



FULL SCALE ARENA
GSA TEST REPORT

Rendered to:

Solar Gard®

MODEL DESIGNATION: Solar Gard® Armorcoat® Safety & Security Films

PRODUCT TYPE: Safety and Security Films

This report contains in its entirety:

Cover Page: 1 page
Report Body: 8 pages
Appendix A: 12 pages
Appendix B: 2 pages
Appendix C: 6 pages
Revision Log: 1 page

Test Report No.: F5228.02-801-12

Test Date: 05/13/16

Report Date: 05/26/16

Test Report Retention End Date: 05/26/20

Solar Gard®
 Solar Gard® Armorcoat® Safety & Security Films

1.0 MANUFACTURER'S IDENTIFICATION

- 1.1 Name of Applicant: Saint-Gobain Solar Gard
 4540 Viewridge Avenue
 San Diego, CA 92123
 Voice: 800-359-8468
- 1.2 Contact Person: Miguel Detres

2.0 SCOPE OF WORK

- 2.1 Introduction
 Solar Gard retained Architectural Testing, Inc. (ATI) to conduct a full scale arena blast test on their Solar Gard Armorcoat window film per the requirements of GSA-TS01-2003.

3.0 PRODUCT IDENTIFICATION

- 3.1 Product Type: Safety & Security Film
- 3.2 Model Designation: Solar Gard Armorcoat
- 3.3 Performance Class: 159 ft Standoff: exceeds 4.35 psi - 28 psi-msec
 (48.46 m Standoff: exceeds 30 kPa – 193 kPa-msec)
- 3.4 Overall Size: Specimens 1-4: 48-3/4" (w) x 66 (h)
 (1238 mm (w) x 1676 mm (h))
- 3.5 Location: Lynn County, Texas
- 3.6 Elevation: 3126 ft. (952.8 m)
- 3.7 Test Dates: 05/13/2016
- 3.8 Test Times: 2:00 p.m.
- 3.9 Ambient Temperatures: 83° F (28.33° C)
- 3.10 Relative Humidity's: 38%
- 3.11 Weather Conditions: Windy
- 3.12 Configuration: Fixed
- 3.13 Drawing: This test report is incomplete if not accompanied by Solar Gard drawing labeled "Test Specimen Drawings" (sheets 1 through 12) bearing the digital stamp of Architectural Testing, Inc.
- 3.14 Sample Source: Specimens provided by Solar Gard.

4.0 EXPLOSIVE CHARGE

- 4.1 Charge Type: ANFO(Ammonium Nitrate Fuel Oil)
- 4.2 Charge Weights: 400 lbs (181.43 kg)
- 4.3 Standoff Distances: 159 feet (48.46 m)PDM

5.0 BLAST REACTION CHAMBER

The blast reaction chamber construction consists of wide flange steel beams, steel tubes, and steel skin that enclose the chambers. ATI also placed four (4) foot (1219 mm) wide wing walls on the blast reaction chamber top and sides to reduce clearing effects on the reflecting surface. The overall dimensions of the blast reaction chamber are twenty-eight (28) feet (8534 mm) wide, sixteen (16) feet (4876 mm) tall, and ten (10) feet (3048 mm) deep. The blast reaction chamber encloses a volume that houses witness panels and structural members. The sealed surfaces of the blast reaction chamber prevent air blast pressure from wrapping around the test specimen so that the blast pressure loads only one side of the test specimen.

6.0 PRODUCT DESCRIPTION

6.1 Frame Construction

The frame was fabricated using the aluminum extrusions defined in Tables 1 and 2.

Table 1: Aluminum Extrusion Details- Insulated Glass Unit YKK YES 45 FI

Description	Manufactured Part #	Overall Dimensions	Material
Head	E9-1013	4.5" x 2" x 0.094" (114mm x 50.8mm x 2.4 mm)	6063 T5 Aluminum
Jamb	E9-1013	4.5" x 2" x 0.094" (114mm x 50.8 mm x 2.4 mm)	
Sill	E9-1089	4.5" x 2" x 0.071" (114 mm x 50.8 mm x 1.8 mm)	
Glazing Stop	E9-1015	1.3" x 1.3" x 0.055" (33mm x 33mm x 1.40 mm)	
Fastener	PC-1216 #12	1" (25.4 mm)	CRS
Gasket (vinyl filler)	E2-0052		EPDM

Table 2: Aluminum Extrusion Details- Single Lite Unit YKK YES 45 FS

Description	Manufactured Part #	Overall Dimensions	Material
Head	E9-1003	4.5" x 1.75" x 0.094" (114mm x 44.5mm x 2.4mm)	6063 T5 Aluminum
Jamb	E9-1003	4.5" x 1.75" x 0.094" (114mm x 44.5mm x 2.4mm)	
Sill	E9-1069	4.5" x 1.75" x 0.071" (114mm x 44.5mm x 1.8mm)	
Glazing Stop	E9-1005	1.92" x 1.06" x 0.055" (48.8mm x 26.7mm x 1.4mm)	
Fastener	PC-1216 #12	1" (25.4mm)	CRS
Gasket (vinyl filler)	E2-0052		EPDM

6.1.1 Corner Construction

The frames were all square cut and assembled using fastener PC-1216 #12 (1" (25.4 mm)).

