NATIONAL GLASS ASSOCIATION with GANA

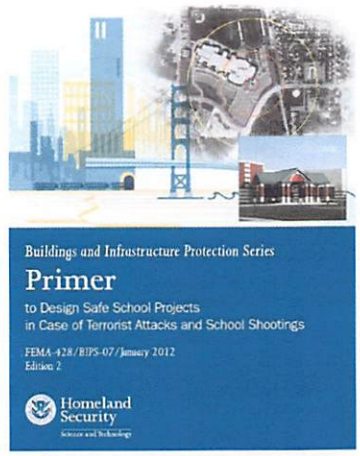
## Glass Technical Paper

**FB71-21**

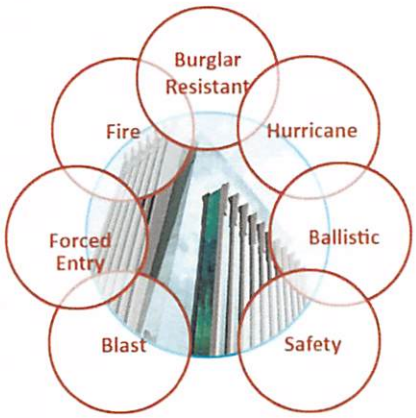
# School Security Glazing

The objective of this document is to provide information on security (delayed forced entry) glazing options for windows and doors installed in schools. It is important to determine the assets, the potential threats and hazards, and the level of vulnerability in order to know what level of testing or certification is required, before specifying the glazing. Many test standards are available to determine the suitability of glass for safety applications. This document is a guide to the standardized methods recommended and used by the glass industry.

Those determining the glass specifications will need to understand and determine the threats and hazards present in each area of the building. The Federal Emergency Management Agency (FEMA) has updated its publication: "Primer to Design Safe School Projects in Case of Terrorist Attacks and School Shootings" (December 2012) with an appendix that provides a checklist for use in these assessments.




### Multifunctional Glazing Considerations




This document does not purport to address other code requirements such as fire, hurricanes, etc., as it is the responsibility of the user of this document to determine all applicable regulatory requirements. When selecting products, multifunctional glazing may be needed to fulfill all applicable codes. The glazing should be tested by a certified laboratory for all required functions such as fire resistance, impact resistance and forced entry.

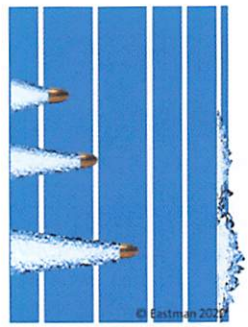
## Security Selection

The appropriate glazing penetration resistance should be determined based on the below descriptions of levels of resistance: Basic, Enhanced, Ballistic Protection, Forced Entry, Enhanced Forced Entry, Multiple Forced Entry Assault (Ballistics + Forced Entry) and Blast Mitigation.

**Basic:** The basic level of safety glazing is based on human impact forces and glass containment upon breakage. Often written into building codes, the intent is to ensure the glass has enough strength to withstand accidental impact with the glass, and also has requirements that glass fragments be contained to avoid injury. The products rated for this category are recommended for situations such as slowing immediate entry through glass and reducing the ability of someone to reach through an opening to release a door handle. Products such as laminated glazing or surface-applied safety films are readily available to meet applicable test standards.

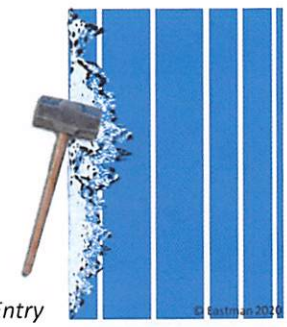
**Enhanced:** Burglary resistant glazing can be a deterrent to smash-and-grab crimes involving the use of hands, elbows, fists and general burglary tools such as a hammer. Products in this category are intended to deter vandalism such as breaking into a display case or entering the building and fleeing.

**Ballistic Protection:** Bullet-resistant (BR) glazing is designed to resist penetration from a variety of firearm ammunitions. Several examples of bullet resistant laminated glazing include all-glass laminates, glass clad polycarbonate laminates, glass laminates containing other rigid polymers, laminated polycarbonates, and glass/exposed plastic laminates (exposed polycarbonate or PET). Bullet-resistant glazing provides an improved safety barrier against bullets and related flying glass or plastic fragments (spall or splinters).



