

# Safety and Burglary-Resistant Glass

## Introduction

Laminated safety glass is a multifunctional glazing material that can be used in applications ranging from residential to commercial installations. All model building codes require that the glass used in certain locations, such as doors, sidelites, patio doors, tub and shower enclosures and certain other glazed openings, must be safety glass that meets the requirements of the Consumer Products Safety Commission (CPSC) 16 CFR 1201 *Safety Standard for Architectural Glazing Materials*. Oldcastle Glass® laminated glass meets these requirements.

When impacted, laminated glass typically breaks safely and remains an integral part of the opening. The plastic interlayer minimizes splinters and glass fragments, reducing the risk of injury or property damage. The external envelope of the building is maintained, and therefore boarding up may not be necessary. This is particularly important during natural disasters such as hurricanes, tornadoes and earthquakes, and it is widely specified for these types of applications. Impulse burglaries can also be resisted by laminated glass because it is difficult to gain access or remove property, even if a puncture is made in the interlayer.

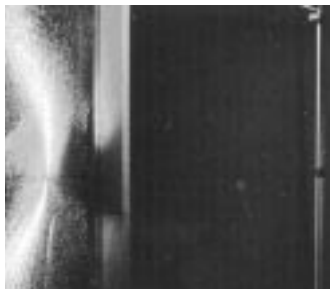
## Description

Laminated safety glass is manufactured by permanently bonding two or more lites of clear, tinted, Low-E, patterned, wired or reflective glass with one more or more layers of polyvinyl butyral (PVB) sheets. Assembly takes place in the carefully controlled environment of a clean room, ensuring no contaminants are trapped in the product. Final bonding is achieved in an air autoclave under heat and pressure, which creates a single solid construction. The glass can be

annealed, heat-strengthened or fully tempered, and the lites can be of equal or unequal thickness. Laminated safety glass can be used as the inboard, outboard or both lites in an insulating glass unit.

By combining tinted glass, reflective coatings, silk-screened patterns and pigmented interlayers, a wide array of laminated glass configurations can be used to meet specific visual, aesthetic, security, performance and code requirements.

### Impact Performance of Glazing Materials: Initial Point of Contact with Swing Weighted Ball



#### Laminated Glass

Breaks safely. May crack under impact, but typically remains integral. Splinters and sharp fragments tend to adhere to Saflex® interlayer.



#### Annealed Glass

Easily fractures. Typical breakage (including thicker glass) produces long sharp-edged splinters.

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## Safety and Burglary-Resistant Glass

### Description (continued)

Glass Designation		Construction (glass-PVB-glass)		Weight		Test Standards	
Traditional inches	Metric mm	Traditional inches	Metric mm	Traditional lbs/ft <sup>2</sup>	Metric kg/m <sup>2</sup>	Safety Category <sup>(1)</sup>	UL 972 Burglary
1/4	5.8	Lami - 0.015 - Lami	2.7 - 0.38 - 2.7	2.93	14.30	I	-
1/4	6.1	Lami - 0.030 - Lami	2.7 - 0.76 - 2.7	3.01	14.69	II	-
1/4	6.4	1/8 - 0.015 - 1/8	3 - 0.38 - 3	3.33	16.26	I	-
1/4	6.8	1/8 - 0.030 - 1/8	3 - 0.76 - 3	3.42	16.70	II	-
5/16	7.5	1/8 - 0.060 - 1/8	3 - 1.52 - 3	3.58	17.48	II	yes
5/16	8.2	1/8 - 0.090 - 1/8	3 - 2.28 - 3	3.75	18.31	II	yes
3/8	10.8	3/16 - 0.030 - 3/16	5 - 0.76 - 5	5.05	24.65	II	yes
7/16	11.5	3/16 - 0.060 - 3/16	5 - 1.52 - 5	5.21	25.44	II	yes
7/16	12.2	3/16 - 0.090 - 3/16	5 - 2.28 - 5	5.38	26.27	II	yes
1/2	12.8	1/4 - 0.030 - 1/4	6 - 0.76 - 6	6.67	32.56	II	yes
9/16	13.5	1/4 - 0.060 - 1/4	6 - 1.52 - 6	6.83	33.34	II	yes
9/16	14.2	1/4 - 0.090 - 1/4	6 - 2.28 - 6	7.00	34.17	II	yes
13/16	21.5	3/8 - 0.060 - 3/8	10 - 1.52 - 10	10.09	49.26	II	yes
13/16	22.2	3/8 - 0.090 - 3/8	10 - 2.28 - 10	10.26	50.09	II	yes

This table shows data for symmetrical lay-ups. Asymmetrical lay-ups, having two different thickness of glass, are also available on request.

(1) Applies to CPSC 16 CFR 1201 and CAN/CGSB-12.1. All laminated safety glass also meets ANSI Z97.1.

### Performance

#### Safety

Laminated safety glass is tested using a taped, leather bag filled with lead shot weighing 100 lbs. A standard size piece of glass is clamped vertically in a frame. The impactor is supported from a wire cable so that it will impact the glass in the center. The ball is lifted to the required height and allowed to swing freely into the glass. Numerous cracks and fissures may occur, but no shearing or opening, through which a 3-inch diameter sphere may pass freely, will develop. All laminated glass with a minimum of 0.015" (0.38 mm) PVB meets the requirements of safety glass as defined by ANSI Z97.1, CPSC 16 CFR 1201, Category I and CAN/CGSB-12.1, Category I. Laminated glass with a PVB thickness of 0.030" (0.76 mm) and greater also meets the requirements of CPSC 16 CFR 1201, Category II and CAN/CGSB-12.1, Category II.

#### Burglary

Thicker PVB laminates will also meet the requirements of Underwriters Laboratories, UL 972 *Burglary Resisting Glazing Material*. This standard uses a 5 lb. steel ball dropped on the glass from various heights to simulate a typical "smash and grab" attack.

#### Structural Strength

Laminated glass strength and deflection are discussed in detail in ASTM E1300 *Standard Practice for Determining the Load Resistance of Glass in Buildings*. The model building codes contain requirements for wind, snow and dead loads on glass. The applicable state laws and local building codes must be checked to determine minimum glass strength requirements governing each project.

#### Seismic

For details on the use of Laminated Glass in Seismic applications, please refer to the Green Seismic Tab.

