

Security Glazing

kuraray

Trosifol®

SentryGlas®

Introduction

Interlayer strength, depth and capabilities

Delivering your window into the world of advanced interlayers for laminated safety glass, Kuraray's Advanced Interlayer Solutions Division is underpinned by decades of innovation, application knowledge, domain experience and market success.

OUR ADVANCED INTERLAYER PORTFOLIO – comprising Trosifol® PVB Division and SentryGlas® ionoplast interlayers – has continually revolutionized aesthetic, structural and functional design, fabrication and installation in the architectural and automotive/ transportation segments.

Designed to benefit consumers, society and industry, our products are advancing the functionality of glass, while our engineers and consultants are setting new application benchmarks by collaborating on solutions that both sustain and inspire.

We are committed to helping you transform your mindset and take your applications to the next level – aesthetically, functionally and structurally. Enjoy greater design freedom and give your glazing strength, clarity, character and purpose with solutions that cover safety, security, sound insulation, UV/solar/energy management, color and print.

OUR DIVERSE PRODUCT RANGE, the broadest on the global market and our domain expertise create strength; and we channel this strength into helping you succeed. We strive to be your strongest ally and supporter and will help you navigate and conquer the ever-changing demands of the global glass industry. Worldwide production, R&D and support, means we are always by your side... no matter where you are.





➤ San Francisco Police Department, USA

Photo: © Tim Griffith/HOK + Mark Cavagnero Associates

More protection in aesthetic glass design

Architects are incorporating more glass in buildings for better aesthetics, improved daylighting, and occupancy comfort. Despite these benefits, glass is also the most vulnerable component of the building envelope when it comes to attacks by intruders. The use of laminated glass not only offers improved safety, but also can help to prevent intrusion. Laminated glass can be designed for enhanced performance beyond basic safety to provide burglary and forced entry resistance, as well as bullet resistance.

Kuraray offers a range of products to meet various security glazing requirements. Laminates made using Trosifol® PVB, Trosifol® Spallshield® CPET or SentryGlas® ionoplast interlayer provide superior durability when compared to glass clad polycarbonate solutions.



SentryGlas®

SENTRYGLAS®

- SentryGlas® is 100 times stiffer and 5 times more tear resistant than PVB
- Excellent tear resistance-improved resistance from physical attack
- Lowest yellowness index of all interlayers. Ideal for use with low iron glass and/or thick laminates
- Provides highest level of security glazing performance

SENTRYGLAS® XTRA™ (SGX™)

- Next generation SentryGlas®
- Improvements over SentryGlas®
 - Improved optics over SentryGlas® in thick constructions making it an ideal choice in higher security protection constructions
 - Ideal for multi-ply laminates as no adhesion promoter required



Photo: © Joaquin Corbalan P/shutterstock.com



Photo: © Mr. Music/shutterstock.com

Trosifol®

TROSIFOL® CLEAR

- Meets global safety standards for safety glass
- Works very well to delay entry into building by attacker vs standard monolithic glass

TROSIFOL® SPALLSHIELD® CPET

- Composite of polyester and durable hard coat that provides spall protection to occupants
- Spall is a term used to describe the action of glass splintering and flying inward after the glazing is struck by object or bullet
- Increases penetration resistance
- Commonly used in bullet resistant and high level bomb blast glazing

TROSIFOL® ULTRACLEAR

- Ideal for use with low iron glass and/or thick laminates
- Lowest Yellowness Index of any PVB
- YID 0.76 mm < 0.4
- YID 7.6 mm < 4 vs traditional clear < 10.0



Types of security glazing

Laminated glass can be designed to meet the requirements from basic safety to various types of intrusion. Security glazing is designed to deter intruders by making it difficult to gain entry through the glazing and delaying the time required to penetrate the glass. This delay gives law enforcement more time to respond, and may discourage the attacker from continuing the assault on the glass.

Types of laminated glass

	Safety	Enhanced	Forced entry
Entry delay time	<1 min	< 3 min	> 3 min
Threat to glazing	Accidental human impact Minimum requirement for lobby, entry, first floor windows and doors	Burglary/smash and grab	Very high risk areas, schools
Test method	ANSI Z97.1 EN12600 ASTM F3006	UL 972 ASTM E2395 ASTM F3561 Level 1-3 EN 356 level 1-5	ASTM F1233 ASTM F3561 Level 4-6 HPW-TP-0500.03 EN356 level 6-8
Typical construction*	Glass 0.89 mm (35 mil) SentryGlas® Glass	Glass 2.28 mm (90 mil) SentryGlas® Glass	Glass 4.56 mm (180 mil) SentryGlas® Glass



TAB 1 • * These represent the minimum laminated glass construction required to meet the lowest level requirements of the standard. Adding double laminate IGU will further increase delay time to greater than 2 times the current amount of time. Depending on security level, may need to increase thickness of interlayer or add multiple plies of glass. For very high threat levels should consider a double laminate IGU.