6.1.2 Glazing Bite

Each window unit had a glazing bite of 3/8" (9.5 mm).

6.2 Glazing Details

6.2.1 Glazing Dimensions

6.2.1.1 Daylight opening of 44 ¾" by 62" (1137 mm by 1575 mm)

6.2.1.2 Overall unit 48 ¾" by 66" (1238 mm by 1676 mm)

6.2.2 Glazing constructions & attachment system description (illustrated in Appendix A)

6.2.2.1 Specimen 1 - Single glazed unit

6.2.2.1.1 ¼" (6 mm) tempered glass

6.2.2.1.2 Anchored with EdgPro™ flexible mechanical attachment system

6.2.2.1.3 Solar Gard Armorcoat 8mil safety film

6.2.2.2 Specimen 2 - Single glazed unit

6.2.2.2.1 ¼" (6 mm) annealed glass

6.2.2.2.2 Anchored with EdgPro™ flexible mechanical attachment system

6.2.2.2.3 Solar Gard Armorcoat 8mil safety film

6.2.2.3 Specimen 3 – Insulated glass unit

6.2.2.3.1 ¼" (6 mm) tempered glass + ½" (12.7 mm) air + ¼" (6 mm) tempered glass

6.2.2.3.2 Anchored with EdgPro™ aluminum mechanical attachment system on two sides

6.2.2.3.3 Solar Gard Armorcoat 8mil safety film

6.2.2.4 Specimen 4 – Insulated glass unit

6.2.2.4.1 ¼" (6 mm) annealed glass + ½" (12.7 mm) air + ¼" (6 mm) annealed glass

6.2.2.4.2 No attachment system applied

6.2.2.4.3 Solar Gard Armorcoat 7mil safety film

6.3 Safety and Security Film

The specimen used the safety film Solar Gard® Armorcoat® 7mil and Solar Gard® Armorcoat® 8mil.

7.0 PRODUCT INSTALLATION

7.1 Table 3 provides details of the product installation into the steel opening.

Table 3: Product Installation Details

Fastener Schedule	Fastener Description
4-1/2" (114mm) from ends and 10" (254 mm) on center thereafter	Two (2) 1-1/2" x 1-1/2" (38.1 mm x 38.1 mm) angles were welded together using two (2) 1/4" (6.35 mm) fillet welds and used to sandwich the frame on either side. The exterior angles were mechanically fastened to the steel opening using one (1) 3/8" x 1-1/2" (9.53 mm x 38.1 mm) HH Gr. 5 Bolt and the interior angles were welded to the steel opening using two (2) 1/4" (6.35 mm) fillet welds–
4-1/2" (114mm) from the Top and Bottom	2" (50.8 mm) clips on the verticals of the angle

8.0 INSTRUMENTATION

8.1 Data Acquisition System

ATI used a high speed data acquisition system with a system record time of one-hundred thousand (100,000) samples per second.

8.2 Reflected Pressure Transducers

ATI placed two (2) reflected pressure transducers on the single span blast reaction chamber to measure the reflected blast pressure time histories acting on the surface of the mock-up. The reflected pressure transducer locations are given in Figures 1.

8.3 Internal Pressure Transducer

ATI used one (1) pressure transducer to measure the internal incident air blast pressure time history in the single span chamber. No significant internal pressure was recorded during the test.

8.4 High Speed Cameras

ATI used digital high speed cameras to record system response under air blast pressure. One (1) camera filmed the exterior of the mock-up and one (1) camera filmed the interior of each of the mock-ups during air blast pressure loading.

8.5 Witness Panels

ATI used witness panels defined in ISO 16933:2007 Section 6.6. The witness panel makeup consisted of two layers of material. The outer layer consisted of one-half (1/2) inch (12.70 mm) thick rigid foam plastic thermal insulation board composed of polyisocyanurate foam bonded to a durable white-matte non-glare aluminum facer and a reflective reinforced aluminum facer with a density of two (2) pounds per cubic foot (32.03 kilograms per cubic meter). The inside layer consisted of one (1) inch extruded polystyrene insulation with a density of 1.8 pounds per cubic foot (28.83 kilograms per cubic meter).

9.0 BLAST PRESSURE DATA AT 159 FEET STANDOFF

9.1 Reflected Pressure Transducer Location

Figure 1 shows the locations of the reflected pressure transducers on the single span reaction chamber.

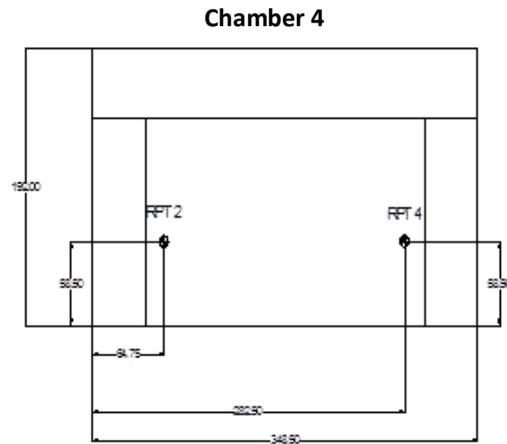


Figure 1: Reflected Pressure Transducer Locations

9.2 Reflected Air Blast Pressure Results

Table 4 summarizes the reflected blast pressure and positive phase impulse for each pressure transducer location. Figures 2 and 3 provide the reflected air blast pressure (red) and impulse (blue) time histories graphically.