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## Safety and Burglary-Resistant Glass

### Performance (continued)

Safety Standard	Category/ Class	Weight of Impactor lbs	Height of drop inches	Energy Ft-lbs	Required thickness of PVB, inches
<b>CPSC 16 CFR 1201</b>	I	100	18	150	0.015
<b>CPSC 16 CFR 1201</b>	II	100	48	400	0.030
<b>ANSI Z97.1</b>	A <sup>(1)</sup>	100	48	400	0.030
<b>ANSI Z97.1</b>	B <sup>(1)</sup>	100	18	150	0.015
<b>ANSI Z97.1</b>	C <sup>(1)</sup>	100	12	100	0.015
<b>CAN/CGSB-12.1</b>	I	100	18	150	0.015
<b>CAN/CGSB-12.1</b>	II	100	48	400	0.030

(1) At the time of publication, these classifications are still in a proposal stage.

### Butt-Joint Glazing Systems

Laminated glass supplied by Oldcastle Glass® is recommended for butt-joint glazing systems—i.e., systems where the glass is captured in a frame on two edges, and the other two edges butt up against each other with a small space, without use of a frame. Any silicone sealant used at this butt-joint can, under certain circumstances, cause a discoloration of the edge of the laminate over time. The extent of this depends on the actual sealant, but it generally does not exceed about 1/4". Where possible, especially in internal

applications, it is advisable not to use any sealant on the gaps between the glass. If a sealant is used, please check for compatibility with the manufacturer of the sealant. The use of a black sealant often produces a better visual effect.

### Inspection and Quality

The tolerance and quality standards for these products are detailed in ASTM C1172 *Standard Specification for Laminated Architectural Flat Glass*—reference to which should be made in any specification.

### ASTM C1172 Length and Width Tolerance for Rectangular Shapes of Symmetrically Laminated Glass

Laminate Thickness Designation, t inches (mm)	Transparent Glass inches (mm)	Patterned and wired glass inches (mm)	Heat-Strengthened and Tempered Glass inches (mm)
t ≤ 1/4 (6.4)	+5/32 (4.0) -1/16 (1.6)	+5/16 (7.9) -1/8 (3.2)	+7/32 (5.6) -3/32 (2.4)
1/4 (6.4) < t ≤ 1/2 (12.7)	+1/4 (6.4) -1/16 (1.6)	+5/16 (7.9) -1/8 (3.2)	+1/4 (6.4) -1/8 (3.2)
1/2 (12.7) < t ≤ 1 (25.4)	+1/4 (6.4) -1/8 (3.2)	+5/16 (7.9) -1/8 (3.2)	+5/16 (7.9) -1/8 (3.2)

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## Safety and Burglary-Resistant Glass

### Performance (continued)

#### ASTM C1172—Maximum Allowable Laminating Process Blemishes: inches (mm)

Blemish	Up to 25 ft <sup>2</sup> (2.5 m <sup>2</sup> )		25-75 ft <sup>2</sup> (2.5-7.0 m <sup>2</sup> )		Over 75 ft <sup>2</sup> (7.0 m <sup>2</sup> )	
	Central <sup>A</sup>	Outer <sup>A</sup>	Central <sup>A</sup>	Outer <sup>A</sup>	Central <sup>A</sup>	Outer <sup>A</sup>
<b>Boil</b> (bubbles)	<b>1/16</b> (1.6)	<b>3/32</b> (2.4)	<b>1/8</b> (3.2)	<b>3/16</b> (4.8)	<b>1/4</b> (6.4)	<b>1/4</b> (6.4)
<b>Blow-in;</b> edge boil	B	CE <b>1/4</b> (6.4) EE <b>1/32</b> (0.8)	B	CE <b>1/4</b> (6.4) EE <b>1/16</b> (1.6)	B	CE <b>5/16</b> (8.0) EE <b>3/32</b> (2.4)
<b>Fuse</b>	<b>1/32</b> (0.8)	<b>1/16</b> (1.6)	<b>1/16</b> (1.6)	<b>3/32</b> (2.4)	<b>3/32</b> (2.4)	<b>5/32</b> (4.0)
<b>Hair, lint</b> (single strand)	light intensity	medium intensity	light intensity	medium intensity	medium intensity	medium intensity
<b>Inside dirt</b> (dirt spot)	<b>1/16</b> (1.6)	<b>3/32</b> (2.4)	<b>3/32</b> (2.4)	<b>5/32</b> (4.0)	<b>1/8</b> (3.2)	<b>3/16</b> (4.8)
<b>Lint</b> -areas of concentrated lint	light intensity	light intensity	light intensity	light intensity	light intensity	light intensity
<b>Separation,</b> discoloration	none	none	none	none	none	none
<b>Short interlayer;</b> unlaminated area chip	B	CE <b>1/4</b> (6.4) EE <b>1/16</b> (1.6)	B	CE <b>1/4</b> (6.4) EE <b>3/32</b> (2.4)	B	CE <b>1/4</b> (6.4) EE <b>1/4</b> (6.4)
<b>Interlayer scuff;</b> streak	light intensity	light intensity	light intensity	light intensity	light intensity	light intensity

**A**—The central area is an area, formed by an oval or circle, whose axis, when centered, does not exceed 80% of the overall dimension. The outer area is the area outside the central area. **B**—not applicable; **CE**—covered edge of glass edge bite; **EE**—exposed edge (if CE or EE is unknown, use CE tolerance).

**Light Intensity**—barely noticeable at 36 inches (914.4 mm); **medium intensity**—noticeable at 36 inches (914.4 mm) but not at 11 feet (3352.8 mm).

All imperfections noted should be separated by a minimum of 12 inches (305 mm).

### Special Applications

Oldcastle Glass® regularly supplies laminated glass for special applications such as swimming pools and aquariums, zoo enclosures, glass floors and stairs, balustrades and handrails. These applications all have structural loading conditions very different from those for conventional architectural glass and therefore require careful consideration. To date, there are no national consensus standards for these applications.

Typically, the loading is of a longer-term duration than for wind load. The key issue related to the selection of the appropriate glass types and thicknesses for these applications is limiting the maximum stress in the glass in order to keep

the probability of breakage to a very low level. Often, failure of this type of glass constitutes a life safety issue. Where total failure of the glazing is unacceptable, multiple lite laminated glass should be used and designed so that a breakage of one lite will not result in total failure.

The remaining lites should provide reasonable assurance that they will withstand the load for a limited period of time until the unit can be replaced.

Determining the risk of failure and deciding on the appropriate design of the glazing are the responsibility of the design professional, so reference should always be made to an engineer with experience in these types of glass design.



