

# **An Information Paper on the Fenestration Industry**

## **Focus on Protective Glazing Systems**

*By the Protective Glazing Council International*

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### **Introduction**

The fenestration industry has and continues to work cooperatively with government organizations to establish standards that address security design and performance requirements for protective glazing. While there has been some movement to establish a Security Fenestration Rating Council, the Protective Glazing Council (PGC) International, along with other members within the protective glazing community, take the position that organizations, test systems, and standards capable of meeting the United States' needs in the area of security fenestration currently exist. If there is a need for further standards or certification programs related to security design and performance requirements for protective glazing, a well established industry infrastructure is equipped to meet that need.

### **Fenestration Industry Associations**

Currently, there are a number of associations that set standards and develop certification programs and/or actively participate in third-party activities setting standards and developing certification programs for the fenestration industry. Such associations include:

- **Protective Glazing Council (PGC) International** represents manufacturers of protective glazing products and systems, suppliers to these manufacturers, consultants and testing organizations. The association supports government and industry in the development of standards and specifications, as well as use of protective glazing products for blast, bullet, natural disasters, fire, and forced entry threats.
- **American Architectural Manufacturers Association (AAMA)** represents window, door, and skylight manufacturers, component suppliers, distributors, and service and consulting companies. AAMA is a source of performance standards, product certification, and educational programs for the fenestration industry.
- **Association of Industrial Metallizers, Coaters and Laminators (AIMCAL)** serves as the global forum for the flexible film metallizing, coating, and laminating industry by providing resources, services, and information. AIMCAL collects and distributes information to increase industry knowledge, while fostering an environment that builds relationships and a spirit of cooperation between member companies worldwide.
- **Door and Hardware Institute (DHI)** is a professional organization that serves the North American marketplace as an advocate and primary resource for information, professional development, and certification resources for the architectural openings industry with a focus on the channels of distribution.

- **Glass Association of North America (GANA)** represents the entire glass and glazing industry. The association is divided into seven divisions: Building Envelope Contractors, Decorative, Flat Glass Manufacturing, Insulating, Laminating, Mirror, and Tempering. GANA provides a forum for exchanging information and ideas, for reaching consensus and presenting a unified voice on matters affecting the glass and glazing industry, and for developing the management and technical sophistication needed to remain competitive. GANA Technical Committees develop educational resources, informational bulletins, voluntary standards, product specifications and training and work cooperatively with other industry groups.
- **Glazing Industry Code Committee (GICC)** represents the interests of glass, glazing and fenestration at a code level. GICC is a collaborative glass and glazing industry organization with a mission of promoting the reasonable use of glass and fenestration within the model building codes. The committee is made up of industry members from the primary glass, fabrication, film, window and curtain wall segments as well as members that have an association with glass and glazing use in the United States. The committee has two code consultants on staff, concentrating in the areas of safety, structural, fire and energy, to represent the consensus interest of the members at code hearings.
- **International Window Film Association (IWFA)** represents dealers, distributors, manufacturers, and suppliers of window film. IWFA promotes business best-practices within the film industry, conducts testing and analysis, and works closely with the glass industry. Ongoing educational accreditation programs, including one on safety/security window film use, are also administered by IWFA.
- **Window and Door Manufacturers Association (WDMA)** is a trade association representing approximately 145 U.S. and Canadian manufacturers and suppliers of windows and doors for the domestic and export markets. Members sell to distributors, dealers, builders, remodelers, architects, contractors and other specifiers in residential, commercial and institutional markets. WDMA members manufacture high performance products designed and built to performance-based standards.

The associations listed above are the more prominent and well established, but do not encompass all of the organizations involved in the glass and glazing industry.

### **Industry Involvement in Governmental Standards & Specifications**

The fenestration industry has a long history of taking a proactive approach to the development of governmental standards and specifications. This approach benefits public safety and the industry, ensuring that a solid understanding of the products available, their appropriate uses, and other important factors is taken into consideration.

The U.S. General Services Administration (GSA) Office of the Chief Architect (OCA) has created several national standards and criteria for blast resistance of building façade components. Some of these are:

- Window Glazing Analysis Response and Design (WINGARD) LE, PE and MP
- U.S. General Services Administration (GSA) Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings

In addition to GSA, a number of other federal agencies are involved with the setting of standards and specifications for protective glazing as it applies to federal facilities. A partial list of these agencies includes:

- Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA)
- Department of Defense (DoD)
- Department of Justice (DoJ)
- US Marshall's Service (USMS)
- Department of State (DoS)
- Department of Transportation (DoT)
- Department of Energy (DoE)
- Federal Aviation Administration (FAA)

Many federal agencies are involved with fenestration indirectly. For example, of the above listed agencies, the DoD sets the standards for the construction and retrofitting of military installations and the State Department establishes criteria for U.S. Embassies throughout the world. The fenestration industry has been actively involved in every stage of the development of these national standards and criteria.

