Kuraray Glass Laminating Solutions

Technical Bulletin
BLAST PERFORMANCE OF LAMINATED GLASS

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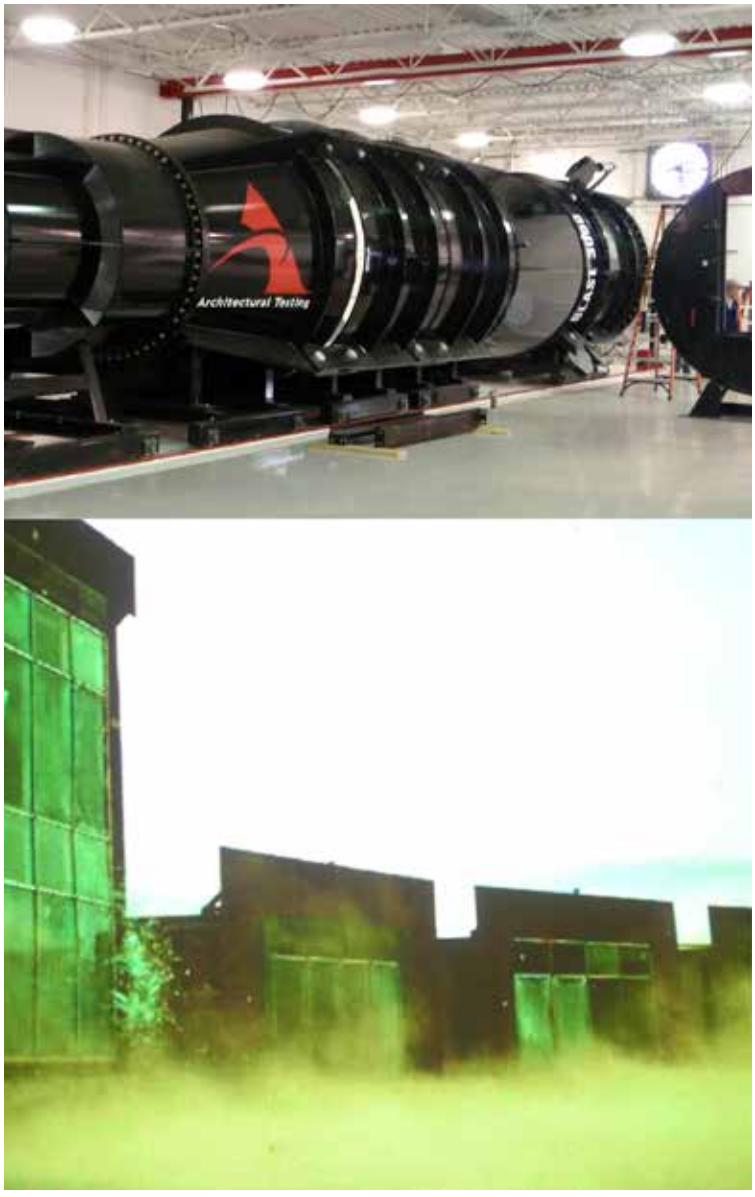
In blast-resistant glazing materials and systems, laminated glass can be used to reduce the hazards associated with an explosion. Laminates made with Butacite® PVB or SentryGlas® ionoplast interlayers are typically used in window, door, curtain wall, and storefront systems designed to provide a higher level of performance than standard systems.

Shock tube and arena test results support the use of both PVB and ionoplast interlayers in blast-resistant glazing.

This bulletin summarizes blast resistance test results for glazing systems made with PVB and SentryGlas® ionoplast interlayers.



