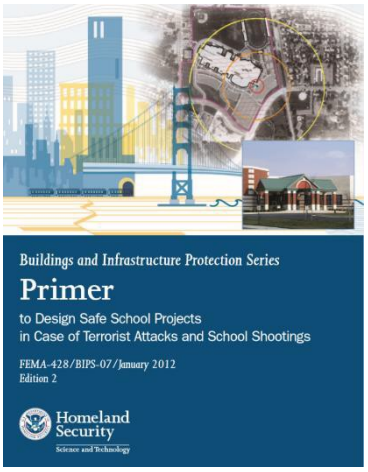
NATIONAL GLASS ASSOCIATION with GANA

Glass Technical Paper FB43-14 (2020)

Security Glazing

The objective of this document is to provide information on security (forced entry) glazing options for windows and doors installed in schools, commercial, medical, public, worship and other building types. Before the glazing is specified, it is important to determine the assets, threat/hazard, vulnerability, and risk associated with the specific building type.

For example, 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

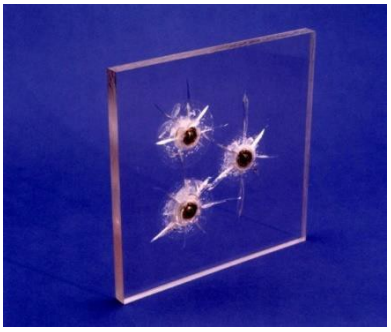
This document does not purport to address other code requirements such as fire, hurricane, etc. It is the responsibility of the user of this document to determine all applicable regulatory requirements. When selecting products, multifunctional glazing may be needed to fulfill the applicable codes. The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

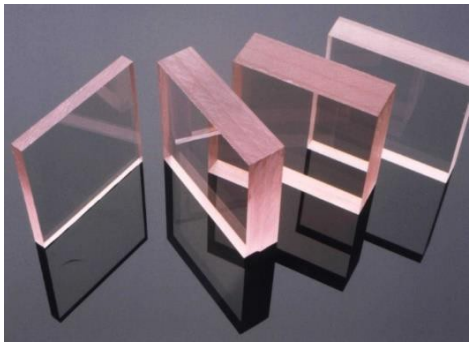
Types of Security Glazing

Burglary resistant glazing can be a deterrent to smash-and-grab crimes. Burglary resistant laminated glazing can be tested according to Underwriters Laboratories (UL) Standard 972 *Standard for Safety for Burglary Resisting Glazing Materials;* ASTM F 3006 *Standard Specification for Ball Drop Impact Resistance of Laminated Architectural Flat Glazing*; and ANSI Z97.1 *For Safety Glazing Materials used in Buildings – Safety Performance Specifications and Methods of Test*.

Forced entry (FE) resistant glazing can be used in detention facilities or other installations with high risk of attack and may also resist penetration from hand-held or hand-thrown objects such as hammers, crowbars, bats, knives, bricks, and rocks. Glazing makeups can be tested according to ASTM F 1233 *Standard Test Method for Security Glazing Materials and Systems*; ASTM F 1915 *Standard Test Method for Glazing for Detention Facilities;* and ASTM E 2395 *Standard Specification for Voluntary Security Performance of Window and Door Assemblies with Glazing Impact.*

Bullet-resistant (BR) glazing is designed to resist penetration from a variety of firearm ammunitions. There are numerous types of bullet resistant laminated glazing, including all-glass laminates, glass clad polycarbonate laminates, glass laminates containing other rigid polymers, laminated polycarbonates, and glass/exposed plastic laminates (exposed polycarbonate or PET).





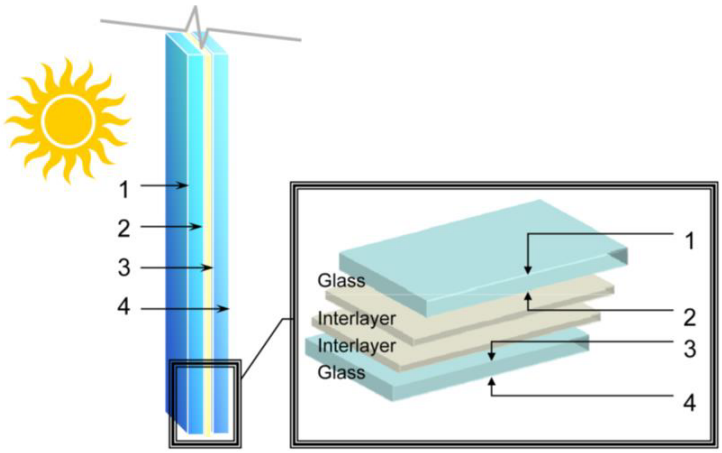
Bullet-resistant glazing must be tested in accordance with standard procedures to demonstrate their ability to resist a specific ballistic threat level. Bullet-resistant glazing provides an improved safety barrier against bullets and related flying glass or plastic fragments (spall or splinters). Testing is done according to Underwriters Laboratories (UL) Standard 752 *Standard for Bullet Resisting Equipment; ASTM F 1233; National Institute of Justice (NIJ) Standard 0108.1 - Ballistic Resistant Protective Materials, and Walker –McGough-Foltz& Lyerla (WMFL) 30 & 60 Minute Retention - Ballistics and Forced Entry Test Procedure.*

