Pass
	0 to 32	300	0.20	0.01	Pass
	27 to 42	600	0.23	0.02	Pass
	16 to 53	100	0.26	0.01	Pass
Negative	-23 to -78	50	0.53	0.04	Pass
	-39 to -62	1050	-	-	**Fail**
	0 to -47	50	-	-	-
	-16 to -39	3350	-	-	-

Notes:

1. Tape and polyethylene film were utilized to seal the specimen for excessive air leakage, and in the PRI-CMT witness’s opinion did not influence the test results.
2. Deflection and permanent set were captured on the meeting stiles, the unsupported span measured 97-3/4”.
3. Upon completion of testing the specimen did not meet the requirements outlined in the Florida Building Code section 1626.2.8. The operable glass lite deglazed at 228 cycles into the sequence. Due to early failure within the cycle no deflections/sets were captured.

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Statement of Attestation:

Testing was conducted in accordance with the methods designated in Testing Application Standard (TAS) 201-94 Impact Test Procedures and Testing Application Standard (TAS) 203-94 Criteria for Testing Products Subject to Cyclic Wind Pressure Loading. Upon completion of testing, the test specimens supplied did not meet the requirements of sections 1620 and 1626 of The Florida Building Code. The laboratory test results presented in this report are representative of the specimen supplied. This report does not constitute certification of this product which may only be granted by the certification program administrator.

Issue History:

Issue #	Date	Pages	Revision Description (if applicable)
Original	11/08/2023	11	N/A

Appendix Follows…

Photographs:

Test Assembly Prior to Testing (Typical Level 1 & 2)

Left Panel - Fixed **Right Panel Operable**

Continued on the Next Page…

Test Specimen 1: After Impacts

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Test Specimen 1: After 26 Cycles 1st Sequence Negative Loading FAILURE DUE TO DEGLAZING

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Test Specimen 2: After Impacts

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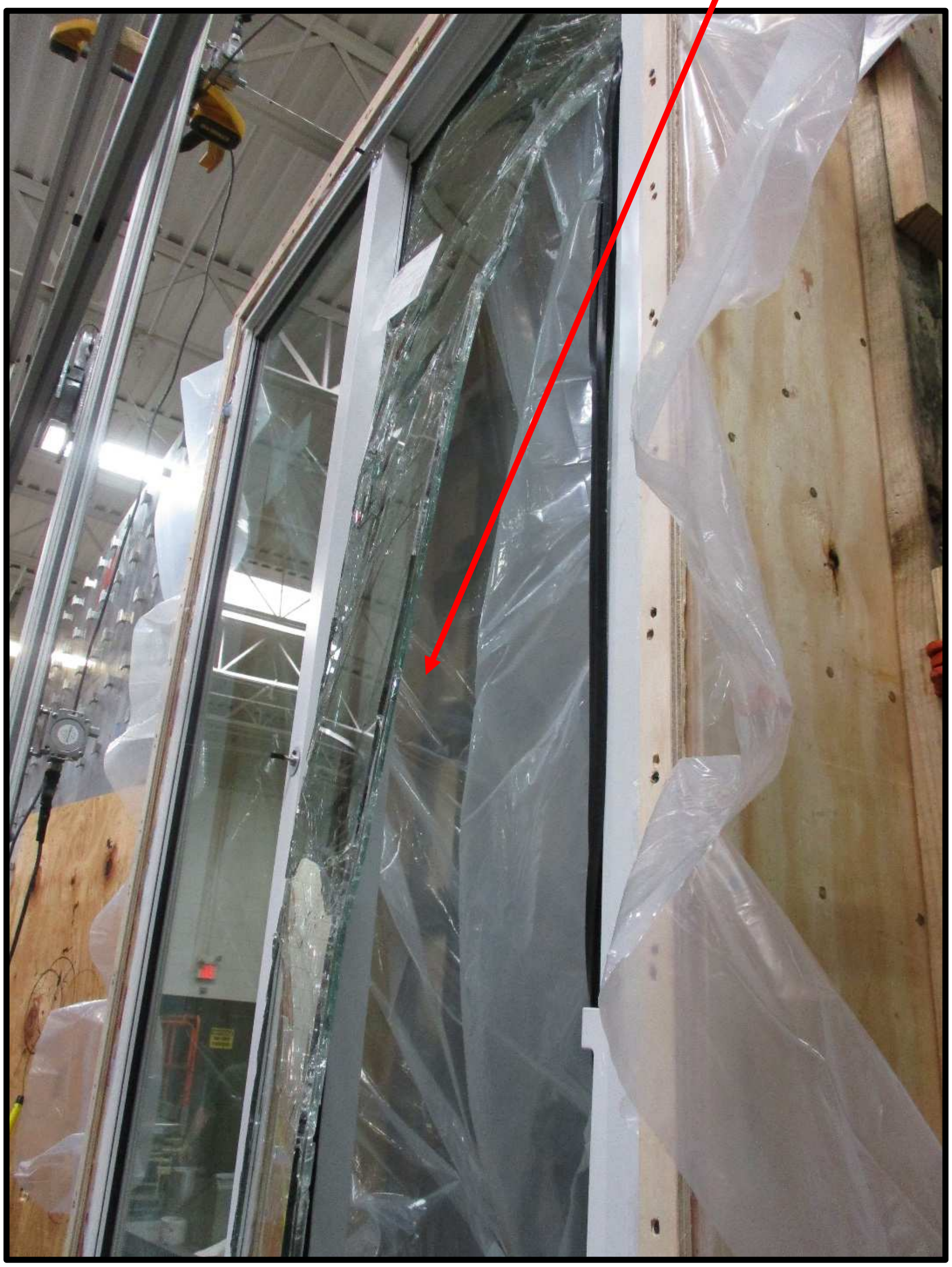
Test Specimen 2: After 228 Cycles 2nd Sequence Negative Loading FAILURE DUE TO DEGLAZING