### **Industry Involvement in Development of GSA–Glass Hazard Rating Criteria**

GSA has developed a system for evaluating the protection levels related to glazing response during a blast event. These systems and standards have been adopted by the U.S. DHS. The hazard rating criteria was developed using the fenestration industry's test data for glazing of glass products.

### **Industry Involvement in Consensus Standards & Specifications**

The fenestration industry has a long history of active participation in the development of consensus standards and specifications through American National Standards Institute (ANSI), Consumer Product Safety Commission (CPSC) and ASTM International (formerly known as the American Society for Testing and Materials). ANSI, CPSC and ASTM provide the forum for the independent development of product and application consensus standards.

### **Development of Design Software Resources**

A number of software programs currently exist on the open market that help professionals in the civil engineering and construction industries to determine project-specific construction specifications for glazing. In addition to commercial products, the United States government has also developed software, which has been made available to the public, that predicts glass hazards related to blast loads and calculates values such as predicted load distribution and response of the system. Below is a partial listing of software programs currently available to fill these needs. Others are being developed to add to this body of knowledge.

**3DBlast** – This is a GSA sponsored program developed to rapidly predict the blast load engulfment of generic, typical buildings. This program allows for quick analyses of facilities and shows the gradation of pressure and impulse in both space and time across the structure. The program is available to US Government employees and to authorized blast consulting personnel.

**ATBlast** – This software estimates the blast loads that develop during an open-air explosion. Users input minimum and maximum range, explosive charge weight, and angle of incidence. From this information, the software calculates the following values: Shock Front Velocity (V),

Time of Arrival (TOA), Pressure (P), Impulse (I), and duration (td). This is a proprietary computer program developed by Applied Research Associates and is provided at no cost to the government and to authorized users on the PGC International website.

**Blast Resistant Glazing Design 2007** - This software finds its basis in the ASTM F 2248 design standard. The software enables the user to size rectangular laminated glass and insulating glass constructed with at least one laminated glass lite to resist explosive threats UFC 4-010-01 Explosive Weight 1 (Standoff distance up to 148 ft (45m)), UFC 4-010-01 Explosive Weight II (Standoff distance up to 82 ft (25m)), ISA Medium Threat (GSA Level C), ISA Higher Threat (GSA Level D) or a User Defined threat. This software returns a 3-sec equivalent design load suitable for designing window glass constructions fabricated with laminated glass, recommended nominal thickness designations for single laminated glass or both lites of a double glazed insulating glass unit fabricated with one or two laminated glass lites and the recommended bead size for structural sealant to hold the glazing in its frame during an explosion. For more information, visit [www.standardsdesign.com](http://www.standardsdesign.com).

**Window Glass Design 2004** - This software package performs all the required calculations to design window glass according to ASTM E 1300-04. This software also performs window glass design using ASTM E 1300-02/03, ASTM E 1300-98/00 and ASTM E 1300-94. The Glass Association of North America (GANA) endorses the Window Glass Design 2004 Program as being the best tool available to aid in designing window glass to resist wind and long-term loadings. For more information, visit [www.standardsdesign.com](http://www.standardsdesign.com).

**Wind Loads on Structures 2005** - This software performs all the wind load computations in ASCE 7-98, -02 or -05, Section 6. It allows the user to “build” structures within the system (buildings, signs, chimneys, tanks, and others). It provides basic wind speeds from a built-in version of the wind speed map or allows the user to enter a wind speed. The software provides for input of topographic features. It also allows the user to have different exposures for different wind directions. For more information, visit [www.standardsdesign.com](http://www.standardsdesign.com).

**Window Glazing Analysis Response and Design, Professional Edition (WINGARD PE)** – This GSA sponsored software provides a state-of-the-art method to analyze and predict behavior of window glass under blast loads. WINGARD PE is presented by the GSA as the national standard and has been accepted by the Department of State and Department of Defense. It performs dynamic calculations to predict glazing hazards and has repeatedly demonstrated good correlation with the results of explosive testing for a wide range of blast loads. WINGARD PE (professional edition) is available to government employees and blast consulting firms who support US Government contracts.

