ABS Consulting
RISK CONSULTING DIVISION

Pentagon Protection USA

Shock Tube Testing for Window Systems

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San Antonio, Texas

ABS Consulting Project Number 1865120

ABSG Consulting, Inc. • 14607 San Pedro, Suite 215 • San Antonio, TX 78232 USA • Tel: 210-495-5195 • Fax: 210-495-5134
www.absconsulting.com

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Introduction

ABSG Consulting, Inc. (ABS Consulting) has conducted testing of two window retrofit systems for Pentagon Protection. Six total tests were conducted. Five of the tests were conducted in accordance with testing protocol for both ASTM F1642-04[1] and US General Services Administration (GSA)[2]. The objective of the testing was to certify the performance of the Pentagon Elite 4-sided film anchoring system attached with two different types of attachment tape, ST 1200 and WT 4112. Both systems utilized 8 mil window film applied to ¼" monolithic annealed glass. Five window systems were subjected to blast loads resulting from attack scenarios defined by the Unified Facilities Criteria (UFC)[3]. One test was performed specifically for the GSA level C and Interagency Security Committee (ISC) Medium protection level. Testing was conducted at the ABS Consulting facilities in San Antonio, Texas, USA September 8-9, 2008.

Test Approach

Blast loads were applied using a "shock tube" as shown in Figure 1. This device uses a sudden burst of compressed air to create a blast pulse, which travels down the tube and is applied to the test specimen which is secured to the end of the tube. An enclosure (test cubicle) is attached to the end of the tube. The blast load creates a specified positive blast pressure and impulse on the test specimens. Testing was conducted with blast loads designed to meet the various threat – standoff combinations as described in the UFC and ISC Security Design Criteria.

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[1] ASTM Standard, F 1642-04, "Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings," ASTM Book of ASTM Standards, Vol. 04.07, March 2004.
[2] US General Services Administration (GSA), GSA-TS01-2003, "Standard Test Method for Glazing and Glazing Systems Subject to Dynamic Overpressure Loadings," GSA, January, 2003.
[3] Department of Defense (DoD), Unified Facilities Criteria (UFC) UFC4-010-01, "DoD Minimum Antiterrorism Standards for Buildings," DoD, October 2003.

Figure 1. ABS Consulting Shock Tube Apparatus

Fixtures and Specimens

Two window retrofit systems were tested in this program:

- Pentagon Elite 4-sided anchored film (8mil [.008 in.] film with ST 1200 tape)
- Pentagon Elite 4-sided anchored film (8mil film with WT 4112 tape)

Pentagon Protection provided the window fully assembled with the film and anchoring systems installed. ABS Consulting personnel measured framing and glazing dimensions and confirmed glass type for all window assemblies as they were installed. Additional untested specimens were inspected to confirm construction. Glazing for all of the windows tested consisted of 1/4 inch monolithic annealed glass.

Window frame assemblies were rigidly supported along the top and bottom simulating windows attached at the head and sill. Window anchorage and attachment to the wall substructure was not evaluated in the testing. Steel angle and plate were used to support the framing to prevent translation. This configuration simulates a properly anchored window system installed in the field. Figure 2 shows a typical window mounted in the ABS test sub-frame affixed to the test enclosure. A close-up view of the window mounted in the sub-frame is shown in Figure 3. In order to fit the opening of the sub-frame (48-inches by 70-inches), the window frame was shimmed with wood.

The test enclosure, nominally 10 feet deep, 10 feet wide and 10 feet tall, was placed flush with the end of the tube. A bulkhead plate on the end of the tube prevented blast pressures from wrapping around the structure and reaching the back side of the window. This represents a typical window installation on an exterior wall. A witness panel was provided on the back wall to detect the impact of glass shards. Composition of the witness panel was in accordance with ASTM F1642.