*Example of Ballistics*

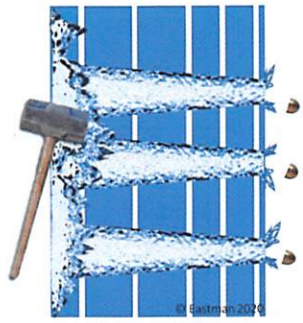
**Forced Entry:** Forced entry (FE) resistant glazing is designed to increase the amount of time required to gain entry. This additional time is intended to allow for the enactment of lock-down protocols. These products may be used in areas with high risk of prolonged attack or in critical areas such as entry vestibules. Forced entry resistant glazing should meet the criteria above and also resist penetration from hand-held or hand-thrown objects such as hammers, crowbars, bats, knives, bricks, and rocks. Note that while the diagrams in this document illustrate multi-layer glass products, significant protection from forced entry can be achieved with standard two-ply laminated glass using the proper thickness interlayer.



*Example of Forced Entry*

**Enhanced Forced Entry:** Products in this category are intended to meet the requirements for forced entry resistant glazing after being weakened by ballistic assault. They are ***not*** designed for ballistic classification; thus, the bullets may penetrate the glazing. Enhanced forced entry testing can include shooting through the glass to weaken it followed by physical impact with various weapons. The glazing classification would carry an indication of the type of ballistic assault used along with a forced entry classification. The goal is to resist entry for an adequate amount of time to allow for the arrival of emergency response personnel.

*Example of Enhanced Forced Entry:*



**Multiple Forced Entry Assault (Ballistics + Forced Entry):** Products in this category are designed to combine the resistance of ballistics classified laminates with additional resistance to forced entry. Testing for these glazing systems involves weakening the sample by ballistic assault but not allowing the bullets to penetrate. The glazing is then tested to withstand physical impact and attack with various weapons. This glazing would carry a ballistic and forced entry classification and would be used in very high-risk areas, where intruders may be armed with guns.

*Example of Multiple Forced Entry Assault (Ballistic + Forced Entry):*

**Blast Resistance:** Blast-resistant glazing can substantially reduce injury from flying glass resulting from direct blast shock waves (over-pressures). When properly designed, framed, and anchored, blast-resistant glazing is capable of maintaining the integrity of the building envelope following an explosion and reducing interior damage. Blast-resistant glazing may offer some level of burglary or forced entry resistance but without testing to burglary or forced entry standards, how much resistance is not quantifiable. Also, this glazing is not typically bullet-resistant without being tested to a ballistic threat level.

**Table 1: Security Selection Quick Reference Summary**

| | | *Security Level of the Selection** | | |
|---|---|---|---|---|
| *Security Selection* | *Test Standard* | **Low** | **Medium** | **High** |
| **Basic Safety Glazing** | ANSI Z97.1 | Class B Type 1 | n/a | Class A Type 1 |
| | CPSC | Cat I | n/a | Cat II |
| | CAN CGSB | Class B Type 1 | n/a | Class A Type 1 |
| | ASTM F3561 | Level 1 | Level 1 | Level 1 |
| | ASTM F3006/F3007 | 0.75 m Cat 2 | 3.66 m Cat 3 | 3.66 m Cat 2 |
| **Enhanced** | UL 972 | Std – 10 ft | Ind/Outdoor | High Energy (40 ft) |
| | ASTM E2395 | L1 | L3 | L5 |
| | ASTM F1233 | 1.0 | 1.1 | 1.2 |
| **Forced Entry** | ASTM F1233 | 1.4 | 2.3 | 5.0 |
| | ASTM F3038 – mob with hand tools | 5 min | 15 min | 30 min |

| | | | | |
|---|---|---|---|---|
| **Enhanced Forced Entry** | ASTM F3561 | 10 shots AR15 with M193 bullet; Level 1-2 | 10 shots AR15 with M193 bullet; Level 3-5 | 10 shots AR15 with M193 bullet; Level 6 – 8 |
| | ASTM F1233 Annex A2 | 3 shots with 9 mm handgun; Class 1.4 | 3 shots with .357 Magnum; Class 2.3 | 3 shots with .44 Magnum; Class 5.0 |
| **Ballistic Protection (Handguns)** | UL 752 | 1 (9 mm handgun) | 2 (.357 Magnum) | 3 (.44 Magnum) |
| | ASTM F1233 | HG3 (9 mm handgun) | HG2 (.357 Magnum) | HG4 (.44 Magnum) |
| **Multiple Forced Entry Assault (Ballistics + Forced Entry)** | ASTM F1233 | HG1/R1-1.4 | HG2/R2-2.3 | HG4/R3-5.0 |
| **Blast Resistance** | ASTM F1642/F2912 | H3 | H2 | H1 |

* This is not meant to be all-inclusive; there are levels existing outside of this table.