Enhanced forced entry

> 6 min

Very high risk areas, schools

ASTM F1233
 ASTM F3561 Level 7-8
 HPW-TP-0500.03
 5-aa1

Glass
 6.84 mm (270 mil) SentryGlas®
 Glass



Ballistics protection

> 11 min

Ballistics protection

UL 752
 EN 1063
 NIJ 0108.01

Glass
 1.52 mm (60 mil) SentryGlas®
 Glass
 1.52 mm (60 mil) SentryGlas®
 Glass
 1.52 mm (60 mil) SentryGlas®
 Glass
 0.76 mm (30 mil) Trosifol® Clear/0.18 mm
 (7 mil) Trosifol® Spallshield® CPET



Multi-ply – Number of plies increases with threat level. Includes a layer of Trosifol® Spallshield® CPET on the occupant side to prevent spall of glass.



Basic safety glazing

The table shows the constructions that meet global safety glazing codes.

Global safety glazing codes

Safety standards	CPSC 16 CFR 1201		ANSI Z97.1		CAN/CGSB 12.1 M90		EN12600		EN356	
	Category I	Category II	Class B	Class A	Class B	Class A	1B1	2B2	P2A	P1A
3 mm (1/8") AN – 0.38 mm (15 mil) Trosifol® Clear – 1/8" (3 mm) AN	✓		✓		✓					
3 mm (1/8") AN – 0.76 mm (30 mil) Trosifol® Clear – 1/8" (3 mm) AN	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3 mm (1/8") AN – 0.76 mm (30 mil) SentryGlas® – 1/8" (3 mm) AN	✓		✓		✓			✓		
3 mm (1/8") AN – 0.89 mm (35 mil) SentryGlas® – 1/8" (3 mm) AN	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3 mm (1/8") AN – 0.89 mm (35 mil) SentryGlas® Xtra™ – 1/8" (3 mm) AN	✓	✓	✓	✓	✓	✓	✓	✓		
3 mm (1/8") AN – 0.76 mm (30 mil) SentryGlas® Xtra™ – 1/8" (3 mm) AN							✓	✓		✓

TAB 2 •



Forced entry

There are two categories of forced entry:

FORCED ENTRY

- ASTM F1233 Standard Test Method for Security Glazing Materials and Systems
- EN356 Glass in Building-Security Glazing-Testing and Classification of Resistance against Manual Attack
- UL972 UL Standard for Safety Burglary Resisting Glazing Material

UL 972 STANDARD FOR BURGLARY RESISTING MATERIAL

Underwriters Laboratories (UL) testing was conducted for multiple impacts and high impact energy at 21–27°C. (70–80°F.). Glazing that meet these requirements are typically used to deter smash and grab type threats seen in store fronts and display cases.

UNDERWRITERS LABORATORIES (UL) TESTING

- Multiple impacts required
- Five impacts of a 8.3 cm (3-1/4 inches) 2.27 kg (5 lb.) steel ball from a vertical height of 3 meters (10 feet)
- The High Energy Impact Test required one impact from a vertical height of 12 meters (40 feet).
- Pass criteria – no penetration of the glass

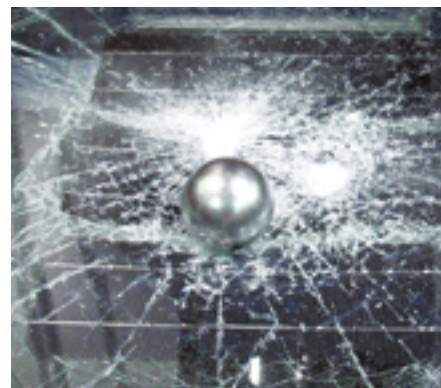
Minimum constructions to pass

Construction	Multiple impact penetrations	High energy impacts penetration
3 mm (1/8") annealed/1.52 mm (60 mil) SentryGlas®/3 mm (1/8") annealed	0	0
3 mm (1/8") annealed/1.52 mm (60 mil) Trosifol® Clear/3 mm (1/8") annealed	0	0