Table 4: Reflected Air Blast Pressure Results

Air Blast Parameter	RPT 2	RPT 4	Average
Peak Pressure, psi (kPa)	4.77 (32.89)	5.28 (36.40)	5.03 (34.68)
Positive Phase Impulse, psi-msec (kPa-msec)	25.98 (179.13)	30.49 (210.22)	28.24 (194.71)
Positive Phase Duration (msec)	13.10	12.05	12.58

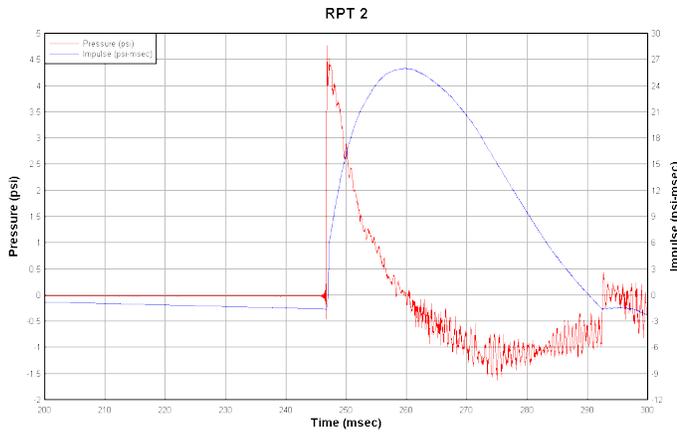


Figure 2: Reflected Air Blast Pressure (RPT #2)

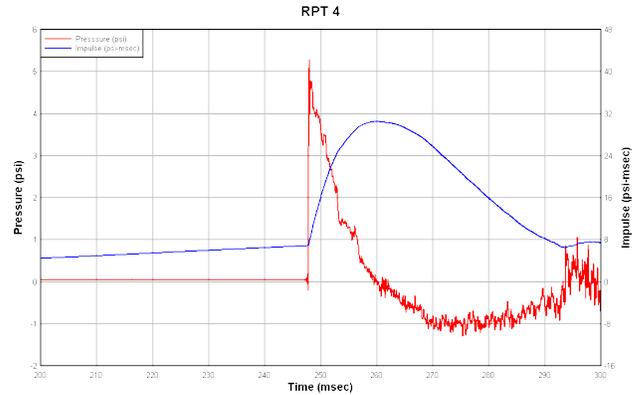


Figure 3: Reflected Air Blast Pressure (RPT #4)

10.0 TEST RESULTS

10.1 Chamber 1

10.1.1 Glazing Response

Zero (0) perforations or fragment indents were observed anywhere in the vertical witness panel. Table 5 provides a summary of the glazing response during air blast pressure loading.

Table 5: Glazing Response Summary

Specimen	Fracture Status		Comments
	Inboard	Outboard	
1	NA	Yes	Lite fractured with full perimeter pullout to the exterior. Fragments in the chamber up to 9-ft.
2	NA	Yes	Lite fractured with full perimeter pullout to the exterior. Small fragments in the chamber.
3	Yes	Yes	Both interior and exterior lites fractured and pullout on the head, sill, and lower 10" at each jamb. Fragments in the chamber up to 9-ft.
4	Yes	Yes	Both interior and exterior lites fractured. No fragments in the chamber. Pullout full width at the head and full length of right jamb.

10.1.2 Frame Response

The frame was undamaged.

11.0 PERFORMANCE CONDITION

11.1 GSA-TS01-2003

11.1.1 Specimen 1- Mono Tempered

The system performed consistent with a "Performance Condition 3b." The lite of the specimen yielded during the air blast pressure loading. The glass was pulled from the test frame to the exterior. The pullout of the unit allowed fragments to enter the test chamber no further than 10 feet from the specimen.

- 11.1.2 Specimen 2- Mono Annealed
 The system performed consistent with a “Performance Condition 3b.” The lite of the specimen fractured during air blast pressure loading. The glazing remained in the opening. The pullout of the unit caused glass to enter the test chamber no further than 10 feet from the specimen.
- 11.1.3 Specimen 3- IGU Tempered
 The system performed consistent with a “Performance Condition 3b.” The exterior lite and interior lite of the specimen fractured during the air blast pressure loading. The glazing remained in the opening. The pullout of the unit allowed fragments to enter the test chamber no further than 10 feet from the specimen.
- 11.1.4 Specimen 4- IGU Annealed
 The system performed consistent with a “Performance Condition 3a.” The exterior lite and interior lite of the specimen fractured during air blast pressure loading. No fragments entered the test chamber.