Figure 2. Window Mounted in Test Fixture

Figure 3. Close-up View of Mounting

Blast pressure gauges (gauges 1-5) measuring reflected pressure were mounted on the shock tube bulkhead face and on the front face of the test cubicle facing the oncoming blast wave, immediately adjacent to the test specimen (see Figure 4). A blast gauge (gauge 6) was also mounted inside the test cubicle to measure internal incident blast pressure. Blast pressures gauges were PCB 102A piezoelectric type gauges calibrated for 0-10 psi peak pressure range. Pressure waveforms were recorded by a Yokagawa DL series scope sampling at 1,000 kHz.

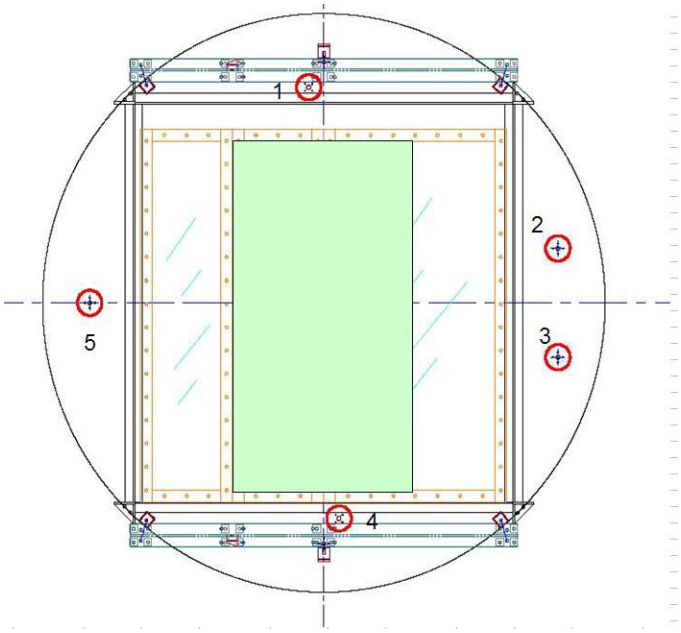

Figure 4. Pressure Gauge Locations

Test Procedure

Testing was conducted in accordance with ASTM F1642-04, and the GSA "Standard Test Method for Windows and Glazing Systems Subject to Dynamic Overpressure Loadings" dated January 1, 2003. The objective of the testing is to determine the performance of the windows as defined in Table 2-1 and 2-2 in the UFC. Blast loads were selected to encompass specified charge weights and standoffs as defined by the UFC, nominally 5.8 psi/41 psi-ms. Test 3 used the GSA load level "C"/ISC Medium (4 psi, 28-psi-ms) and was not used for certification per the ASTM standard. Window performance conditions were assigned in accordance with the performance criteria in ASTM F1642 and the GSA test protocol.

Ambient and glass temperatures were recorded at 30 minutes and 5 minutes prior to each test. Photographs were taken of test specimens and the test setup prior to and following each test to document window performance. Appendix B contains all photographs taken of the test specimen throughout the testing.

Following each test, glass fragments were collected and the unified dimensions of fragments projected into the test cubicle were determined for classification per the ASTM F1642 protocol.

Fragments striking and embedding in the witness panel were collected and documented. Performance conditions for each test item were assigned and recorded in accordance with ASTM F1642-04 and the GSA criteria as shown in Figure 5 and Figure 6, respectively.