TAB 3 •

ENHANCED FORCED ENTRY

- Forced entry testing performed after weakening glass with ballistic assault. Bullets are allowed to penetrate the glazing.
- ASTM F1233 Standard Test Method for Security Glazing Materials and Systems – Multiple Ammunition Choices
- ASTM F3561 Standard Test Method for Forced-Entry-Resistance of Fenestration Systems After Simulated Active Shooter Attack
- 5-aa1 Certification Standards for Retrofitting and Reinforcing of Standard Commercial Entry Systems, Windows and Glazing (not a recognized standard)



• Ball drop test

Forced entry and enhanced forced entry results

ASTM F1233

Sequence	Test implements	Impacts	Minutes	Class achieved
1	Ball pen hammer	10		1.0
2	Ball pen hammer	10		1.1
3	1-1/2" diameter pipe	25		1.2
4	Extinguisher, CO ₂		1	1.3
5	Sledge hammer	25		1.4
6	Propane torch flame		5	1.5
7	Ripping bar	10		2.0
8	Ram	10		2.1
9	4" diameter pipe/sledge	25		2.2
10	Sledge hammer	25		2.3
11	Propane torch flame		5	2.4



• ASTM F1233 Torch test

ASTM F1233 INCLUDES THE FOLLOWING TYPES OF ATTACKS

- Blunt impacts
- Sharp tools
- Thermal stress
- Chemical deterioration

TAB 4 • First 11 of 41 sequences

Pass criteria

- Contraband - No opening that allows the passage of an 3 mm (1/8") diameter rod
- Body - No opening that allows the passage of an 20 cm x 20 cm x 12 cm (8" x 8" x 5") block

ASTM F1233 results (ballistics – 3 shots from 9 mm)

Interlayer product	Ballistics	Thickness		Class achieved													
		[mm]	[mil]	1.0	1.1	1.2	1.3	1.4	1.5	2.0	2.1	2.2	2.3	2.4			
Trosifol® Clear	w/o	1.52	60	█													
	w/o	2.28	90	█	█												
	w & w/o	4.56	180	█	█	█	█	█									
	w & w/o	6.84	270	█	█	█	█	█									
SentryGlas® ionoplast	w/o	1.52	60	█													
	w/o	2.28	90	█	█												
	w & w/o	4.56	180	█	█	█	█	█									
	w/o	6.84	270	█	█	█	█	█	█	█	█	█	█	█	█	█	█
	w/	6.84	270	█	█	█	█	█									

TAB 5 • w/o = without ballistic assault / w = with ballistic assault - bullet allowed to penetrate
Laminated glass only testing with 2 x 3 mm (2 x 1/8") annealed glass

5-aa1

- Ballistics with 7.62 mm NATO projectile followed by a series of attacks
- Pass criteria
 - No opening that allows passage of a 4" (10 cm) diameter ball without touching glazing

5-aa1

Sequence	Test implements	Impacts	Minutes	Time to pass [min]
1	Shot 7.62 mm round	5		
2	Bricks	20		
3	Kicks with steel toe	10		
4	Tools set #1*		2	2
5	Tools set #2**		3-1/2	5.5
6	Sledge hammer		6	11.5

TAB 6 • * Tools set #1: wrench, small 2 x 4 wood, claw hammer
 ** Tools set #2: 3 lb hammer, aluminum baseball bat

Ballistics allowed to penetrate the glazing.



5-aa1 Sledge hammer test – Sentry Glas®

5-aa1 Test results

Interlayer product	Thickness		Ballistic impact	Concentrated assault		Forced entry			Forced entry protocol time***	Notes
	[mm]	[mil]		5 shots 7.62 mm	20 Bricks	10 Kicks	Tools 2 min*	Tools 3-1/2 min**		
Trosifol® Clear	1.52	60	████████	████████					N/A	
	2.28	90	████████	████████	████████				N/A	
	4.56	180	████████	████████	████████	████████	████████		5 min 30 sec	
	6.84	270	████████	████████	████████	████████	████████	████████	11 min 30 sec	Small openings
SentryGlas® ionoplast	1.52	60	████████	████████	████████				N/A	
	2.28	90	████████	████████	████████	████████			2 min	
	4.56	180	████████	████████	████████	████████	████████	████████	11 min 30 sec	Small openings
	6.84	270	████████	████████	████████	████████	████████	████████	11 min 30 sec	No openings

TAB 7 • * 2 min tools - a small 5 x 10 cm (2 x 4"), claw hammer and wrench
 ** 3-1/2 min tools - 1.36 kg (3 lb.) hammer and aluminum baseball bat
 *** Total test time is 11 min 30 seconds

Laminated glass only testing with 2 x 3 mm (2 x 1/8") annealed glass.