**Window Glazing Analysis Response and Design, Limited Edition (WINGARD LE)** – This GSA sponsored software contains a subset of the capabilities of WINGARD PE in a form intended for broad distribution. WINGARD LE (limited edition) is available to architects, engineers, and window professionals.

**Window Glazing Analysis Response and Design, Multi-Pane (WINGARD MP)** – This GSA sponsored software expands the WINGARD PE capabilities to multi-paned window systems. The complex interaction between the window frame and the glass are analyzed dynamically providing a coupled, state-of-the-art method to analyze and predict behavior of window glass

and window framing under blast loads. WINGARD MP (multi-pane) is available to government employees and blast consulting firms who support US Government contracts. The program requires a good understanding of window response to blast loads and Finite Element Modeling Techniques to develop effective models and interpret the results.

### **Protective/Security Glazing Guideline Specifications**

Many standards and specifications are in place related to security glazing materials and systems. These include the following:

#### **ASTM International**

- C 1048 – Standard Specification for Heat-Treated Flat Glass-Kind HS, Kind FT Coated and Uncoated Glass
- C 1172 – Standard Specification for Laminated Architectural Flat Glass
- C 1184 – Standard Specification for Structural Silicone Sealants
- C 1349 – Standard Specification for Architectural Flat Glass Clad Polycarbonate
- C 1564 – Standard Guide for Use of Silicone Sealants for Protective Glazing Systems
- E 119 – Standard Test Method for Fire Tests of Building Construction and Materials
- E 1300 – Standard Practice for Determining Load Resistance of Glass in Buildings
- E 1886 – Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Storm Shutters Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials
- E 1996 – Standard Specification for Performance of Exterior Windows, Glazed Curtain Walls, Doors and Storm Shutters Impacted by Windborne Debris in Hurricanes
- F 1233 – Standard Test Method for Security Glazing Materials and Systems
- F 1642 – Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loading
- F 1915 – Standard Test Methods for Glazing for Detention Facilities
- F 2248 – Standard Practice for Specifying an Equivalent 3-Second Duration Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass

#### **Federal Aviation Administration (FAA)**

Security Reference Manual, Part 3 – Blast Design and Assessment Guidelines

#### **Interagency Security Committee (ISC)**

ISC Security Design Criteria for New Federal Office Buildings and Major Modernization Projects, September 29, 2004

#### **National Institute of Justice**

NIJ-STD-0108.01 – Ballistic Resistant Protective Materials

#### **National Fire Protection Association (NFPA)**

- NFPA 80 Standard for Fire Door and Other Opening Protectives
- NFPA 80A Recommended Practice for Protection of Buildings from Exterior Fire Exposures
- NFPA 257 Standard on Fire Test for Window and Glass Block Assemblies
- NFPA 252 Standard Methods of Fire Tests of Door Assemblies
- NFPA 251 Standard Methods of Tests of Fire Resistance of Building Construction and Materials

**Underwriters Laboratory (UL)**

- UL 9 – Standard for Fire Test of Window Assemblies
- UL 10B – Standard for Fire Test of Door Assemblies
- UL 10C – Standard for Positive Pressure Fire Tests for Door Assemblies
- UL 263 – Standard for Fire Tests of Building Construction and Materials
- UL 752 – Standard for Bullet-Resisting Equipment
- UL 972 – Burglary Resistant Glazing Material

**United Facilities Criteria (UFC)**

UFC 4-010-01 include change 1 dated 22 January 2007 – DoD Minimum Antiterrorism Standards for Buildings

**United States Army – Corps of Engineers**

Security Engineering Manual (SEM), Omaha District: January 1990

Bullet and Forced Entry Resistant Window Design: Performance Design –  
Mandatory Center of Expertise ETL 1110-7-1 (FR) Missouri River District, Omaha District:  
8 October 1990

**United States – Department of State**

SD-STD-01.01, Revision G-1992 (amended April 1993) Certification Standard –  
Forced Entry and Ballistics Resistance of Structural Systems

**United States – General Services Administration (GSA)**

Standard Test Method for Glazing and Glazing Systems Subjected to Airblast Loading

**United States Tri-Services**

Design Guidelines for Physical Security of Facilities – Department of Defense,  
MIL-HDBK-1013/1A, 1993

Evaluation and Selection Analysis of Security Glazing for Protection Against Ballistic, Bomb, and  
Forced Entry Tactics, Department of Defense, MIL-HDBK-1013/12, 1997

UFGS Section 11191 – Detention and Security Windows, USACE/NAVFAC/AFCEA,  
September 1999

UFGS Section 11192 – Detention and Security Glazing, USACE/NAVFAC/AFCEA,  
September 1999

**H.P. White Laboratories**

HPW-STP-0500.02-93 – Test Procedure, Transparent Materials for Use in Forced Entry or  
Containment Barriers (Ballistics/physical attack)

The above list demonstrates many ratings related to security glazing currently exist and how the ratings should be applied to fenestration products.