**Security Glazing – Educational Facilities Active Standards**

**Security Glazing Testing – Glass Only**

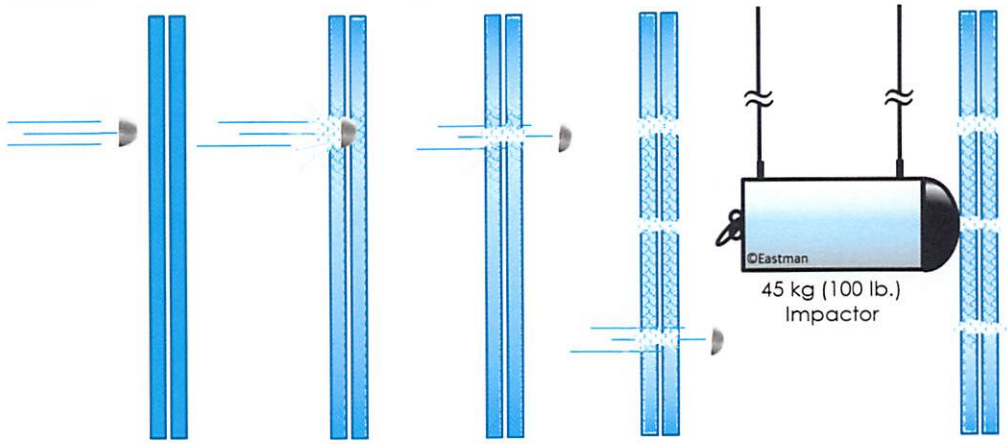
**UL 972** - Underwriters Laboratories *Standard for Safety for Burglary Resisting Glazing Materials*

- This is a mechanical test in which a 5 lb. steel ball is dropped from different heights to give a consistent impact force on the glass. This is a multiple impact test.
- The purpose of this test is to evaluate glazing resistant to repeated impact as a result of attempted burglary.

**ASTM F3561** *Standard Test Method for Forced-Entry-Resistance of Fenestration Systems After Simulated Active Shooter Attack*

- This is a mechanical test in which the glass is weakened with ballistic attack, then impacted multiple times with a 100 lb. impactor. Drop height of impactor increases with performance level. Two impacts from each drop height are required to meet level requirements.
- This test simulates weakened glazing systems and gives a range of performance options. There is a glass-only testing option (pre-test qualification), however this is a system test.

Sequence of Ballistic Weakening and Forced Entry Impact for ASTM F3561



**ASTM F1233** – ASTM International *Standard Test Method for Security Glazing Materials and Systems*

- This test gives a wide range of threat levels and uses various hand tools and/or ballistic attack to give a resistance rating to the penetration of the glass.
- Glazing tested with ballistic attack prior to forced entry attempts is rated based on whether or not the bullet passes through the glazing.

**ANSI** (American National Standards Institute) **Z97.1 Standard** - *Safety Glazing Materials used in Buildings – Safety Performance Specifications and Methods of Test*

- This test is based on the force of a 100-pound person traveling at the equivalent of a 4-minute mile and impacting the glass. A 100 lb. swing bag is dropped from two different heights to determine the rating.

**ASTM F3006** - ASTM International *Standard Specification for Ball Drop Impact Resistance of Laminated Architectural Flat Glazing*

- This test evaluates the penetration of the glass categorized by the force generated by the different drop heights at which a 5 lb. ball is released. This is a single impact test.
- The purpose of this test is to evaluate general glazing strength for safety.

**UL 752** – Underwriters Laboratories *Standard for Bullet-Resisting Equipment*

- This test evaluates the ballistic resistance of glazing.

**NIJ 0108.01** – National Institute of Justice *Ballistic Resistant Protective Materials*

- This is a test standard that evaluates the ballistic resistance of glazing.
- NIJ Standard is not included in Table 1: *Security Selection Quick Reference Summary* because it does not correspond with non-Federal standards.