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. ASTM F 2912 *Standard Specification for Glazing and Glazing Systems Subject to Airblast Loadings* and ASTM F 1642 *Test Method for Glazing and Glazing Systems Subject to Airblast Loadings* can give guidance to specifiers. Blast-resistant laminated glazing may offer some level of burglary or forced entry resistance, but typically are not bullet-resistant without further specification of a ballistic threat level.

Hurricane resistant laminated glazing reduces the effects of windstorms on buildings by preserving the integrity of the building and preventing glass particle fallout. Laminates are typically tested in systems according to ASTM E *1886 Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and impact Protective Systems Impacted by Missiles and Exposed to Cyclic Pressure Differentials*. The accompanying specification is ASTM E1996 *Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Windborne Debris in Hurricanes.* Hurricane resistant laminated glazing may offer some level of burglary or forced entry resistance, but typically are not bullet resistant without further specification of a ballistic threat level.

Glazing Constructions

Burglary resistant laminated glass typically consists of two layers of annealed, heat-strengthened or tempered glass bonded together by a 0.060 in. (1.52 mm) or thicker interlayer. The glass can be installed into insulating glass units for improved thermal performance. Burglary resistant glazing may also include self-adhesive PET films that are on the exposed, interior side of the glass.

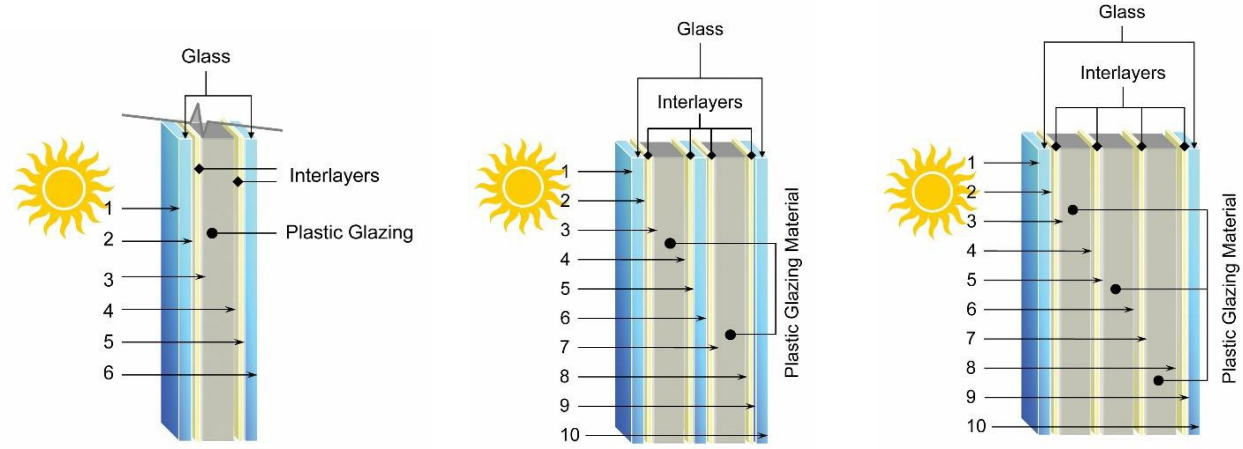


Laminated Security Glazing

Forced entry resistant laminated glazing can consist of either multiple plies of glass and interlayers or can be multiple plies of glass and polycarbonate bonded together by a polyurethane (PU) interlayer.

Bullet-resistant laminated glazing typically consists of multiple layers of glass, interlayers, resins, and/or plastic materials such as polycarbonate or acrylic. Glass layers are intended to deform projectiles and slow their velocity. Plastic layers are designed to capture the deformed projectile, and interlayers act to hold all layers together through the assault. The layer on the protected or witness side may have abrasion-resistant polycarbonate or PET film for spall/splinter protection. Overall thickness of the glazing typically may range from 0.5 in to 2.25 in. (12 mm – 57 mm) but could be larger.

Low level blast-resistant laminated glazing typically consists of two layers of glass bonded together by a .030 in. (0.76 mm) or thicker interlayer. For higher level blasts, thicker constructions may be needed. The glass can be annealed, heat strengthened or fully tempered. The glass can be installed into insulating glass units for improved thermal performance.