Ballistics allowed to penetrate the glazing.



ENHANCED FORCED ENTRY – ASTM F3561

Simulates an active shooter forced entry situation where the glass is pre-weakened with shots from a 5.56 mm round followed by progressive impacts from a cylindrical impactor.

- Shot 10 x with AR-15 5.56 NATO FMJ
- The bullets are allowed to penetrate the laminate.
- Steel 152 mm (6") diameter impactor weighing 45 kg (100 lb) with a polymer nose cone
- 8 levels based on drop height
- 2 impacts per level
- Progressive impacts



Enhanced Forced Entry – ASTM F3561

Level	Potential energy, J		Drop Height, H	
	[J]	[ft*lb]	[mm]	[ft]
1	68	50	152	0.50
2	136	100	305	1.00
3	203	150	457	1.50
4	271	200	610	2.00
5	339	250	762	2.50
6	407	300	914	3.00
7	475	350	1067	3.50
8	542	400	1219	4.00

TAB 8 •

Enhanced Forced Entry – ASTM F3561 – Test results

Interlayer	Thickness		5.56 M193 (10 shots)	Class achieved								
	[mm]	[in]		1	2	3	4	5	6	7	8	
Trosifol® PVB	1.52	0.060	Penetrated	■	■							
	2.28	0.090	Penetrated	■	■							
	4.56	0.180	Penetrated	■	■	■	■	■				
	6.84	0.270	Penetrated	■	■	■	■	■	■	■	■	■
SentryGlas®	1.52	0.060	Penetrated	■	■							
	2.28	0.090	Penetrated	■	■	■						
	4.56	0.180	Penetrated	■	■	■	■	■	■	■	■	
	6.84	0.270	Penetrated	■	■	■	■	■	■	■	■	■

TAB 9 • Laminated Glass only testing with 2 x 3mm (2 x 1/8") Annealed Glass
Results per ASTM F3561-23 version



Burglary resistance EN356

(Axe Test – Resistance against manual attack)

EN356 P1A THROUGH P5A

Impact-resistant safety glass provides protection from burglary and vandalism in buildings and resists unpremeditated assault on the glazing. The P-A categories defined in EN 356 cover five groups with ascending protective effect. The test method simulates heavy projectiles with the following test set-up:

EN356 TEST SET-UP

- Steel ball: 4.11 kg (9 lb.) mass, 10 cm (4") diameter
- Laminated safety glass test size: 900 x 1100 mm (35.4 x 43.3")
- Test procedure: three steel balls are dropped from the same height onto an impact triangle. The test is passed if no ball smashes through the glass.

EN 356 P6B THROUGH P8B

Penetration-resistant testing is conducted using a machine axe that simulates an attack using a handheld axe weighing 2 kg. The test established the number of strikes required to produce a 400 x 400 mm hole in a 900 x 1100 mm test specimen. The glazing is initially impacted with hammer strikes to break the glass before the axe strikes begin. The total number of hammer and axe strikes count toward the overall number of strikes. The rating is based on the number of strikes.

Significantly, thinner constructions are possible with SentryGlas®.

Thin constructions with SentryGlas®

Level	Total number of strikes	Total Trosifol® laminate thickness [mm]	Total SentryGlas® laminate thickness [mm]
P6B	30-50	21.8	11
P7B	51-70	22.5	11
P8B	Over 70	28	16.5