**Security Glazing Testing – Glazing System (Frame + Glass)**

**ASTM F3561** *Standard Test Method for Forced-Entry-Resistance of Fenestration Systems After Simulated Active Shooter Attack*

- This is a mechanical test in which the glass is weakened with 10 shots from an AR15 with M193 bullets and is impacted after weakening with a 100 lb impactor. Drop height of impactor increases with performance level. Two impacts from each drop height are required to meet level requirements.
- This test simulates weakened glazing systems and gives a range of performance options. The pass/fail criteria is determined by the ability of the weakened glazing assembly to prevent the impactor from passing through the glazing or a solid 6-inch sphere from passing through with little force, whichever is less.

**ASTM F3038** - ASTM International *Standard Test Method for Timed Evaluation of Forced-Entry-Resistant Systems*

- A glazing impact test with timed assault sequences. This test method is designed to simulate a spontaneous mob using readily available hand tools as the primary threat for forced entry.

**ASTM E2395** – ASTM International *Standard Specification for Voluntary Security Performance of Window and Door Assemblies with Glazing Impact*

- A glazing impact test using timber missiles, followed by the striking of the glazing with a hammer 10 times at its highest rating level.
- This specification addresses the capability of window and door assemblies to frustrate and potentially delay

or deter opportunistic entry by unskilled and semi-skilled intruders. This specification does not address detention facilities or window and door assemblies attacked by professional, sophisticated intruders.

**ASTM F1642** - ASTM International *Test Method for Glazing and Glazing Systems Subject to Airblast Loadings*

- A test method that evaluates hazards of glazing against intentional or accidental explosions, such as bomb blasts.
- The data obtained from testing under this method shall be used to determine the glazing or glazing system hazard rating using ASTM Specification F2912.

**Additional Considerations when Specifying Glazing System**

- Appropriate framing system, rated to appropriate performance level or higher, to hold glass and resist entry
  - Select performance level from ASTM F476, F588, F842
- Certain glazing products may use exposed plastic surfaces on the interior/safe side. This type of glazing and the installation environment should be considered carefully as these plastics do not have the same chemical and abrasion resistance of glass or ceramic.
- Be aware that the application of safety and security window films should be part of the initial design discussion with the window supplier. Selection of safety and security window films should be based on the performance requirements and the window system capability, including the film type and attachment method, the glass type and thickness, whether single or multi-paned glazing, window size and frame type, fire-rating and other variables. Consult the glass manufacturer/fabricator prior to applying films to annealed, heat-absorbing (tinted) glass. Some manufacturers will void their warranties for insulating glass, laminated glass and glass-clad polycarbonate if films are applied.
- Proper installation.
- Proper cleaning: consult with the manufacturer for proper techniques.
- Appropriate design based on test methods from recognized Standard Development Organizations (SDO), such as those listed in this document.

## Specification Considerations

When deciding what level of protection to specify, consider these factors:

- Direct line of sight to students
- Location and movement of students during an active shooter event
- Distance and time for first responders

FEMA publication *Primer to Design Safe School Projects in Case of Terrorist Attacks and School Shootings* includes the following considerations in Appendix F:

- Use extensive glazing at main entrance to enhance visual surveillance to parking lots and pedestrian routes.
- Install openings or windows in solid walls to make areas adjacent to the school without line of sight visible from the interior.
- Consider using burglary- and ballistic-resistant glazing in high-risk school areas.
- Consider using steel window frames securely fastened or cement grouted to the surrounding structure.

**Emergency Egress**

Security glazing is designed to remain intact after breakage. This may increase the amount of time and effort required for firefighters and first responders to vent and clear the building during an emergency. The U.S. General Services Administration (GSA) has developed a training program that addresses emergency egress through security glazing. Architects specifying systems and schools installing security windows need to be aware of the potential time needed to get through security glazing. The proper tools, education and training should be in place at any school installing security glazing. Other possible means of emergency egress for teachers and students should be clearly identified.

**Sources of Security Glazing Systems**

Many window, door and curtain wall manufacturers have systems that have been tested with security glazing. More information is available from these manufacturers.

**References**

FEMA Primer to Design Safe School Projects in Case of Terrorist Attacks and School Shootings (December 2012) (see Checklist in Appendix) https://www.dhs.gov/xlibrary/assets/st/bips07_428_schools.pdf

**Additional Resources**

NGA Glass Technical Paper FB16-07 *Bullet Resistant Glazing*

NGA Glass Technical Paper FB43-14 (2020) *Security Glazing*

*NGA/PGCI Protective Glazing Manual*

*NGA Laminated Glazing Reference Manual*

Glass & Metals 401: Guide to Protective Glazing:
http://www.glassmagazinedigital.com/publication/?m=22077&i=155958&p=12

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