12.0 CERTIFICATION AND DISCLAIMER STATEMENT

All tests performed on these test specimens were conducted in accordance with the specifications of the applicable codes, standards and test methods listed below by ATI. ATI does not have, nor does it intend to acquire or will it acquire, a financial interest in any company manufacturing or distributing products tested at ATI. ATI is not owned, operated or controlled by any company manufacturing or distributing products it tests. This report is only intended for the use of the entity named in Section 1.0 of this report. Detailed assembly drawings showing wall thickness of all members, corner construction and hardware applications are on file and have been compared to the test specimens submitted. ATI will service this report for the entire test record retention period. Test records that are retained such as detailed drawings, datasheets, representative samples of test specimens, or other pertinent project documentation will be retained by ATI for the entire test record retention period.

All results obtained apply only to the specimens tested and they do indicate compliance with the performance requirements of the test methods and specifications listed in the following section.

If test specimens contain glazing, no conclusions of any kind regarding the adequacy or inadequacy of the glass in any glazed test specimens can be made. This report does not constitute certification of this product nor an opinion or endorsement by this laboratory. It is the exclusive property of the client so named herein and relates only to the specimens tested. This report may not be reproduced, except in full, without the written approval of ATI.

13.0 APPLICABLE CODES, STANDARDS, AND TEST METHODS

GSA-TS01-2003: *US General Services Administration Standard Test Method for Glazing and Window Systems Subject to Dynamic Overpressure Loadings.*

14.0 WITNESSES (ALL OR PARTIAL)

Andy Cost	Lab Manager	Architectural Testing, Inc.
Sierra Conner	Project Engineer	Architectural Testing, Inc.
Jerod Brinkman	Technician	Architectural Testing, Inc.
Michael Sorenson	Technician	Architectural Testing, Inc.
Miguel Detres	Program Manager-Safety and Security Films	Solar Gard®



15.0 APPENDICES

This test report is incomplete if not accompanied by the following Appendices.

Appendix A: Test Specimen Drawings..... 13 Pages
 Appendix B: Test Setup..... 2 Pages
 Appendix C: Photographic Record 6 Pages
 Revision Log 1 Page

Andy Cost.
 Lab Manager

John H. Waskow, P.E.
 Operations Manager

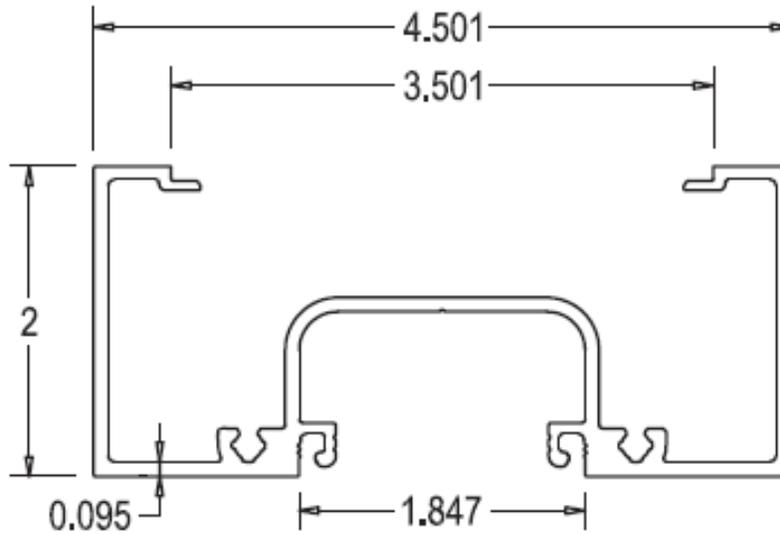
APPENDIX A:
“Test Specimen Drawings”
12 SHEETS



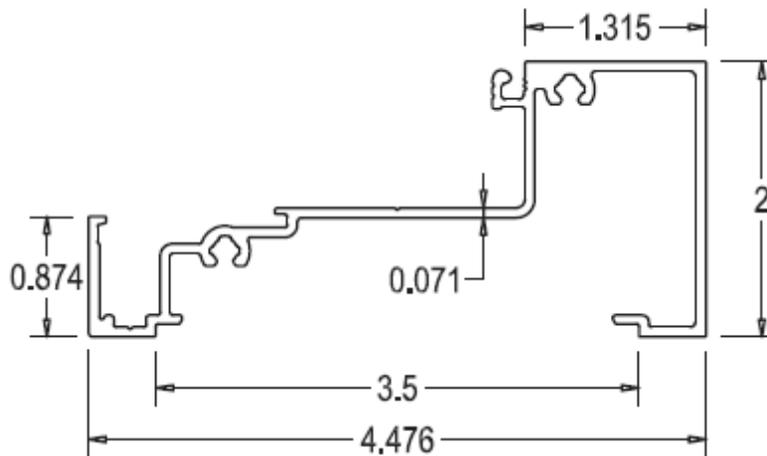
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Test Specimen Drawings – GSA TS01-2003 Solar Gard® Armorcoat® Safety & Security Films