## Safety and Burglary-Resistant Glass

### Additional Important Information

#### Design Criteria

*Details on the following important topics can be found in the Black Design Criteria Tab: Glazing Instructions, Thermal Stress, Deflection, Glass Design Loads, Glass Thickness Selection, Spontaneous Breakage of Tempered Glass, Roller Wave Distortion in Heat-treated Glass, Mock-ups and Warranties.*

#### Specifications

*A sample Section 08800 Specification for North America can be found in the Black Specifications Tab. Information specific to two-ply (two lites of glass) laminated glass can be found in Part 2 Products, 2.02 Materials.*


For specifications on other laminated glass makeups, call 1-866-OLDCASTLE(653-2278) or log on to [www.oldcastleglass.com](http://www.oldcastleglass.com) and click on “Need Assistance with a Project,” click on “General Inquiry” and enter your request.

#### Contact Us

For any additional information, including details, technical data, specifications, technical assistance and samples, or to speak with an architectural specialist, call 1-866-OLDCASTLE(653-2278).

#### Visit Us on the Web

Log on to [www.oldcastleglass.com](http://www.oldcastleglass.com) for project photos, product colors, general inquiries and project assistance.

To view performance data on a wide range of glass makeups, or to build your own product specification, log on to [www.oldcastleglass.com](http://www.oldcastleglass.com) and choose GlasSelect™ 

## ArmorProtect™ Forced-Entry-Resistant Glass

### Introduction

**ArmorProtect™** is used where glazing is required to resist penetration for some considerable time, typically measured in minutes rather than seconds. These types of attacks are usually planned, sustained attacks executed by more than one intruder having experience of security glazing and using more than one type of weapon.

When considering these types of attacks, two methods of failure are generally considered. The lesser test is to see when an opening large enough to pass contraband, such as drugs or weapons, is created. The more exacting test is to establish when an opening is created that is large enough for the passage of a whole body.

### Description

Glass in this product category can be divided into three broad categories.

**ArmorProtect™** burglary and attack-resistant/institutional laminates offer improved detention security and provide unobstructed vision while eliminating the confined look of bars and metal screens. Typical applications include penal institutions, detention centers, psychiatric hospitals and police stations. In addition, institutional laminated architectural glass provides increased protection in other high-security locations such as embassies, computer centers and sensitive research centers. These products are multi-ply laminates with three or more layers of glass bonded together with two or more layers of PVB. Increasing amounts of PVB gives greater performance.

**ArmorProtect™ Plus** prolonged attack-resistant security glazing laminates contain the toughest plastics available, often containing multiple layers for maximum forced-entry resistance. Typically, these products are used in jails and other secure establishments.

ArmorProtect™ Plus includes a family of multi-ply laminates containing one or more core layers of polycarbonate, often called glass-clad polycarbonates. Polycarbonates offer the strongest available clear plastic and have 250 times the impact strength of glass. Both the inner and outer lites of the laminate are glass, to provide

the durability that the polycarbonate alone could not offer. The polycarbonate is laminated to the outer glass lites using an aliphatic urethane inter-layer. Both the polycarbonate and urethane are very clear, haze-free plastics that maintain high light transmission, even with thick laminates having multiple layers of polycarbonate and urethane. High visible light transmittance is essential for observing detainees. Composite materials having several thin layers bonded together give a greater attack resistance than one thick layer. The outer glass surfaces add to the durability of heat and light stable glass-clad polycarbonates. The outer glass lites are usually heat-strengthened to provide increased impact resistance against accidental damage during installation and service. Tempered glass should not be used where it is necessary to retain reasonable vision after the glass has been cracked.

**ArmorProtect™ Max** are all lightweight laminates having multiple layers of polycarbonate containing no glass and offering extreme levels of forced-entry protection. These products also offer ballistic protection, and because there is no glass on either face, there is no spalling.

Sheets of aliphatic urethane are used to bond the layers of polycarbonate permanently together. The external faces of polycarbonate are protected with a mar-resistant hard coating to provide durability; however, they are not recommended for external use.

## ArmorProtect™ Forced-Entry-Resistant Glass

### Capabilities

#### Test Procedures

Several test procedures evaluate glazing performance in the medium and high/maximum-security institutional setting. Each one specifies the specimen size and condition, the opening size that constitutes failure, the weapons used and the number of impacts and sequence of attacks using those specified weapons. This section provides only a summary of the various test methods. It is essential that the design professional has a full understanding of the complete test document.

ASTM F1233 *Standard Test Method for Security Glazing Materials and Systems* (see Table 1).

The H.P. White Laboratories HPW-TP-0500 procedure (replacing the outdated HPW-TP-0100 and 0100.01) *Transparent Materials for Use in Forced-Entry or Containment Barriers* (see Table 2).

The Walker-McGough-Foltz & Lyerla (WMFL) thirty- and sixty-minute “Ballistics and Forced-Entry Test Procedure” (see Table 3).

Oldcastle Glass® manufactures a comprehensive range of laminated products for Forced-Entry Resistance (see Table 4).

**Table 1: ASTM F1233 Main-Force/Forced-Entry Test Sequences**

Test Sequences for Each Class of Security Glazing					
Test Implement (Assault)	Class I	Class II	Class III	Class IV	Class V
<b>Blunt Impact</b> (Impacts)					
Sledgehammer (25)	NR <sup>(1)</sup>	5	10,16	19,22,27	30,33,36,39
4" pipe/sledge (25)	NR	NR	9	18	29
Ram (10)	NR	NR	8	17	28
Ball peen hammer (10)	1	2	NR	NR	NR
<b>Sharp Tools</b> (Impacts)					
Ripping bar (10)	NR	7	12	23	NR
Chisel/hammer (25)	NR	NR	13	25	35,40
Angle iron/sledge (25)	NR	NR	15	NR	NR
1.5" pipe sledge (25)	NR	3	NR	NR	NR
Fire axe (25)	NR	NR	NR	24	32,38
Wood-splitting maul (25)	NR	NR	NR	21	34,41
<b>Thermal Stress</b> (Minutes)					
CO2 extinguisher (1)	NR	4	NR	NR	NR
Propane torch (5)	NR	61	112	202	312
<b>Chemical Deterioration</b> (Amount)					
Gasoline (0.5 pints)	NR	NR	14	NR	NR
Acetone (0.5 pints)	NR	NR	NR	26	37
<b>Total Test Sequences</b>	1	7	16	27	41

(1) NR—Not Required.