## **Industry Products & Systems**

The standards and specifications for protective/security glazing generally cover these fenestration products and services:

### **Glazing Products**

1. Monolithic Glass
  - a. Thermally Tempered
  - b. Thermally Heat-Strengthened
  - c. Chemically-Strengthened
  - d. Annealed
2. Laminated Glass
  - a. Glass Clad Polycarbonate Laminates
  - b. Glass-Glass Laminates
  - c. Glass-Plastics Laminates
  - d. Plastic Laminates
3. Laminated Glass Interlayers
  - a. PVB (polyvinyl butyral)
  - b. UV Cured Resins
  - c. Thermal Cure Resins
  - d. Ionomer
  - e. Thermoplastic Polyurethane
  - f. EVA (ethylene vinyl acetate)
4. Insulating Glass
  - a. Combination of above products with a spacer in between separate lites of glass.
5. Engineering Thermoplastic Sheet
  - a. Laminated Polycarbonate
  - b. Multi-layer Polycarbonate – Acrylic Composites
  - c. Hard-coated Optical Grade Monolithic Polycarbonate
  - d. Uncoated Optical Grade Monolithic Polycarbonate
  - e. Acrylics
6. Surface Applied Fragment Retention Films
  - a. minimum of 4 mils. or greater in thickness
7. Fire-rated Glazing
  - a. Fire protective glazing
  - b. Fire resistive glazing

### **Attachments**

1. Secondary Catch-Systems
  - a. Static/Dynamic Catch-Bars
  - b. Nets
  - c. Blast Shields & Curtains
  - d. Blinds
  - e. Secondary Glazing Systems
2. Film Attachments (mechanical, sealants, etc.)
  - a. Mechanical Frame (retrofit)
  - b. Sealants (wet-glazed)
  - c. Secondary Glazing Systems
  - d. Flexible Systems (systems with adhesive tape)

## **Systems**

1. Curtain Wall
2. Doors
3. Glazed Partitions
4. Store Fronts
5. Skylights
6. Windows

## **Services**

1. Threat, Vulnerability and Risk Assessments
2. Security Engineering Support
3. Blast Consulting
4. Software Development
5. Testing and Product Evaluation

## **Applications**

1. Blast Resistant
2. Ballistic Resistant
3. Fire-rated
4. Forced Entry Resistance
5. Natural Disasters
  - a. Windstorms
  - b. Earthquakes
6. Radio Frequency Attenuation
7. Safety
8. Sound Attenuation

## **Product Testing**

**Table 1: Interagency Security Committee (ISC) Security Design Criteria protection levels for glazing response to blast.** This table summarizes the requirements of the glass for each protection level.

<b>Performance Condition</b>	<b>Protection Level</b>	<b>Hazard Level</b>	<b>Description of Window Glazing Response</b>
<b>1</b>	Safe	None	Glazing does not break. No visible damage to glazing or frame.
<b>2</b>	Very High	None	Glazing cracks but is retained by the frame. Dusting or very small fragments near sill or on floor acceptable.
<b>3a</b>	High	Very Low	Glazing cracks. Fragments enter space and land on floor no further than 1 m (3.3 ft.) from the window.
<b>3b</b>	High	Low	Glazing cracks. Fragments enter space and land on floor no further than 3 m (10 ft.) from the window.
<b>4</b>	Medium	Medium	Glazing cracks. Fragments enter space and land on floor and impact a vertical witness panel at a distance of no more than 3 m (10 ft.) from the window at a height no greater than 0.6 m (2 ft.) above the floor.
<b>5</b>	Low	High	Glazing cracks and window system fails catastrophically. Fragments enter space impacting a vertical witness panel at a distance of no more than 3 m (10 ft.) from the window at a height greater than 0.6 m (2 ft.) above the floor.