- a. Insulated glass unit frame detail
 - i. Head and Jamb detail

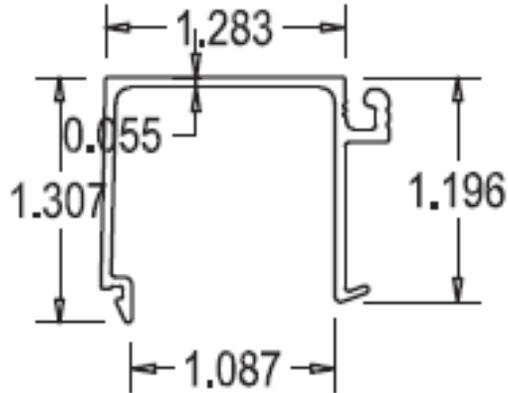


- ii. Sill detail

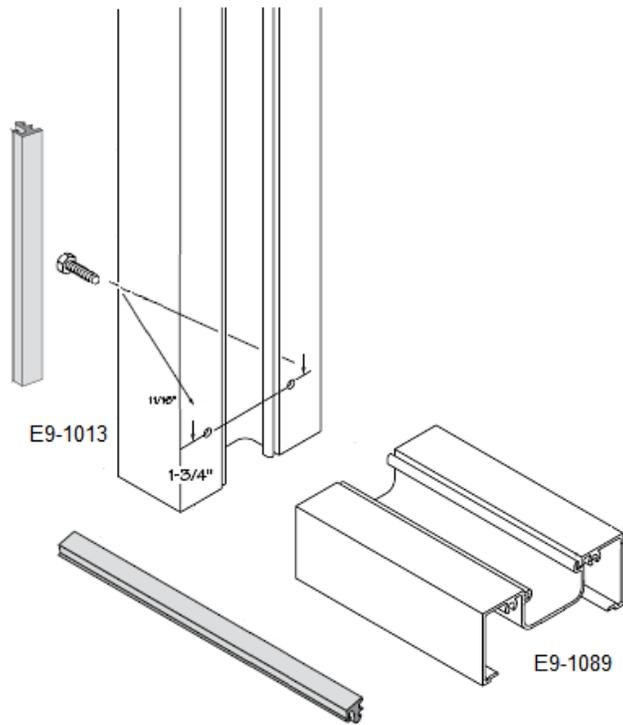


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iii. Glazing stop

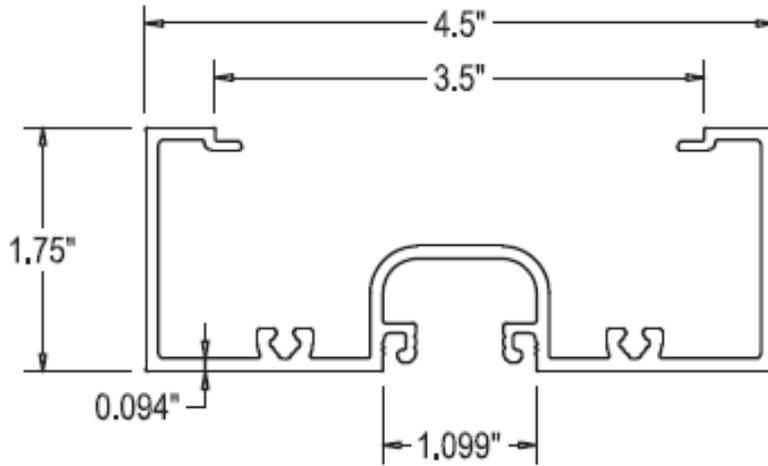


iv. Assembly

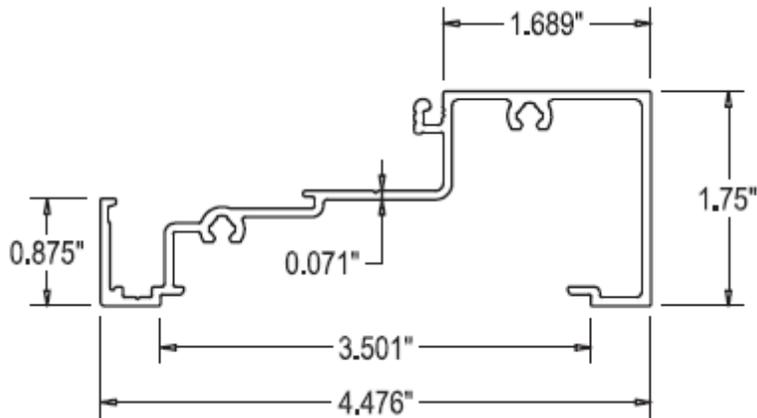


b. Single pane glass frame detail

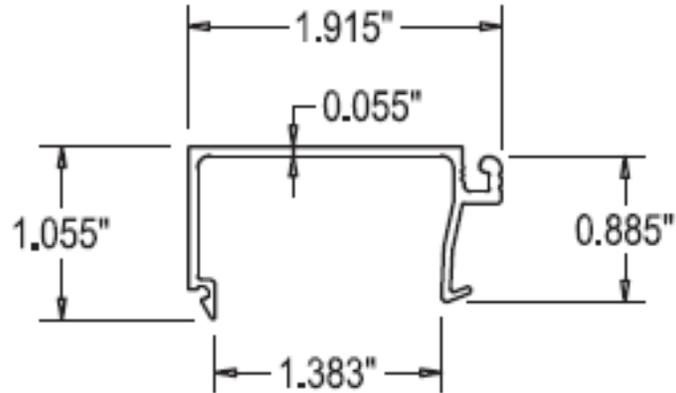
i. Head and Jamb detail



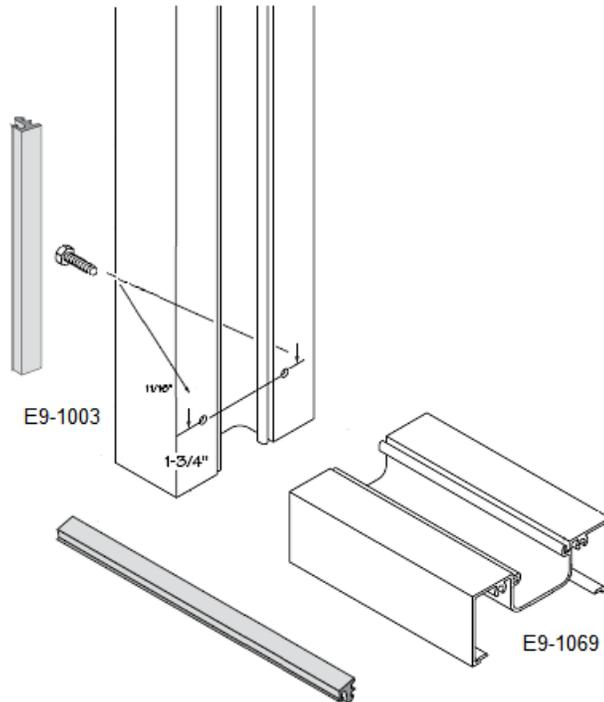
ii. Sill detail



iii. Glazing stop