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# ArmorProtect™ Forced-Entry-Resistant Glass

## Capabilities (continued)

**Table 2: H.P. White TP-0500 Ballistics and Forced-Entry Test Procedure**

Test Sequences for Each Class of Security Glazing					
Phase I-Ballistics-optional	Level A	Level B	Level C	Level D	Level E
<b>Caliber</b>	.38 Special	9 mm	.44 Mag.	7.62 mm, M80	.30-06 AP
<b>Shots</b>	3	3	3	3	3
After the sample has successfully resisted one of the optional ballistic threats of the Phase I test, follow numerical sequence (1-54) below.					
Phase II-Forced-Entry	Level I	Level II	Level III	Level IV	Level V
<b>Blunt Impacting</b> (Impacts)					
Sledgehammer/wedge(25)	1,4	8,10	18,24,26	29,32,39	42,45,48,51,54
4" dia. pipe/sledge (25)	2	7	17	28	41
Ram (10)	NA <sup>(3)</sup>	6	16	27	40
Pinch bar <sup>(1)</sup>					
<b>Sharp Tool</b> (Impacts)					
Chisel/hammer(25)	v	12	21,23	33,36,38	47,52
Angle iron/sledge(25)	NA	13	22	NA	NA
1-1/2" dia. pipe/sledge(25)	5	NA	NA	NA	NA
Fire axe(25)	NA	NA	NA	35	44,50
Wood maul(25)	NA	15	20	31	46,53
Keyhole saw <sup>(2)</sup>					
Hacksaw <sup>(2)</sup>					
<b>Thermal Stress</b> (Minutes)					
Extinguisher, CO <sub>2</sub> (1)	3	9	NA	NA	NA
Propane burner(5)	NA	11	19	30	v
Acetylene(5)	NA	NA	NA	NA	43
<b>Chemical Deterioration</b> (Amount)					
Gasoline (1/2 pint)	NA	14	NA	NA	NA
Windshield washer (1/2 pint)	NA	NA	25	34	NA
Acetone (1/2 pint)	NA	NA	NA	NA	49
<b>Total Forced-Entry Sequences</b>	<b>5</b>	<b>15</b>	<b>26</b>	<b>39</b>	<b>54</b>

(1) Pinch or ripping bars may be substituted for any portion of the blunt impacting sequence at the rate of 1 minute for each 5 impacts (test director's option).

(2) Additional sequences of one-minute intervals in conjunction with all sharp tool sequences except sequences 5 and 15 (see paragraphs 3.5.7 and 3.5.8).

(3) **NA**– Not Applicable.

The numbers in this chart indicate the sequence number. For example, to successfully pass Level 1, a glazing must resist 25 impacts from a sledgehammer, followed by 25 impacts from a 4"-diameter pipe, followed by 1 minute of a CO<sub>2</sub> extinguisher, followed by a further 25 impacts from a sledgehammer, followed by 25 impacts from a 1-1/2" pipe—a total of 5 sequences. To successfully pass Level II, the glazing must resist all those sequences of Level 1, followed by all the sequences of Level II detailed in the table—a total of 15 sequences.

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## ArmorProtect™ Forced-Entry Resistant Glass

### Capabilities (continued)

**Table 3: WMFL Ballistics and Forced-Entry Test Procedure**

Attack Tools & Sequence of Use	Ballistics and 60-Minute Physical Attack	60-Minute Physical Attack	30-Minute Physical Attack
<b>.44 magnum 240 grain soft point</b>	25 rounds	NA <sup>(1)</sup>	NA
<b>Nominal 2 lb. claw hammer, claw end</b>	5 minutes	5 minutes	5 minutes
<b>Cold steel chisel or screwdriver</b> hitting end with nominal 2 lb. hammer	5 minutes	5 minutes	5 minutes
<b>Nominal 10 lb. sledgehammer</b>	5 minutes	5 minutes	5 minutes
<b>1-1/2"-diameter steel pipe, 3 ft. long,</b> or 2" x 2" x 1/4" steel angle, 3 ft. long	5 minutes	5 minutes	NA
<b>Grade 60, No. 8 rebar, 3 ft. long</b>	5 minutes	5 minutes	NA
<b>4" x 4" oak post, 3 ft. long</b>	5 minutes	5 minutes	NA
<b>Dry chemical fire extinguisher</b>	5 minutes	5 minutes	5 minutes
<b>Nominal 10 lb. sledgehammer</b>	5 minutes	5 minutes	NA
<b>Clothes hanger or knife</b> with 10" long x 1/4" thick cold steel blade, heated during use	5 minutes	5 minutes	NA
<b>Propane burner</b> with nozzle sized to create approximately a 1"-diameter heat source (applied within 4" or less of glass surface)	5 minutes	5 minutes	5 minutes
<b>Nominal 4 lb. hammer</b>	5 minutes	5 minutes	5 minutes
<b>3"-diameter steel pipe, 3 ft. long</b> or 1" x 1" x 1/4" steel angle, 3 ft. long	5 minutes	5 minutes	NA

(1) **NA**—Not Applicable.

Where more than one weapon is specified in a given 5-minute time period, each weapon was used for approximately equal portions of the time. Spall is not measured in the ballistic test of WMFL.

### Inspection and Installation Guidelines

Tolerances and quality references are detailed in ASTM C1349 *Standard Specification for Architectural Flat Glass-Clad Polycarbonate*. Most laminated glazing designed for security applications has been engineered to provide extreme performance and therefore, contain several layers of glass and plastic lites. Moderate distortion due to the extrusion of the polycarbonate and the heat-treating of the glass lites is unavoidable, especially with thick laminates that provide protection to high test levels. Optical distortion

is usually not obtrusive in service and is not a cause for rejection. Holes, notches, pass-throughs, etc., often show greater distortion around these fabricated areas. (See *Installation Guidelines, pages 42-43 for additional information.*)

### Specifications

For specifications on security laminates, please call 1-866-OLDCASTLE(653-2278) or log on to [www.oldcastleglass.com](http://www.oldcastleglass.com), and click on "Need Assistance with a Project," click on "General Inquiry," and enter your request.