Hurricane resistant laminated glazing typically consist of two layers of glass bonded together by an interlayer. The interlayer thickness is typically 0.060 (1.52 mm) or thicker based on the intended use of the glazing in the building and the expected missile size for the elevation of the building. Some hurricane resistant systems have also been successfully tested for blast resistance. These systems may provide a level of burglary or forced entry resistance as well.

Security Glazing – Educational Facilities Active Standards

Window/Door System – Frame Only

ASTM F588

- Forced entry frame attack – windows; various tools; no glazing impact; Anthromorphic

ASTM F842

- Forced entry frame attack – sliding doors; various tools; no glazing impact; Anthropomorphic

ASTM F476

- Forced entry frame attack – hinged doors; various tools; no glazing impact; Anthropomorphic

Security Glazing Testing – Glass Only

UL 972

- Burglary Resistant Glazing – Repetitive Ball Drop: Mechanical

ASTM F1233

- Impacts with various weapons, ballistic assault; Anthropomorphic

ASTM F1915

- Glazing impact; various weapons; Mechanical

ASTM F3006

- Penetration resistance; Ball Drop; Mechanical

ANSI Z97.1

- Penetration resistance for Type 1; Mechanical

CPSC 16 CFR 1201

- Penetration resistance for Category II; Mechanical

UL 752

- Ballistic assault

NIJ 0108.01

- Ballistic Assault

Security Glazing Testing – Glazing System (Frame + Glass)

ASTM F3038

- Glazing impact with timed assault sequences; Anthropomorphic

ASTM E2395

- Framing tested per ASTM F476, F588 & F842; Glazing impact L1-L4 per ASTM E1996; L5 glazing impact per ASTM F1233; various graduated levels; Anthropomorphic

Security Selection

Select glazing penetration resistance:

- Basic = human impact; glass containment upon breakage; immediate deterrence to entry; reduced ability for reach and release; readily available – minimum requirements for lobby, entry, first floor windows and doors
- Enhanced = simulated weapon impact by 2 x 4, repeatable; industry accepted practice; various levels; extended deterrence to entry; affordable options
- Forced Entry = repeated assaults; longer duration deterrence; non-monitored areas; high risk glazing
- Forced Entry + Ballistics = ballistic assault followed by forced entry impact to gain entry; very high-risk areas; deterrence time extended; protection of occupants

Ballistic Protection = ballistic assault using various ammunition classes with no penetration of witness panel; Note: UL 752 does not allow particle embedding or damage of witness panel.

Table 1: Security Selection Quick Reference Summary

Glazing Penetration Resistance	Basic Safety Glazing	Enhanced	Forced Entry	Forced Entry + Ballistics	Ballistic Protection
Threat to Glazing	Accidental Human Impact	Simulated weapon impact by 2 x 4	Repeated assaults	Ballistic assault followed by forced entry impact to gain entry	Ballistic assault using various ammunition classes
Typical Application	Minimum requirements for lobby, entry, first floor windows and doors	Burglary risk areas	Non-Monitored areas; High risk glazing; Detention facilities	Very high-risk areas	Ballistic risk areas
Typical Laminate	Two glass layers with interlayer	Two glass layers with minimum 0.060-inch interlayer	Multiple plies of glass and/or polycarbonate with polyurethane interlayer	Multiple layers of glass, interlayers, resins, and/or plastic materials such as polycarbonate or acrylic	Multiple layers of glass, interlayers, resins, and/or plastic materials such as polycarbonate or acrylic
Test Standards	ANSI Z97.1 CPSC 16 CFR-1201 ASTM F3006	UL972	ASTM F3038 ASTM F1915 ASTM E2395 ASTM F1233 (forced entry class)	ASTM F1233 (forced entry plus ballistic class)	UL 752 NIJ 0108.01
Test Criteria	Glass containment upon breakage	Extended deterrence to entry	Longer duration deterrence	Deterrence time extended	No penetration of witness panel from glass or plastic spall

Frame Selection Process

Ensure frame is adequate to hold glass and resist entry

- Select performance level from ASTM F476, F588, F842
- Ensure framing system is rated to appropriate performance level or higher

Product Considerations

- Certain transparencies 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 inherent chemical and abrasion resistance of glass or ceramic.
- Proper installation
- Proper cleaning. Note: Consult with the manufacturer for proper cleaning techniques.

Review and/or design to test methods from recognized Standard Development Organizations (SDO) such as those listed in this document.

Emergency Egress

Security laminates are 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 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 for 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

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

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

Documents to consider as additional resources are the FB16-07 *Bullet Resistant Glazing, NGA/PGCI Protective Glazing Manual,* and *NGA Laminated Glazing Reference Manual.*

Visit www.glass.org/store for a complete list of Glass Technical Papers, as well as other glazing and glass building products industry reference materials. Most Glass Technical Papers are available free of charge to NGA members and for a small fee to nonmembers.

This Paper was developed by dedicated member volunteers and subject matter experts. The original version of this document was approved and published in 2014. This edition of the paper was updated and published in July 2020.