A shock tube (top right) focuses a blast-level pressure wave against a mounted glass sample. Outdoor arena testing (right) exposes full-scale facade glazing to an actual explosion

Shock Tube Testing

Laminated glass panels made with Butacite® PVB and SentryGlas® ionoplast interlayers were tested in a shock tube at ATI Laboratories in York, Pennsylvania. A peak pressure of 41 kPa (6 psi) and impulse of 282 kPa-msec (41 psi-msec) were chosen to represent performance levels found in the Unified Facilities Design Criteria (UFC) of the U.S. Department of Defense. The test specimens were 126 cm (49.72 inches) x 172 cm (67.75 inches), wet-glazed in a wooden frame.

Blast testing was conducted according to ASTM F1642 Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings. This standard enables the user to determine a hazard rating for the glazing or system utilizing either a shock tube or arena test. ASTM Hazard Ratings are expressed differently than those of the U.S. General Services Administration (GSA). GSA Condition 3a equates to the Very Low Hazard level defined in ASTM F1642 where the glass cracks, and fragments land on the floor no further than 1 meter. GSA Condition 2 equates to ASTM F1642 No Hazard, where glass cracks but is retained in the frame. The results of the test program are presented in Table 1.

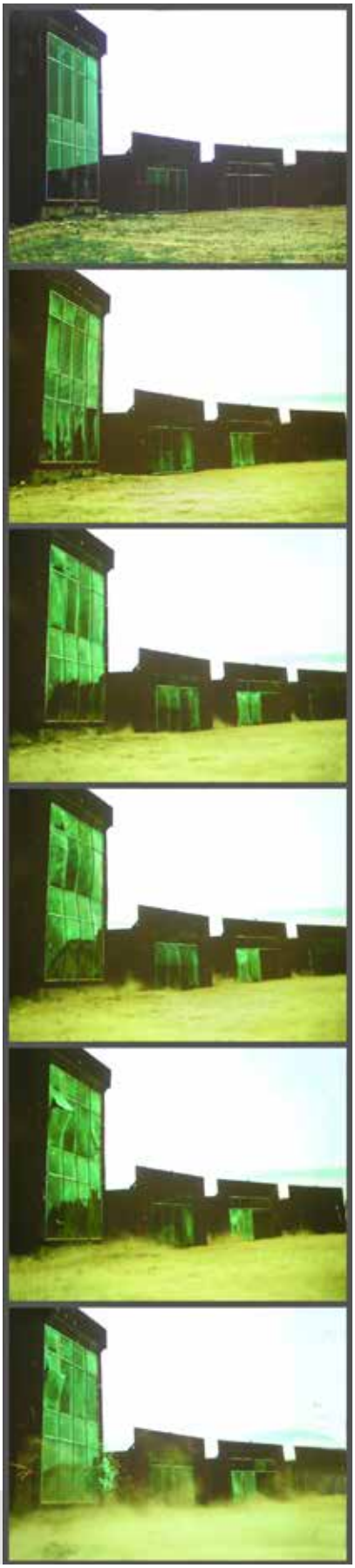
In addition, WINdow Glazing Analysis Response and Design (Wingard) software was used to compare the actual shock tube results to those predicted by the software. The study confirmed a high level of correlation between the two. All three versions of the Wingard software (Wingard LE, PE, and MP) contain PVB and SentryGlas® ionoplast interlayer properties data.

Table 1. Summary of results from ATI shock tube testing.
Blast level: 41 kPa (6 psi) 282 kPa-msec (41 psi-msec)

Glass	Interlayer Thickness mm (mil)	Interlayer Type	Hazard Rating	GSA Performance Condition
3 mm – 3 mm ⅛" – ⅛"	0.76 (30)	Butacite® PVB	Very low hazard	3a
3mm – 3mm ⅛" – ⅛"	1.52 (60)	Butacite® PVB	None	2
3 mm – 3 mm ⅛" – ⅛"	0.96 (35)	SentryGlas® ionoplast	None	2
6 mm – 6 mm ¼" – ¼"	0.76 (30)	Butacite® PVB	None	2
6 mm – 6mm ¼" – ¼"	1.52 (60)	Butacite® PVB	None	2
6 mm – 6 mm ¼" – ¼"	0.96 (35)	SentryGlas® ionoplast	None	2

Arena Testing

The overall performance of a selection of glazing systems was evaluated in arena tests conducted by HTL Laboratories in Lubbock, TX, according to ASTM F1642 Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings. Results of the arena test program are shown in Table 2. Note that these systems also are designed to perform to various hurricane test protocols required for construction in certain regions of the United States.