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# ArmorProtect™ Forced-Entry-Resistant Glass

## Capabilities (continued)

**Table 4: Oldcastle Glass® Security Laminates for use in Forced-Entry Applications**

Trade name	Product #	HPW-TP-0500		WMFL	ASTM F1233	UL 752	Nominal Thickness inches	Weight lbs/ft <sup>2</sup>	Max Size inches	Assembly <sup>(1)</sup>
		FE	BR							
ArmorProtect™	111000	–	–	–	1-body passage	–	1/2	5.4	60 x 96	AGL
ArmorProtect™	112000	–	–	–	1	–	3/4	7.2	60 x 96	AGL
ArmorProtect™	113000	–	–	–	1	–	1	9.1	60 x 96	AGL
ArmorProtect™ Plus	121000	1	A <sup>(2)</sup>	–	–	–	7/16	4.6	60 x 96	GCP
ArmorProtect™ Plus	121100	1	A <sup>(2)</sup>	–	–	–	9/16	5.4	60 x 96	GCP
ArmorProtect™ Plus	121200	1	B <sup>(2)</sup>	–	–	–	11/16	6.2	60 x 96	GCP
ArmorProtect™ Plus	122000	2	B <sup>(2)</sup>	3	–	–	13/16	6.4	60 x 96	GCP
ArmorProtect™ Plus	123200	2	B <sup>(2)</sup>	2	–	–	15/16	7.2	60 x 96	GCP
ArmorProtect™ Plus	123000	3	B <sup>(2)</sup>	3	–	–	3/4	6.3	60 x 96	GCP
ArmorProtect™ Plus	123100	3	B <sup>(2)</sup>	2	–	–	7/8	7.1	60 x 96	GCP
ArmorProtect™ Plus	124100	–	–	1 <sup>(2)</sup>	–	–	1-1/4	10.8	60 x 96	GCP
ArmorProtect™ Plus	124200	–	–	1	–	3	1-3/8	11.8	60 x 96	GP
ArmorProtect™ Max	132000	2-step 14	A	–	–	–	3/8	2.5	60 x 96	LPC
ArmorProtect™ Max	133000	3-step 16	A	–	–	–	1/2	3.4	60 x 96	LPC
ArmorProtect™ Max	134000	4-step 38	B	–	–	–	3/4	5.0	60 x 96	LPC
ArmorProtect™ Max	135000	5	B	–	–	2	1	6.6	60 x 96	LPC
ArmorProtect™ Max	135100	5	C	2	–	3	1-1/4	8.2	60 x 96	LPC

### HP White Test Summary

HPW-TP-0500	
Forced-Entry	Ballistics
<b>Level 1:</b> Steps 1-5	<b>Level A:</b> 38 Special
<b>Level 2:</b> Steps 1-15	<b>Level B:</b> 9 mm
<b>Level 3:</b> Steps 1-26	<b>Level C:</b> .44 Magnum
<b>Level 4:</b> Steps 1-39	<b>Level D:</b> 7.62 mm
<b>Level 5:</b> Steps 1-54	<b>Level E:</b> .30-06 AP

### ASTM F1233 Test Summary

Forced-Entry
<b>Class 1:</b> Steps 1
<b>Class 2:</b> Steps 1-7
<b>Class 3:</b> Steps 1-16
<b>Class 4:</b> Steps 1-27
<b>Class 5:</b> Steps 1-41

### WMFL Test Summary

<b>Level 3:</b> 30 Minute
<b>Level 2:</b> 20 Minute
<b>Level 1:</b> 60 Minute and 25 rounds .44 Magnum <sup>(3)</sup>

(1) **GP**—glass-clad polycarbonate with exposed polycarbonate; **GCP**—glass-clad polycarbonate; **LPC**—laminated polycarbonate; **AGL**—all-glass laminate.

(2) These products resisted bullet penetration. They are not designed to resist spalling.

(3) This is not a no-spall ballistics test.



# ArmorResist™: Bullet-Resistant Glass

## Introduction

Laminated glass can be designed to resist attacks by a wide range of weapons. There are many standards and test methods available throughout the world. Almost all of these have two main requirements: (1) the glazing must resist penetration by a specified bullet and (2); the spall or flying shards of glass leaving the rear face, as a result of the impact, must be limited. Bullet-resistant laminated

glass can typically meet both of these requirements. It is important to note that some ArmorResist™ bullet-resistant glazing materials are not classified as forced-entry resistant.

ArmorResist™ laminated glazing products consist of assemblies of several different materials. Figures 1 and 2 show typical compositions.

Figure 1.

ArmorResist™ All-Glass Bullet-Resistant Laminate

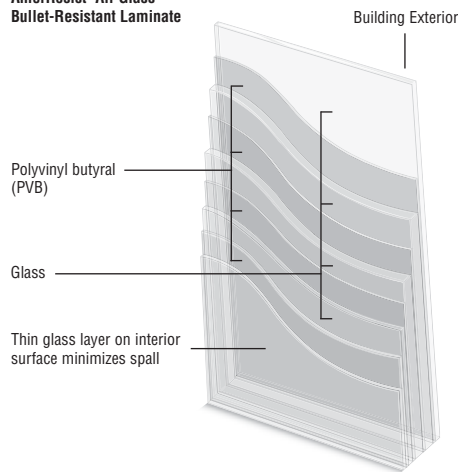
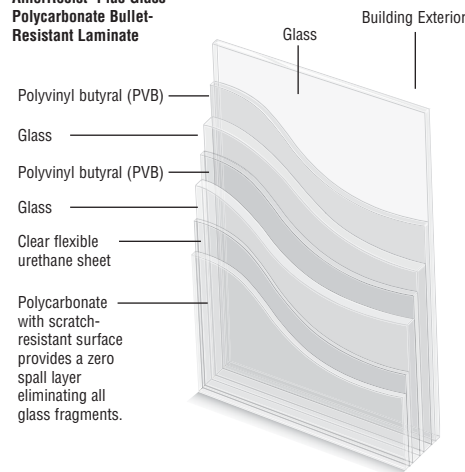


Figure 2.

ArmorResist™ Plus Glass Polycarbonate Bullet-Resistant Laminate



## Description

Oldcastle Glass® manufactures two types of bullet-resistant glass to meet the above requirements.

**ArmorResist™** is a multi-ply laminated glass having multiple layers of glass and PVB bonded together into a monolithic unit. The rear most lite of glass is usually a thin glass that minimizes the spall and therefore allows the glass to meet all the requirements of UL 752. This range of products is the most economical and durable range of bullet-resistant glasses manufactured by Oldcastle Glass®.