iv. Assembly



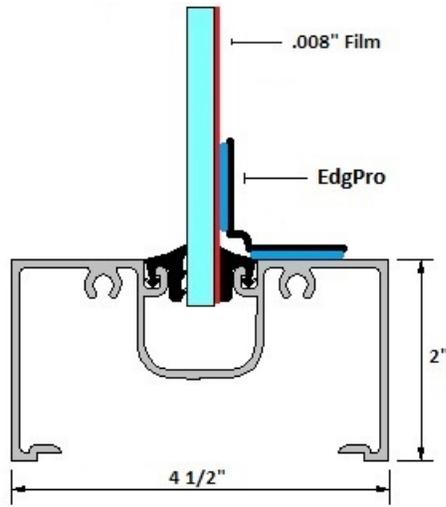


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c. Film installation detail

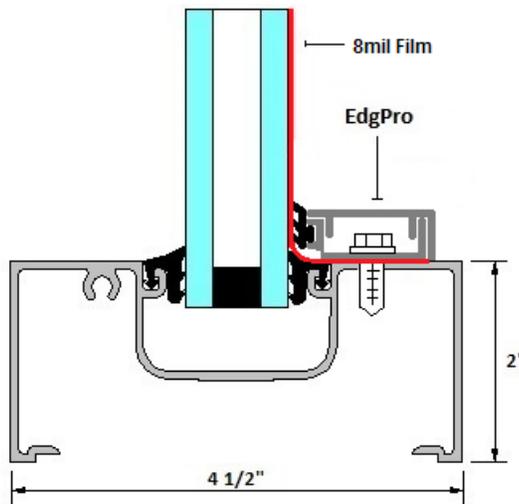
i. Specimen 1 and 2

8mil film on single pane glass with EdgPro flexible mechanical attachment system



ii. Specimen 3

8mil film on film on Insulated glass with EdgPro aluminum mechanical attachment system



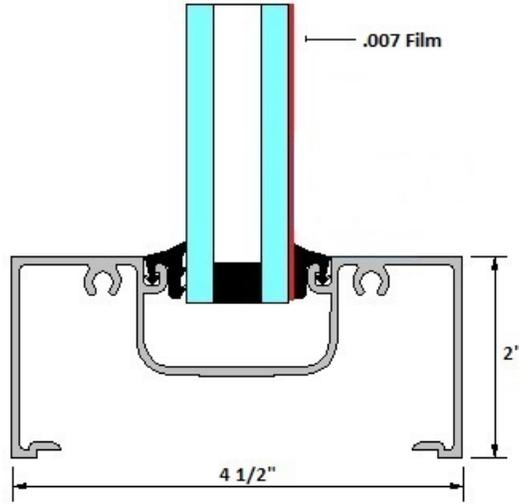
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- iii. Specimen 4
7mil film on Insulated glass