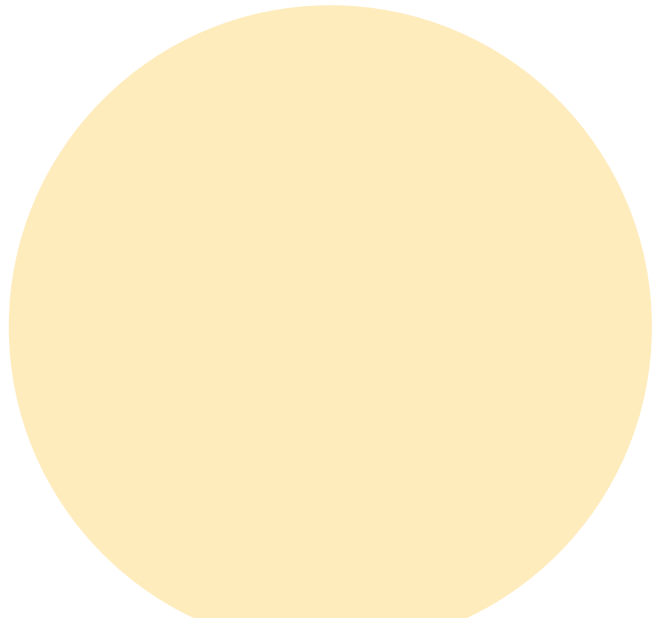
TAB 10 •



EN356 performance levels by construction

EN 356	Level	SentryGlas® ionoplast	SentryGlas® Xtra™ ionoplast	Trosifol® PVB
Ball drop test	P1A	3 mm (1/8") 0.89 mm (35 mil) 3 mm (1/8")	3 mm (1/8") 0.76 mm (30 mil) 3 mm (1/8")	3 mm (1/8") 0.76 mm (0.30 mil)* 3 mm (1/8")
	P2A	4 mm (5/32") 1.52 mm (60 mil) 4 mm (5/32")	4 mm (5/32") 1.52 mm (60 mil) 4 mm (5/32")	4 mm (5/32") 0.76 mm (0.30 mil)* 4 mm (5/32")
	P3A	4 mm (5/32") 1.52 mm (60 mil) 4 mm (5/32")	4 mm (5/32") 1.52 mm (60 mil) 4 mm (5/32")	4 mm (5/32") 1.14 mm (45 mil) 4 mm (5/32")
	P4A	4 mm (5/32") 2.28 mm (90 mil) 4 mm (5/32")		4 mm (5/32") 1.52 mm (60 mil) 4 mm (5/32")
	P5A	4 mm (5/32") 3.04 mm (120 mil) 4 mm (5/32")		4 mm (5/32") 2.28 mm (90 mil) 4 mm (5/32")
Axe test	P6B	4 mm (5/32") 3.04 mm (120 mil) 4 mm (5/32")	4 mm (5/32") 3.04 mm (120 mil) 4 mm (5/32")	3 mm (1/8") 1.52 mm (60 mil) 10 mm (3/8") 2.28 mm (90 mil) 5 mm (3/16")
	P7B	4 mm (5/32") 3.04 mm (120 mil) 4 mm (5/32")		4 mm (5/32") 0.76 mm (30 mil) 8 mm (5/16") 0.76 mm (30 mil) 5 mm (3/16") 0.76 mm (30 mil) 3 mm (1/8")
	P8B	4 mm (5/32") 2.28 mm (90 mil) 4 mm (5/32") 2.28 mm (90 mil) 4 mm (5/32") or 4 mm (5/32") 4.56 mm (180 mil) 4 mm (5/32")	4 mm (5/32") 2.28 mm (90 mil) 4 mm (5/32") 2.28 mm (90 mil) 4 mm (5/32") or 4 mm (5/32") 4.56 mm (180 mil) 4 mm (5/32")	4 mm (5/32") 0.76 mm (30 mil) 6 mm (1/4") 0.76 mm (30 mil) 5 mm (3/16") 0.76 mm (30 mil) 6 mm (1/4") 0.76 mm (30 mil) 4 mm (5/32")

TAB 11 • * not valid for Trosifol® UltraClear



Bullet resistant

Bullet resistant configurations that comply with two of the EN 1063 standard threat levels are shown below:

European standard EN 1063

Threat level	Ammunition	Required velocity		Composition	Thickness		Weight		Number of shots
		[mps]	[fps]		[mm]	[in]	[kg/m ²]	[lbs/ft ²]	
BR 4 NS	0.44 Magnum	430- 450	1411- 1476	6 mm (¼") Annealed glass/ 0.9 mm (35 mil) SentryGlas®/ 6 mm (¼") Annealed glass/ 5 mm (3/16") SentryGlas®/ 2.5 mm (3/32") Annealed glass/ 1.52 mm (60 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET	21.3	0.84	41.72	8.5	3
BR 6 NS	7.62 x 51 mm (M80)	820- 840	2690- 2755	8 mm (5/16") Annealed glass/ 0.76 (30 mil) mm Trosifol® Clear/ 8 mm (5/16") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 8 mm (5/16") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 6 mm (¼") Annealed glass/ 5 mm (3/16") SentryGlas®/ 2.5 mm (3/32") Annealed glass/ 1.52 mm (60 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET	39.5	1.55	85.92	17.6	3