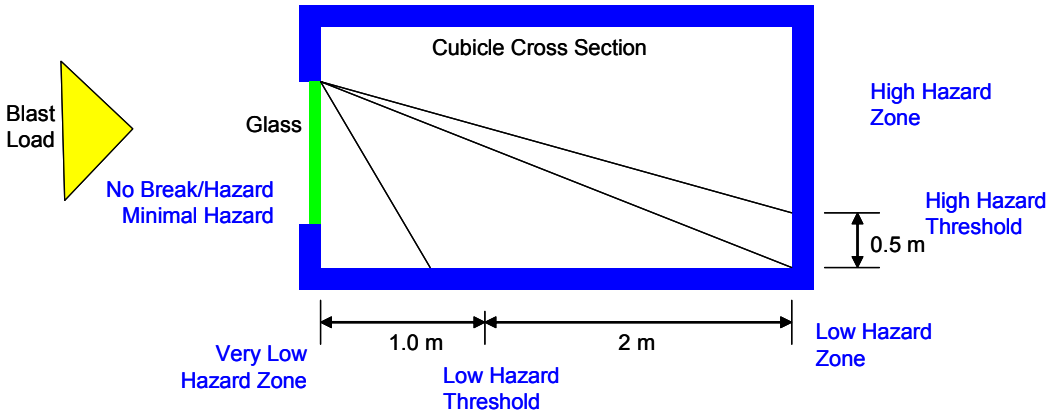

Figure 5. ASTM F1642-04 Performance Criteria

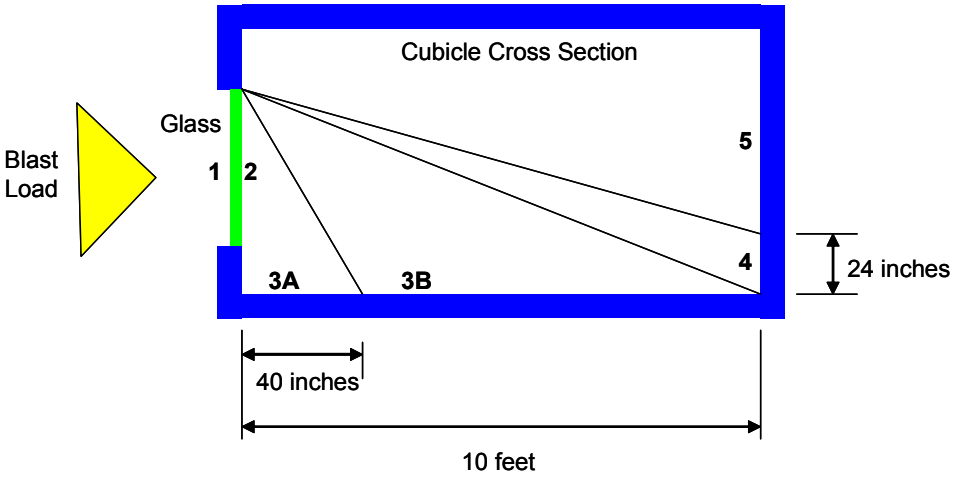

Figure 6. GSA Performance Conditions

Results

Appendix A contains a data sheet for each test specimen. The data sheets contain the following information:

- Detailed description of the unit including the frame, glazing, and attachment into the cubicle.
- Description of the test conditions.
- Detailed description of the performance condition for both ASTM and GSA criteria.
- A pretest and post test photograph.
- A graph of the applied blast history.

Appendix B contains a photographic log for each test.

Results show that for the higher UFC loading both anchoring tapes failed within the tape thickness (cohesive failure) and released the glass panel into the cubicle. The ST 1200 tape did show superior performance compared to the WT 4112 tape. While the filmed lite with ST 1200 landed on the floor of the cubicle, the filmed lite with the WT 4112 impacted the back wall of the cubicle.

For Test 3, conducted on the ST 1200 sample, the loading was reduced to the GSA Level C load: 4 psi, 28 psi-ms. For this loading, the glazing cracked and the anchorage held the film and glass in place. There was dusting, but no fragments entered the cubicle. This corresponds to a GSA performance condition 2.

Three samples with ST 1200 were tested in accordance with the ASTM F1642 test method to permit certification at a "Low Hazard" rating.

Low Hazard (ASTM F1642)
Pentagon Elite 8 mil with ST 1200

GSA Performance Condition 2
Pentagon Elite 8 mil with WT 4112

Approved:

Darrell D. Barker, P.E.
Vice President
Extreme Loads and Structural Risk
San Antonio, Texas