**ArmorResist™ Plus** is a combination of glass and polycarbonate. PVB and/or a Thermo Plastic Urethane (TPU) is used as the interlayer in this

product range. Polycarbonate is one of the toughest clear plastics, having 250 times the impact strength of glass and is used toward the rear of the laminate to flex and absorb the energy of the bullet. The rear face is always exposed polycarbonate with a scratch-resistant coating and therefore produces no spalling when impacted. ArmorResist™ Plus is generally thinner and lighter than the corresponding ArmorResist™ product when it is designed to resist the same threat.

(continued on back)

## ArmorResist™: Bullet-Resistant Glass

### Description (continued)

Underwriters Laboratories UL 752 *Bullet Resisting Equipment* is the most well-known standard in the USA. It defines eight levels of attacks ranging from a 9 mm handgun to a 7.62 mm military rifle. This standard defines the type of round, the muzzle

velocity and the number of shots each sample must receive. This standard also details environmental conditioning at high and low temperatures so that this type of glass can be used externally over a wide range of conditions. (See Table 1 below).

**Table 1: UL 752 Ratings of Bullet-Resistant Materials**

Rating	Ammunition	Projectile Weight		Minimum Velocity <sup>(1)</sup>		No. of Shots
		Grain	grams	ft/sec	m/sec	
<b>Level 1</b>	9 mm Full Metal, Copper Jacket with Lead Core	124	8.0	1,175	358	3
<b>Level 2</b>	357 Magnum Jacketed Lead, Soft Point	158	10.2	1,250	381	3
<b>Level 3</b>	.44 Magnum Lead Semi-Wadcutter, Gas Checked	240	15.6	1,350	411	3
<b>Level 4</b>	.30 Caliber Rifle, Lead Core, Soft Point	180	11.7	2,540	774	1
<b>Level 5</b>	7.62 mm Rifle, Lead Core, Full Metal, Copper Jacket, Military Ball	150	9.7	2,750	838	1
<b>Level 6</b>	9 mm Full Metal, Copper Jacket with Lead Core	124	8.0	1,400	427	5
<b>Level 7</b>	5.56 mm Rifle, Full Metal, Copper Jacket with Lead Core	55	3.56	3,080	939	5
<b>Level 8</b>	7.62 mm Rifle, Lead Core, Full Metal, Copper Jacket, Military Ball	150	9.7	2,750	838	5
<b>Supplementary Shotgun</b>	12-Gauge Rifled, Lead Slug, and 12-Gauge 00 Lead Buckshot (12 pellets)	437	28.3	1,585	483	3
		650	42	1,200	366	3

(1) Maximum velocity is 110 % of the minimum velocity.

(continued on next page)



## ArmorResist™: Bullet-Resistant Glass

### Description (continued)

In addition to UL 752, some specifying authorities use the National Institute of Justice standard NIJ

0108.01: *Ballistic-Resistant Protective Materials*. The test variables are detailed in Table 2 below.

**Table 2: NIJ Standard 0108.01: Ballistic Resistance Test Variables and Requirements**

Armor Type	Test Variables			Performance Requirements		
	Test Ammunition <sup>(1)</sup>	Nominal Bullet Mass	Suggested Barrel Length	Required Bullet Velocity	Required Hits Per Armor Specimen	Permitted Penetrations
I	22 LRHV Lead	2.6g 40gr	15 to 16.5cm 6 to 6.5in	320±12m/s 1050±40ft/s	5	0
	.38 Special RN Lead	10.2g 158gr	15 to 16.5cm 6 to 6.5 in	259±15m/s 850±50ft/s	5	0
II-A	.357 Magnum JSP	10.2g 158gr	10 to 12 cm 4 to 4.75 in	381±15m/s 1250±50ft/s	5	0
	9 mm FMJ	8.0g 124gr	10 to 12cm 4 to 4.75in	332±12m/s 1090±40ft/s	5	0
II	.357 Magnum JSP	10.2g 158gr	15 to 16.5cm 6 to 6.5in	425±15m/s 1395±50ft/s	5	0
	9mm FMJ	8.0g 124gr	10 to 12cm 4 to 4.75in	358±12m/s 1175±40ft/s	5	0
III-A	.44 Magnum LeadSWC GasChecked	15.55g 240gr	14 to 16cm 5.5 to 6.25in	426±15m/s 1400±50ft/s	5	0
	9 mm FMJ	8.0g 124gr	24 to 26cm 9.5 to 10.25in	426±15m/s 1400±50ft/s	5	0
III	7.62 mm (308 Winchester) FMJ	9.7g 150gr	56cm 22in	838±15m/s 2750±50ft/s	5	0
IV	.30-06 AP	10.8g 166gr	56cm 22in	868±15m/s 2850±50ft/s	1	0
<b>Special requirement (See Sec. 2.2.7 of standard)</b>	(2)	(2)	(2)	(2)	(2)	0

(1) **AP**—Armor Piercing; **FMJ**—Full Metal Jacketed; **JSP**—Jacketed Soft Point; **LRHV**—Long Rifle High Velocity; **RN**—Round Nose; **SWC**—Semi-Wadcutter.

(2) These items must be specified by the user.

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## ArmorResist™: Bullet-Resistant Glass

### Description (continued)

Table 3: Oldcastle Glass® Security Laminates for Use in Bullet-Resistant Applications