The GSA standard test method for windows exposed to blast pressure gives manufacturers the ability to evaluate protective glazing products in a scientific and standardized manner in order to meet performance criteria. Additional design considerations include the level of protection needed and whether other structural elements are adequately designed to resist the anticipated airblast pressures.

Private building owners and developers are increasingly adopting and implementing the standards promulgated in the ISC Security Design Criteria and the DoD's Unified Facilities Criteria. While not mandated in the private sector, the government standards are setting a minimum standard of care and an expectation of security within the private sector. Developers, in particular, are interested in staying competitive and able to lease facilities to government tenants.

## **Fenestration Product Certification**

**American Architectural Manufacturers Association (AAMA):** Since 1962, AAMA's ANSI-accredited Certification Program – the original third-party window performance verification program – provides window and door manufacturers with the means to independently demonstrate product performance quality to their customers.

AAMA pioneered the concept of performance-based standards for windows and doors, a key development that bypasses framing material comparisons and eliminates prescriptions for composition and thickness. Performance-based standards rate fabricated windows and doors according to their structural performance under wind loading, resistance to air infiltration, water leakage, and forced entry resistance.

Actual testing of the product is carried out at any of several AAMA-accredited independent laboratories of the certifying manufacturer's choosing. The laboratory conducts performance tests on prototype samples of a particular window type, class, and grade as specified in 101/I.S.2.

**Safety Glazing Certification Council (SGCC):** is a non-profit corporation, established in 1971 by manufacturers of safety glazing products, building code officials, and others concerned with public safety. SGCC maintains a program that provides for the certification of safety glazing materials found to be in compliance with one or both of the following specifications:

- American National Standard Institute's standard for Safety Glazing Materials used in buildings – Safety Performance Specifications and Methods of Test: ANSI Z97.1-2004
- Consumer Product Safety Commission (CPSC) Safety Standard for Architectural Glazing Materials - codified at Title 16, Part 1201 of the Code of Federal Regulations: 16 CFR 1201

**Insulating Glass Certification Council (IGCC):** is a non-profit organization that sponsors and directs a program of periodic accelerated laboratory testing and unannounced plant inspections to insure continuing product performance through specified standards.

In addition to the above are many independent testing, consulting, and engineering firms conducting tests on fenestration materials for public and private entities.

### **Reference Papers**

The following industry documents are available on the PGC International website, [www.protectiveglazing.org](http://www.protectiveglazing.org).

- *Anti-Terrorism: Criteria, Tools & Technology*  
By Joseph L. Smith, Applied Research Associates, Inc.
- *Cross Training for Glazing: Fire-Rated Products Fill Many Purposes*  
By Jerry Razwick, Technical Glass Products
- *Explosive Testing of Window Systems*  
By Kenneth Herrle and Larry Bryant, Applied Research Associates, Inc.
- *Firefighter Forceable Entry Tutorial*
- *GSA Test Method for Glazing Subject to Airblast Loadings*  
By U.S. General Services Administration
- *Laminated Glass*  
By the Glass Association of North America
- *Safety/Security Window Film*  
By the International Window Film Association
- *Security Glazing Specification*  
By the Protective Glazing Council International
- *Standard Test Method for Glazing and Window Systems Subject to Dynamic Overpressure Loadings*  
By the US General Services Administration
- *The Use of Structural Silicone Sealant for Film Attachment*  
By Bill O'Brien and Ken Yarosh, Dow Corning Corporation
- *United Facilities Criteria (UFC): DoD Minimum Antiterrorism Standards for Buildings*  
By U.S. Department of Defense

## **Reference Resources**

The following is a list of additional industry resources for glazing materials and systems:

- *Glazing Manual* – Glass Association of North America ([glasswebsite.com](http://glasswebsite.com))
- *Laminated Glazing Reference Manual* – Glass Association of North America ([www.glasswebsite.com](http://www.glasswebsite.com))

## **Conclusions & Summary**

The fenestration industry believes that existing organizations, resources, standards, specifications, products and design software provide a strong foundation to meet current needs and for future developments in the area of security fenestration. In addition, the industry is committed to further develop the resources and expertise to address issues identified by government agencies and the private sector. Governmental and private sector developers are encouraged to call upon the fenestration industry to provide educational resources, enhanced consensus standards, additional design software, and test rating system to the extent they may be needed. The proper support and use of existing organizations will yield the most effective and economical means of addressing issues relating to protective glazing for blast, bullet, burglar, fire, seismic, and destructive windstorm threats.