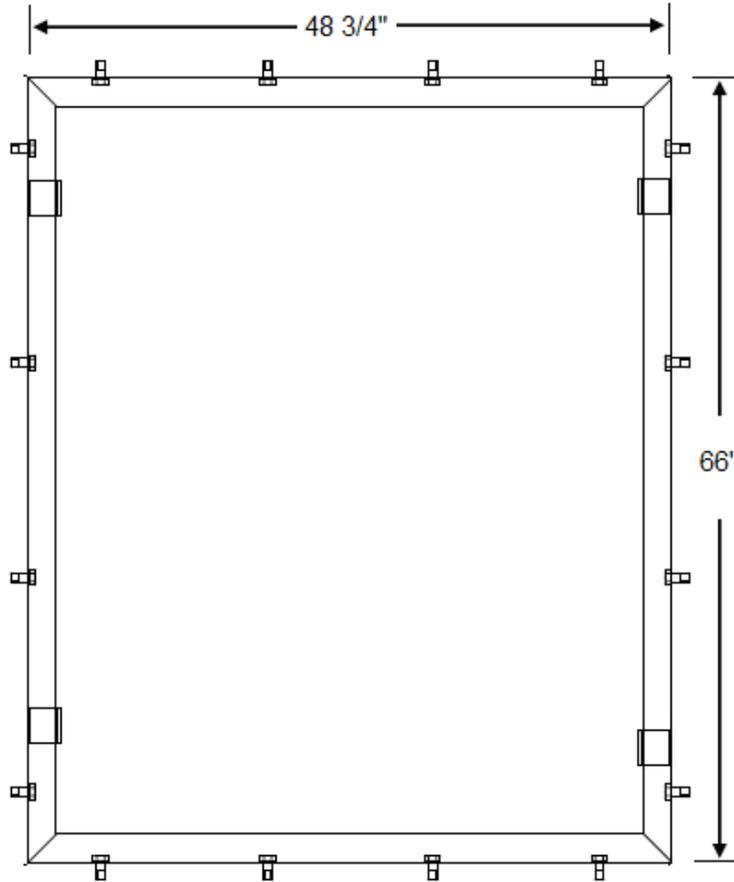
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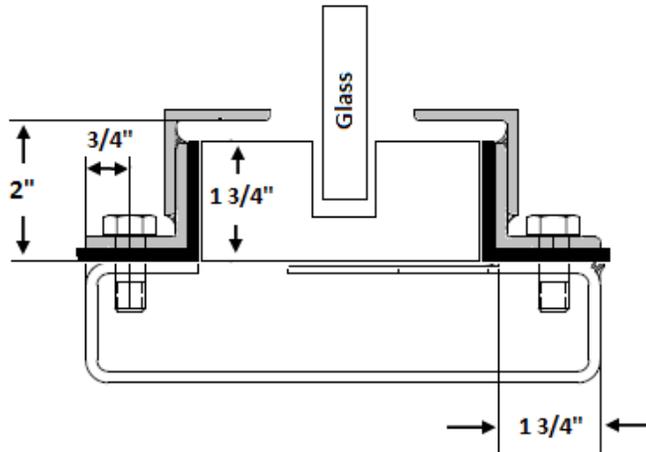
- d. Test Buck & Frame Installation Detail
 - i. Chamber 4



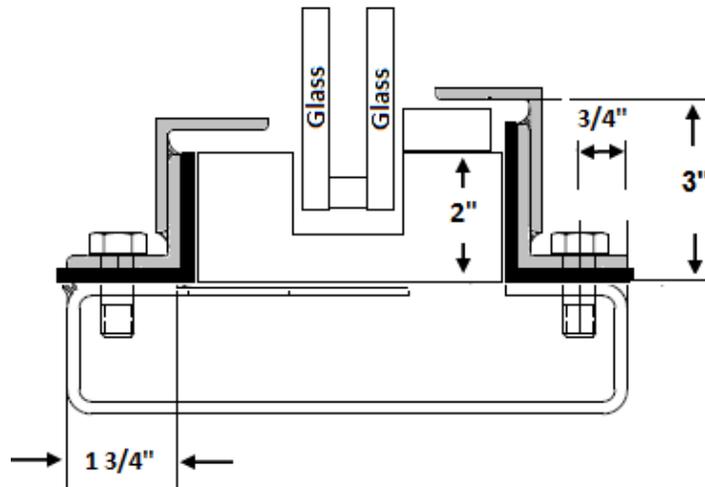
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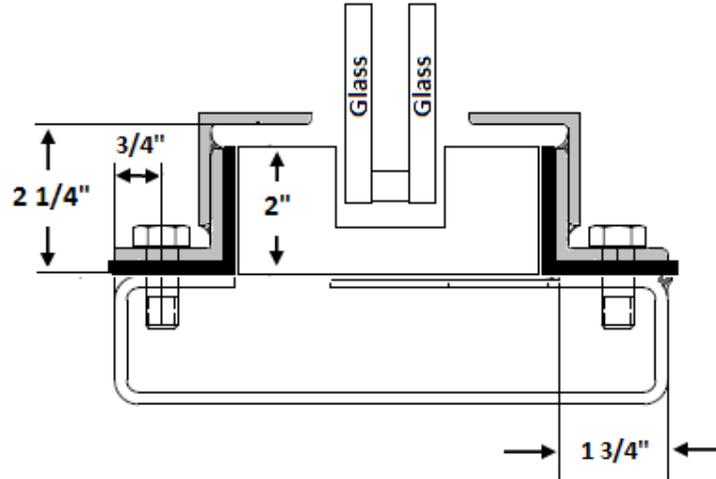
- e. Chamber 4 Bracket Detail
 - i. Specimen 1 and 2