Trade name	Product #	UL 752	NIJ	HPW	Nominal Thickness inches	Weight lbs/ft <sup>2</sup>	Max Size inches	Assembly <sup>(3)</sup>
ArmorResist™	211000	1 <sup>(1)</sup>	–	–	1 3/16	14.7	500 lbs <sup>(2)</sup>	AGL
ArmorResist™	212000	2 <sup>(1)</sup>	–	–	1 1/2	19.3	500 lbs <sup>(2)</sup>	AGL
ArmorResist™	213010	3	–	–	2	25.8	500 lbs <sup>(2)</sup>	AGL
ArmorResist™	214000	4 <sup>(1)</sup>	–	–	2	25.8	500 lbs <sup>(2)</sup>	AGL
ArmorResist™	215000	5 <sup>(1)</sup>	–	–	2	25.8	500 lbs <sup>(2)</sup>	AGL
ArmorResist™	216000	6 <sup>(1)</sup>	–	–	1 13/16	22.6	500 lbs <sup>(2)</sup>	AGL
ArmorResist™	212100	–	2A	–	1 3/16	14.7	500 lbs <sup>(2)</sup>	AGL
ArmorResist™	212200	–	2	–	1 1/2	19.1	500 lbs <sup>(2)</sup>	AGL
ArmorResist™	213100	–	3A	–	1 3/4	22.7	500 lbs <sup>(2)</sup>	AGL
ArmorResist™ Plus	221000	1 <sup>(1)</sup>	–	–	13/16	8.4	60 x 96	GP
ArmorResist™ Plus	222000	2 <sup>(1)</sup>	–	–	1 1/32	11.2	60 x 96	GP
ArmorResist™ Plus	223000	3 <sup>(1)</sup>	–	–	1 7/32	13.5	60 x 96	GP
ArmorResist™ Plus	124200	3	–	–	1 3/8	11.8	60 x 96	GP
ArmorResist™ Plus	224000	4 <sup>(1)</sup>	–	–	1 9/32	13.6	60 x 96	GP
ArmorResist™ Plus	225000	5 <sup>(1)</sup>	–	–	1 9/32	13.6	60 x 96	GP
ArmorResist™ Plus	226010	6 <sup>(1)</sup>	–	–	1 1/16	10.0	60 x 96	GP
ArmorResist™ Plus	227000	7 <sup>(1)</sup>	–	–	2	21.8	60 x 96	GP
ArmorResist™ Plus	228000	8 <sup>(1)</sup>	–	–	2 3/16	25.1	60 x 96	GP
ArmorResist™ Plus	223010	–	3	–	1 11/16	18.5	60 x 96	GP

#### UL 752 Test Summary

Level 1:	9 mm
Level 2:	.357 Magnum
Level 3:	.44 Magnum
Level 4:	.30-06
Level 5:	7.62 mm
Level 6:	9 mm
Level 7:	5.56 mm
Level 8:	7.62 mm

#### HP White Test Summary

HPW-TP-0500	
Level A:	.38 Special
Level B:	9 mm
Level C:	.44 Magnum
Level D:	7.62 mm
Level E:	.30-06 AP

#### National Institute of Justice: NIJ Standard 0108.01

Level 1:	.38 Special
Level 2A:	.357 Magnum/9 mm-LV
Level 2:	.357 Magnum/9 mm-HV
Level 3A:	.44 Magnum/9 mm
Level 3:	7.62 mm
Level 4:	.30-06

- (1) indicates UL certification and permanent UL logo.  
 (2) maximum size is limited by the listed weight.  
 (3) **GP**—glass-clad polycarbonate with exposed polycarbonate; **AGL**—all-glass laminate.



## ArmorResist™: Bullet-Resistant Glass

### Capabilities

Oldcastle Glass® manufactures a wide range of bullet-resistant products. (See Table 3 on previous page.)

Bullet-resistant glazing is not necessarily resistant to a sustained physical attack or forced-entry; however, some glazing is designed to be resistant to both forms of attack. Products which have been designed to resist both forced-entry and ballistic attacks are to be found in the Laminated Glass section under Forced-entry. (See pages 21-25).

### Other Considerations

ArmorResist™ bullet-resistant glass can form part of an insulating glass unit. In this case it is recommended that the bullet-resistant glass be used as the inboard lite of the unit.

### Installation

It is most important that bullet-resistant glass be installed in a framework that is also bullet-resistant. It is up to the installer to verify that the total installation resists the specified threat. ArmorResist™ is usually nonsymmetrical and has a strike face or impact face that faces the threat.

The opposite face is known as the protected or safe side. Oldcastle Glass® applies a removable impact face label, which identifies the threat side. This should be left on until final inspection to ensure that the glass has been installed correctly, as it can be difficult to determine this at a later stage.

Oldcastle Glass® does not recommend butt-glazing ArmorResist™, as the bullet can penetrate the small space between the lites. Any speak-hole covers should also be bullet-resistant.

### Inspection Guidelines

Black specks are an inherent, allowable characteristic of the polycarbonate material used in certain Oldcastle Glass® laminated glass products. Specifications regarding the allowable limits for size are set by industry standards. (See ASTM C1349 for full details). The extrusion process of manufacturing polycarbonate material may produce a minor distortion that is noticeable under certain conditions. Holes, notches, pass-throughs, etc. produce greater distortion around these specially fabricated areas. (See Installation Guidelines, pages 42-43).

### Additional Important Information

#### Design Criteria

Details on the following important topics can be found in the Black Design Criteria Tab: Glazing Instructions, Thermal Stress, Deflection, Glass Design Loads, Glass Thickness Selection, Spontaneous Breakage of Tempered Glass, Roller Wave Distortion in Heat-treated Glass, Mock-ups and Warranties.

#### Specifications

A sample Section 08800 Specification for North America can be found in the Black Specifications Tab. Information specific to two-ply (two lites of glass) laminated glass can be found in Part 2 Products, 2.02 Materials.

For specifications on other laminated glass makeups, call 1-866-OLDCASTLE(653-2278) or log on to [www.oldcastleglass.com](http://www.oldcastleglass.com) and click on


“Need Assistance with a Project,” click on “General Inquiry” and enter your request.

#### Contact Us

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Log on to [www.oldcastleglass.com](http://www.oldcastleglass.com) for project photos, product colors, general inquiries and project assistance.

To view performance data on a wide range of glass makeups, or to build your own product specification, log on to [www.oldcastleglass.com](http://www.oldcastleglass.com) and choose GlasSelect™ 

## Blast-Resistant Glass

### Introduction

In recent years, the bomb has become the weapon of choice for many terrorist attacks. The high-explosive detonation, with its associated property damage, injury, flames and noise, draws immediate attention and instills fear beyond that of armed attacks.

Extensive research has been carried out following terrorist bombing events in New York, Oklahoma, London, Israel, and many other locations. It has

been documented that the blast energy causes collateral damage to many surrounding structures, not just the intended target. Glass fragmentation hazards have been identified as a main cause of injury in the targeted site, as well as the peripheral sites. Because collateral damage often extends several blocks from the site of the bomb, it can affect hundreds, possibly thousands, of people, especially in urban areas.

