Blast-Resistant Glass

Introduction

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.

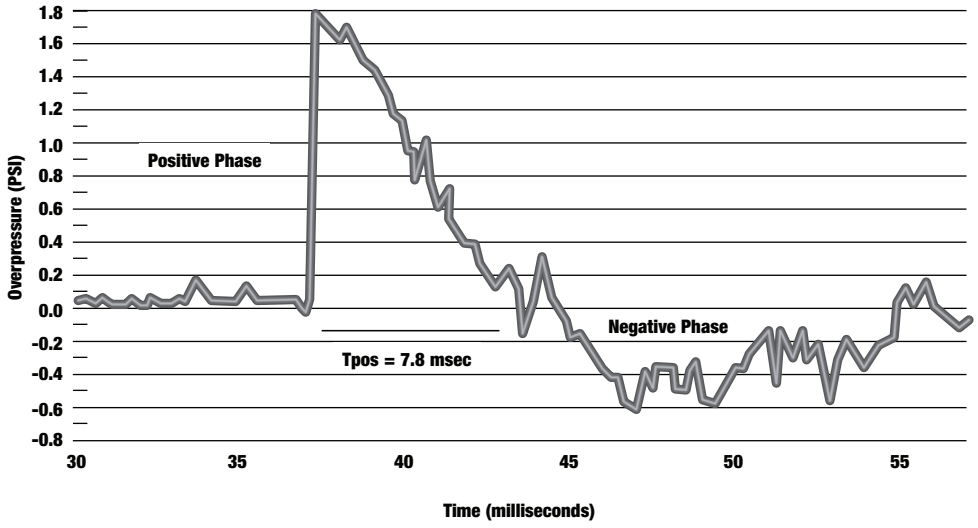
Because collateral damage often extends several blocks from the site of the bomb, it can affect hundreds, possibly thousands, of people, especially in urban areas.

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.

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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 by the Interagency Security Committee (ISC) in their *ISC Security Design Criteria* 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

ISC Building Classification	Examples	Max Overpressure	Max Impulse
A	No protection	0	0
B	No protection	0	0
C	Fed courts, fed buildings, etc.	4 PSI	28 PSI ms
D	High-level military, e.g., Pentagon	10 PSI	89 PSI ms
E	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.

The Department of Defense (DoD) has produced UFC 4-010-01 *DoD Minimum Antiterrorism Standards for buildings.* Section B-3.1 deals with Windows, Skylights and glazed doors and two critical sub-sections are included here.

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Description (continued)

B.3.1.2 Glazing. *Use a minimum of 6-mm (1/4-in) nominal laminated glass for all exterior windows, skylights and glazed doors. The 6-mm (1/4-in) laminated glass consists of two nominal 3-mm (1/8-in) glass panes bonded together with a minimum of a 0.75mm (0.030-in) polyvinyl-butyral (PVB) interlayer. For insulating glass units, use 6-mm (1/4-in) laminated glass inner pane as a minimum.*

B-3.1.2.2 Glazing Frame Bite. *The glazing shall have a minimum frame bite of 9.5-mm (3/8-in) for structurally glazed systems and 25-mm (1-in) for window systems that are not structurally glazed.*

Other subsections in Section B-3.1 give further guidance on installation and anchoring.

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 BuildingEnvelope™ does not recommend tempered laminated glass in this type of application. When insulating glass units are required for thermal performance, Oldcastle BuildingEnvelope™ 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	
	Glass-PVB-Glass: inches	inches	mm	LBS/FT²	kg/m²
110100	1/8–0.060–1/8	5/16	8	3.58	17.5
110110	3/16–0.060–3/16	7/16	11	5.21	25.4
110120	1/4–0.060–1/4	9/16	14	6.83	33.3

Additional Important Information

Specifications

A sample Section 08 81 00 Specification for North America can be found in Section 11M of this binder titled: Sample Architectural Glass Specifications.

For specifications on other laminated glass make-ups, call 1-866-OLDCASTLE (653-2278) or log on to www.oldcastlebe.com and click on “Project Assistance” and enter your request.

Contact Us

For any additional information, including details, technical data, specifications, technical assistance and samples, call 1-866-OLDCASTLE (653-2278).

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