TAB 12 →



Photo: © Kumray

→ Trosifol® Spallshield® CPET impact test

SentryGlas® Xtra™ (SGX) constructions



Threat level	Ammunition	Required velocity		Composition	Thickness		Weight		Number of shots
		[mps]	[fps]		[mm]	[in]	[kg/m ²]	[lbs/ft ²]	
BR 4 NS	0.44 Magnum	430- 450	1411- 1476	6 mm (¼") Annealed glass/ 0.9 mm (35 mil) SentryGlas® Xtra™/ 6 mm (¼") Annealed glass/ 5 mm (⅜") SentryGlas® Xtra™/ 2.5 mm (⅜") Annealed glass/ 1.52 mm (60 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET	21.3	0.84	41.72	8.5	3
BR 6 NS	7.62 mm x 51 mm (M80)	820- 840	2690- 2755	8 mm (⅝") Annealed glass/ 0.9 mm (35 mil) SentryGlas® Xtra™/ 8 mm (⅝") Annealed glass/ 0.9 mm (35 mil) SentryGlas® Xtra™/ 8 mm (⅝") Annealed glass/ 0.9 mm (35 mil) SentryGlas® Xtra™/ 6 mm (¼") Annealed glass/ 5 mm (⅜") SentryGlas® Xtra™/ 2.5 mm (⅜") Annealed glass/ 1.52 mm (60 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET	41.4	1.63	87.39	17.9	3
BR 6 NS	7.62 mm x 51 mm (M80)	820- 840	2690- 2755	8 mm (⅝") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 8 mm (⅝") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 8 mm (⅝") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 6 mm (¼") Annealed glass/ 5 mm (⅜") SentryGlas® Xtra™/ 2.5 mm (⅜") Annealed glass/ 1.52 mm (60 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET	39.5	1.55	85.92	17.6	3

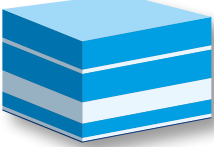
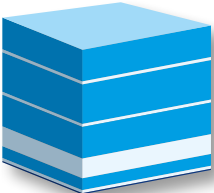
TAB 13 •



Bullet resistant configurations that have been tested and found to comply with commonly specified Indoor UL Standard threat levels are shown below:

Indoor UL 752 Standard for Bullet Resisting Equipment

Threat level	Ammunition	Nominal bullet mass		Required velocity		Composition
		[g]	[grains]	[mps]	[fps]	
1	9 mm full metal copper jacket with lead core 	8.0	124	358-394	1175-1293	6 mm (¼") Annealed glass/ 0.9 mm (35 mil) SentryGlas®/ 6 mm (¼") Annealed glass/ 4.5 mm (177 mil) SentryGlas®/ 3 mm (⅛") Annealed glass/ 0.76 mm (30 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET
2	0.357 Magnum jacketed lead soft point	10.2	158	381-419	1250-1375	3 mm (⅛") Annealed glass/ 0.9 mm (35 mil) SentryGlas®/ 5 mm (⅜") Annealed glass/ 0.9 mm (35 mil) SentryGlas®/ 5 mm (⅜") Annealed glass/ 4.5 mm (177 mil) SentryGlas®/ 3 mm (⅛") Annealed glass/ 0.76 mm (30 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET
3	0.44 Magnum, lead semi-wadcutter gas checked	15.6	240	411-441	1350-1447	4 mm (⅝") Annealed glass/ 0.9 mm (35 mil) SentryGlas®/ 6 mm (¼") Annealed glass/ 0.9 mm (35 mil) SentryGlas®/ 6 mm (¼") Annealed glass/ 4.5 mm (177 mil) SentryGlas®/ 3 mm (⅛") Annealed glass/ 0.76 mm (30 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET
4	0.30-60 caliber rifle lead core soft point	11.7	180	774-852	2540-2794	8 mm (⅝") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 10 mm (⅜") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 8 mm (⅝") Annealed glass/ 5 mm (⅜") SentryGlas®/ 3 mm (⅛") Annealed glass/ 0.76 mm (30 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET
5	7.62 mm rifle lead core full metal copper jacket, military ball 	9.7	150	838-922	2750-3025	8 mm (⅝") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 10 mm (⅜") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 8 mm (⅝") Annealed glass/ 5 mm (⅜") SentryGlas®/ 3 mm (⅛") Annealed glass/ 0.76 mm (30 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET
6	9 mm full metal copper jacket with lead core	8.0	124	427-469	1400-1540	8 mm (⅝") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 10 mm (⅜") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 8 mm (⅝") Annealed glass/ 5 mm (⅜") SentryGlas®/ 3 mm (⅛") Annealed glass/ 0.76 mm (30 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET

Thickness		Weight		Number of shots
[mm]	[in]	[kg/m ²]	[lbs/ft ²]	
21.6	0.85	44.24	9.1	3
				
22.4	0.88	44.78	9.17	3
25.4	1.00	52.20	10.7	3
36.4	1.43	79.63	16.3	1
36.2	1.43	78.67	16.1	1
				
36.5	1.44	79.42	16.3	5



Bullet resistant configurations that comply with several of the NIJ Standard threat levels are shown below:

NIJ 0108.01 Ballistic Protective Glazing Materials

Threat level	Ammunition	Nominal bullet mass		Required velocity		Composition
		[g]	[grains]	[mps]	[fps]	
I	0.22 long rifle high velocity lead	2.6	40	320±12	1050±40	3 mm (1/8") Annealed glass/ 5 mm (3/16") SentryGlas®/ 2.5 mm (3/32") Annealed glass/ 0.76 mm (30 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET
	.38 special round nose lead	10.2	158	259±15	850±50	
II-A	0.357 Magnum jacketed soft point	10.2	158	381±15	1250±50	4 mm (5/32") Annealed glass/ 0.9 mm (35 mil) SentryGlas®/ 4 mm (5/32") Annealed glass/ 5 mm (3/16") SentryGlas®/ 2.5 mm (3/32") Annealed glass/ 1.52 mm (60 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET
	9 mm full metal jacket	8.0	124	332±12	1090±40	
II	0.357 Magnum jacketed soft point	10.2	158	425±15	1395±50	4 mm (5/32") Annealed glass/ 0.9 mm (35 mil) SentryGlas®/ 4 mm (5/32") Annealed glass/ 5 mm (3/16") SentryGlas®/ 2.5 mm (3/32") Annealed glass/ 1.52 mm (60 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET
	9 mm full metal jacket	8.0	124	358±12	1175±40	
III-A	0.44 Magnum lead semi-wadcutter gas checked	15.5	240	426±15	1400±50	6 mm (1/4") Annealed glass/ 0.9 mm (35 mil) SentryGlas®/ 6 mm (1/4") Annealed glass/ 5 mm (3/16") SentryGlas®/ 2.5 mm (3/32") Annealed glass/ 1.52 mm (60 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET
	9 mm full metal jacket	8.0	124	426±15	1400±50	
III	7.62 mm (.308 Winchester) full metal jacket	9.7	150	838±50	2750±50	2.5 mm (3/32") Annealed glass/ 0.76 mm (30 mil) Trosifol® Clear/ 8 mm (5/16") Annealed glass/ 0.76 (30 mil) mm Trosifol® Clear/ 10 mm (3/8") Annealed glass/ 0.76 (30 mil) mm Trosifol® Clear/ 8 mm (5/16") Annealed glass/ 5 mm (3/16") SentryGlas®/ 2.5 mm (3/32") Annealed glass/ 1.52 mm (60 mil) Trosifol® UltraClear/ 0.18 mm (7 mil) Trosifol® Spallshield® CPET

TAB 15 •

Typical applications for bullet-resistant glazing are military installations, banks, prisons, detention centers, prisons and embassies.

Thickness		Weight		Number of shots
[mm]	[in]	[kg/m ²]	[lbs/ft ²]	
11.6	0.46	19.92	4.1	5
18	0.71	33.5	6.9	5
18	0.71	33.5	6.9	5
21.4	0.84	42.2	8.6	5
37.9	1.49	81.2	16.63	5





Behavioral health – psychiatric hospitals

Behavioral health care facilities must minimize risk to patient safety while maintaining a caring and nurturing atmosphere. To ensure safety, behavioral health facilities must meet accreditation standards. Risk is determined by several factors such as population served, patient supervision, and ability of staff to intervene.

Risk can vary throughout parts of the building and patient access to objects. High risk areas are seclusion rooms, bedrooms and comfort spaces.

American Architectural Manufacturers Association (AAMA) 501.8, standard test method for determination of resistance to human impact of window systems intended for use in psychiatric applications.