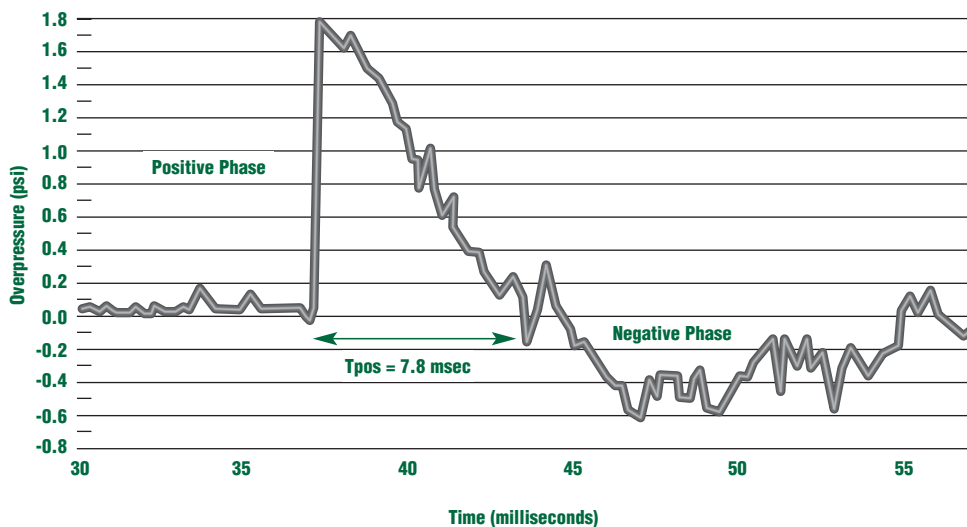
### Description

Laminated glass is an excellent glazing choice in all types of buildings that may be subjected to bomb blasts. The tough plastic interlayer holds the glass together after an impact, and with the proper framing systems, the glazing will be retained in the opening. Thus, the amount of flying glass, as well as the consequential injuries, can be dramatically reduced.

The pressure from a bomb typically consists of a wave that rises almost instantaneously to a very

high peak pressure that falls back to zero in a very short duration, as measured in milliseconds. For example, a 27 lb. bomb detonated from a stand-off distance of 48 ft. produces a peak pressure of 10 psi (1,440 psf) for 3.3 milliseconds. The area under the pressure time graph is called the impulse and is measured in psi-ms. Blast wave energy decreases very rapidly with distance so that the most effective protection is to increase this “stand-off” distance. However, this is not always a viable or economic option.

### Typical Blast Wave—Incident (Side-on) Overpressure



8 lbs of C-4 explosive (TNT equivalent of 10 lbs) detonated 57 feet from target; atmospheric pressure of 12.9 psi.

*(continued on back)*



## Blast-Resistant Glass

### Description (continued)

The General Services Administration (GSA), which is responsible for all US nonmilitary federal buildings, developed an approach for blast resistance. This approach has been included in the Interagency Security Committee (ISC) document that is now being used to evaluate vulnerability and

provide design guidelines for government-owned and leased buildings.

The building type is defined in Table 1, and the protection level is defined in Table 2, taking into account the sensitivity of the area behind the glazing.

**Table 1**

GSA Building Classification	Examples	Max Overpressure	Max Impulse
<b>A</b>	No protection	0	0
<b>B</b>	No protection	0	0
<b>C</b>	Fed courts, fed buildings, etc.	4 psi	28 psi ms
<b>D</b>	High-level military, e.g., Pentagon	10 psi	89 psi ms
<b>E</b>	White House	Classified	Classified

**Table 2**

Hazard 1	Hazard 2	Hazard 3	Hazard 3B	Hazard 4	Hazard 5
No glass breakage	Minimal spall	Spall up to 3ft (1m)	Spall up to 10ft (3m)	Hits back wall up to 2ft high	Hits back wall ≥ 2ft high

Hazard 1 allows no breakage at all. This is required in locations where complete vision must be maintained after the event and where personnel would be situated immediately behind the glazing. Control points and lookout positions would fall into this category. Hazards 2-3 and 3B allow increasing amounts of limited spalling, very small chips of glass, so the immediate injuries would be minor. The glazing in these locations would remain in the frame, providing protection from additional outside debris or the weather. Hazards 4 and 5 occur when larger amounts of glass, or other debris, fly off with considerable energy and can cause serious injury to the occupants of the building. The glazing would not always be retained in the frame. Hazards 4 and 5 would only be specified for very low occupancy buildings and/or storage areas.

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

details a test method for this type of glazing. The newest version of this standard has six hazard criteria similar to the GSA recommendations. However, the detailed definitions vary slightly. The frame is an integral part of the blast mitigation glazing system. The blast pressure applies a load to the glass and will be transmitted to the frame through the fasteners, and on to the structure of the building. If the glazing is made very stiff, this entire load will be transmitted to the building, which can damage the structural integrity of the building. In the case where the glazing is very thick and stiff the structure of the building has to be significantly modified and strengthened to accept this additional load.

Oldcastle-Arpal offers *Blast-Tec*™ blast mitigation, energy-absorbing aluminum framing systems which, together with the laminated glass, absorb much of the blast pressure, allowing only a minimal transfer of energy to the surrounding walls. Thus,

*(continued on next page)*



## Blast-Resistant Glass

### Description (continued)

the *Blast-Tec*™ glazing systems offer design alternatives that result in a cost-effective way to resist a bomb blast without having to reinforce the structure of the building. The *Blast-Tec*™ series includes curtain wall systems, fixed and operable windows, internal blast shields for

historical preservation and doors for all levels of blast threats.

*For full details, please see the Green Blast Mitigation Oldcastle-Arpal, LLC. Tab or log on to [www.oldcastlearpal.com](http://www.oldcastlearpal.com).*

### Capabilities

The following constructions of laminated glass are most commonly specified for bomb-blast resistance. As with all laminated glazing, the glass can be supplied as tinted or reflective for light and solar control purposes. The lites of glass can be either annealed or heat-strengthened. Oldcastle Glass® does not recommend tempered laminated glass in this type of application. When insulating glass units

are required for thermal performance, Oldcastle Glass® recommends that both lites of the IG unit be laminated in order to provide maximum protection for those both inside and outside the building. If only one lite in the IG unit is to be laminated, it must be the interior lite so as to protect the occupants of the building.

Product #	Construction	Thickness		Weight	
		inches	mm	lbs/ft <sup>2</sup>	kg/m <sup>2</sup>
<b>110100</b>	1/8-0.060-1/8	5/16	8	3.58	17.5
<b>110110</b>	3/16-0.060-3/16	7/16	11	5.21	25.4
<b>110120</b>	1/4-0.060-1/4	9/16	14	6.83	33.3

### Additional Important Information

#### Design Criteria

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