- ii. Specimen 3



iii. Specimen 4

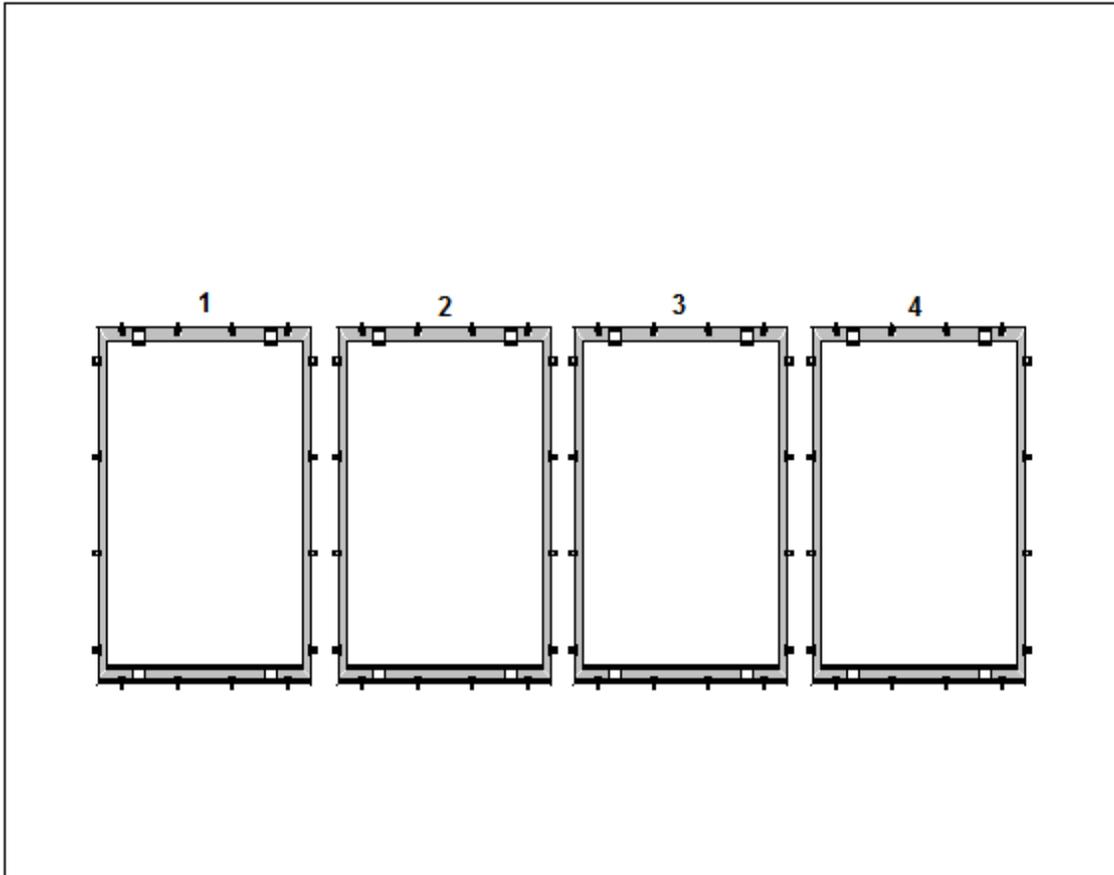




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- f. Chamber drawings
 - i. Chamber 1

	Specimen	Glazing Type	Film Type	Attachment Type
Chamber 1	1	Single Pane Tempered	Solar Gard Armorcoat 8mil	EdgPro Flexible Mechanical
	2	Single Pane Annealed	Solar Gard Armorcoat 8mil	EdgPro Flexible Mechanical
	3	IGU Tempered	Solar Gard Armorcoat 8mil	Two Sided EdgPro Aluminum Mechanical
	4	IGU Annealed	Solar Gard Armorcoat 7mil	N/A



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**APPENDIX B:
TEST SETUP**



Figure B.1: Range Setup, 159-ft. Standoff



Figure B.2: Clip on Window Frame



Figure B.3: Witness Panel



Figure B.4: Frame Stops Meeting

**APPENDIX C:
PHOTOGRAPHIC RECORD**



Figure C.1: Specimen 1
Pre-Blast Condition Exterior



Figure C.2: Specimen 1
Pre-Blast Condition Interior View



Figure C.3: Specimen 1
Post-Blast Condition



Figure C.4: Specimen 1
Glazing Fragments



Figure C.5: Specimen 2
Pre-Blast Condition Exterior



Figure C.6: Specimen 2
Pre-Blast Condition Interior



Figure C.7: Specimen 2
Post-Blast Condition



Figure C.8: Specimen 2
Glazing Fragments



Figure C.9: Specimen 3
Pre-Blast Condition Exterior



Figure C.10: Specimen 3
Pre-Blast Condition Interior



Figure C.11: Specimen 3
Post-Blast Condition



Figure C.12: Specimen 3
Post-Blast Condition



Figure C.13: Specimen 3
Glazing Fragments



Figure C.14: Specimen 3
Edge Pullout



Figure C.15: Specimen 4
Pre-Blast Condition Exterior



Figure C.16: Specimen 4
Pre-Blast Condition Interior



Figure C.17: Specimen 4
Post-Blast Condition



Figure C.18: Specimen 4
Post Blast Conditions

Revision Log

Rev. #	Date	Page(s)	Section #	Revision(s)
0	05/26/16	N/A	N/A	Original Report Issued.