TEST METHOD

- This test assumes a patient is running into a window or strikes or throws an object against it. The energy must be transferred to the hardware, frames and substrates.
- Human impact can impart as much as 2.7 kJ (2,000 ft - lbs.) of energy based on shoulder impact of 90.7 kg (200 lbs.) person moving at 7.62 m (25 ft. /sec)
- Test requires a 90.7 kg (200 lbs.) dropped from 3 meters (10 feet)
- Pass criteria: the impact test load has not breached or penetrated the inner most glazing layer. The inner most glazing remains held in place within the window frame



Photo: © Mike_shots/shutterstock.com

Construction that meets this requirement

Interior glass of IGU

4 mm ($\frac{5}{32}$ ") heat strengthen glass

2.28 mm (90 mil) SentryGlas®

4 mm ($\frac{5}{32}$ ") heat strengthen glass

0.15 mm (6 mil) spall protective layer (occupant side)

UNITED STATES DEPARTMENT OF STATE (DOS) APPROVALS

- Certified SentryGlas® interlayers for SD-STD-01.01 for forced entry (FE) and ballistics resistance (BR) for US Embassies in 2010
- In 2020, SentryGlas® Xtra™ (SGX™) was certified for use in forced entry (FE) and ballistics (BR) for US embassies. SentryGlas® Xtra™ provides improved optical performance in thicker constructions.
- Physical delamination of GCP products is a phenomenon that has been well-documented... The Bureau of Diplomatic Security remains enthusiastic about the use of SentryGlas® laminated glazing systems as a viable alternative to GCP systems. Adopting SG laminates will result in reduced life cycle costs because this product will not delaminate.

The following pass SD-STD-01.01 Rev G (amended) certification for 15 minute FE and Rifle BR.

Exterior/Threat Face

Construction

12 mm (0.47") tempered glass
4.57 mm (180 mil) SentryGlas®
12 mm (0.47") tempered glass
6 mm (0.25") air gap
6 mm (0.25") heat strengthened
4.57 mm (180 mil) SentryGlas®
6 mm (0.25") heat strengthened
0.20 mm (8 mil) shatter resistant window film (daylight or edge-to-edge application) Interior/Protected Face

TAB 17 •

DOS layups

DOS layup 2	DOS layup 3	DOS layup 4
6 mm (¼") annealed glass	6 mm (¼") annealed glass	12 mm (½") annealed glass
2.53 mm (0.1 inch) SGX™	2.53 mm (0.1 inch) SGX™	5 mm (0.2") SGX™
6 mm (¼") annealed glass	6 mm (¼") annealed glass	12 mm (½") annealed glass
2.53 mm (0.1 inch) SGX™	2.53 mm (0.1 inch) SGX™	12 mm (½") air gap
6 mm (¼") annealed glass	6 mm (¼") annealed glass	6 mm (¼") heat str glass
12 mm (½") air gap	12 mm (½") air gap	5 mm (0.2") SGX™
6 mm (¼") heat str glass	6 mm (¼") annealed glass	6 mm (¼") heat str glass
2.53 mm (0.1 inch) SGX™	2.53 mm (0.1 inch) SGX™	0.635 mm (0.025") TPU
6 mm (¼") heat str glass	6 mm (¼") annealed glass	Spall protective layer
2.53 mm (0.1 inch) SGX™	2.53 mm (0.1 inch) SGX™	
6 mm (¼") heat str glass	6 mm (¼") annealed glass	
0.635 mm (0.025") adhesive layer	0.635 mm (0.025") TPU	
Spall protective layer	Spall protective layer	

TAB 18 •

Contact



FOR FURTHER INFORMATION

on products from Kuraray, please visit www.kuraray.com.

You can find further information on our Trosifol® and SentryGlas® products at www.trosifol.com.

Kuraray America, Inc.

Advanced Interlayer Solutions Division
Wells Fargo Tower
2200 Concord Pike, Ste. 1101
Wilmington, DE 19803, USA
P +1 800 635 3182

trosifol@kuraray.com

Kuraray Europe GmbH

Advanced Interlayer Solutions Division
Kronenstr. 55
53840 Troisdorf
Germany
P +49 2241 2555 226

Kuraray Co., Ltd

Advanced Interlayer Solutions Division
Tokiwabashi Tower
2-6-4 Otemachi, Chiyoda-ku
Tokyo 100-0004, Japan
P +813 6701 1508

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**trosifol@kuraray.com
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