END OF UPDATE

AFFIDAVIT OF A. LYNN MILLER, P.E.

STATE OF FLORIDA
COUNTY OF SARASOTA

BEFORE ME, the undersigned authority, personally appeared LYNN MILLER, who after being duly sworn, deposes and says:

1. I am over the age of eighteen (18) years and am competent to execute this Affidavit.

2. I have personal knowledge of the matters set forth in this affidavit.

3. I am currently employed as the Code Compliance Manager at PGT Innovations, Inc. ("PGTI") and am a Florida certified Professional Engineer.

4. Representatives of PGTI and I were physically present during the independent testing of the E.S. Window, Florida Product Approval 22267 wet-glazed systems and I assisted in coordinating the extensive testing of the dry-glazed systems with PGTI representatives and third-party testing entities.

5. Following the independent third-party testing of the fenestration systems, I reviewed the third-party entity's test reports and found them consistent with my own personal knowledge and observations regarding the products' performance capabilities.

6. Accordingly, I am familiar with all conclusions and findings of the third-party independent testing entity regarding E.S. Windows' Florida Product Approval 22267 wet and dry glazed system performance. The following results are true and accurate representations of the E.S. Windows' product performance in testing.

7. The wet glazed 142x120, 2 panel SGD, PVB interlayer level 3 reinforcement system (the "Level 3 System") was assembled on October 18, 2023. Subsequently, panel 1 was

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tested on October 19, 2023, and panel 2 was tested on October 31, 2023. Both tests were performed to the TAS 201 (large missile) and TAS 203 test protocols.

8. The Level 3 System, failed early in the first sequence of an eight-sequence TAS 203 test on October 19, 2023.

9. The dry glazed 57x102, 2 panel SGD, PVB interlayer, level 1 reinforcement system (the "Level 1 System") was tested on October 31, 2023 and November 1, 2023. Both tests were performed to the TAS 201 (large missile) and TAS 203 test protocols.

10. The Level 1 System failed during the fifth sequence of the TAS 203 testing.

11. The dry glazed 57x102, 2 panel SGD, PVB interlayer, level 2 reinforcement system (the "Level 2 System") was tested on October 31, 2023 and November 1, 2023. Both tests were performed to the TAS 201 (large missile) and TAS 203 test protocols.

12. The Level 2 System failed during the sixth sequence of the TAS 203 testing.

13. Each of the systems were tested by an independent third-party testing entity and subsequently failed to perform at the represented design capacities.

14. Each system was assembled in accordance with E.S. Windows' assembly instructions included with its Florida Product Approval 22267.

15. Each of the tests were performed in accordance with all applicable industry standards and supervised by Florida Professional Engineers.

16. As a result thereof, it is the belief of both the third-party independent fenestration testing entity as well as Florida professional engineers that the subject Product does not and cannot perform at the represented design load capacities.

17. I have seen no competent evidence to dispute any of the findings herein nor in support of the Product's purported design pressure capabilities.

FURTHER AFFIANT SAYETH NOT.

A. Lynn Miller

A. LYNN MILLER, P.E.

STATE OF FLORIDA
COUNTY OF SARASOTA

The foregoing instrument was acknowledged before me by means of ___ physical presence or X online notarization, this 19 day of January, 2024, by A. Lynn Miller of ________________, who ☒ is personally known to me or ☐ did produce his/her ________________ Driver's License as identification or ☐ did produce ____________________________ as identification.

____
Print name: ____________________
Notary Public, State of __________
My Commission expires:_______________
Comm. No.:______________________

[notary seal]

SARA M. MCCLELLAN
Commission # HH 073517
Expires January 22, 2025
Bonded Thru Troy Fain Insurance 800-385-7019