In an arena test (right), fully installed glazing systems are exposed to an actual explosive blast, under controlled conditions at a high-security open-air test site.

Table 2. Summary of results from arena testing of several commercial glazing systems incorporating various constructions of laminated glass using a SentryGlas® ionoplast interlayer.
Blast level: 41 kPa (6 psi) 282 kPa-msec (41 psi-msec)

Manufacturer	System Tested	Glass Construction	SentryGlas Thickness, mm (mil)	UFC 4-010-01 Level of Protection	ASTM Hazard Rating	GSA Performance Condition
AlumiGlass, Inc.	6400 Curtain wall	IGU	2.28 (90)	Medium	No Hazard	2
Coral Industries	FL550 Storefront	IGU	1.52 (60)	Medium	Minimal	2
	Series 381 Entrance	Monolithic Laminate	1.52 (60)	Medium	Minimal	2
Crawford Tracey Corp.	ProTech 7SG Storefront	IGU	0.96 (35)	Medium	Minimal	2 &3b
		IGU	2.28 (90)	Medium	Minimal	3b
	ProTech 45S G Storefront	IGU	0.96 (35)	Medium	Minimal	2
		IGU	2.28 (90)	Medium	Minimal	2
EFCO Corp.	5600 Series Curtain wall	IGU	2.28 (90)	Medium	Minimal	2
	D500 Entrance	IGU	0.96 (35)	Medium	Minimal	2
	Concealed Vent			Medium	Minimal	2
ES Windows	ES-7525 Curtain Wall	IGU	2.28 (90)	Medium	Minimal	2
	ES-7530 Unitized Curtain Wall	IGU	2.28 (90)	Medium	Minimal	2
	ES-9000 Entrance	IGU	2.28 (90)	Medium	Minimal	2
PGT Industries	PW-3020	Monolithic Laminate	2.28 (90)	High	No Break	1
West Tampa Glass	WTG-500 Curtain Wall	Monolithic Laminate	0.96 (35)	Medium	Minimal	2
		Monolithic Laminate	2.28 (90)	Medium	Minimal	2
		IGU	0.96 (35)	Medium	Minimal	2
		IGU	2.28 (90)	Medium	Minimal	2
	WTG-700 Curtain Wall	Monolithic Laminate	0.96 (35)	Low	Low	3b
		Monolithic Laminate	0.96 (35)	Medium	Minimal	2
		Monolithic Laminate	4.56 (180)	Medium	No Hazard	2
		IGU	0.96 (35)	Medium	No Hazard	2
		IGU	2.28 (90)	Medium	No Hazard	2
		IGU	2.28 (90)	Medium	No Hazard	2
		IGU	4.56 (180)	Medium	Minimal	2
		IGU	4.56 (180)	Medium	No Hazard	2
	WTG-900 Curtain Wall	Monolithic Laminate	0.96 (35)	High	No Break	1
		Monolithic Laminate	2.28 (90)	High	No Break	1
		IGU	0.96 (35)	High	No Break	1
		IGU	2.28 (90)	High	No Break	1
YKK	Results Upcoming					
Tubelite	Forcefront Blast Curtain Wall	IGU	1.52 (60)	Low	Very Low	3A
			0.96 (35)	Low	Very Low	3A
	Forcefront Blast Entrance	IGU	1.52 (60)	Medium	Minimal	2
			0.96 (35)	Medium	Minimalw	2

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A laminated glass panel is inspected after shock tube blast testing (above), to assess glass fragmentation.

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