Selecting and Specifying the Appropriate Interlayer for Laminated Glass

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PVB Division Kuraray America Inc

kuraray

Who is Kuraray & Advanced Interlayer Solutions?

The broadest product portfolio of laminated glass interlayers in the industry

Safety

Trosifol® Clear

Trosifol® UltraClear

Decorative

Trosifol® Color

Trosifol® Tints

Trosifol® Black & White

Acoustic

Trosifol® Sound Control

- Trosifol® SC Monolayer
- Trosifol® SC Multilayer

Structural & Security

Trosifol® Structural

- SentryGlas®
- SentryGlas® Natural UV
- SentryGlas® Xtra™
- SentryGlas® Translucent White
- Trosifol® Extra Stiff

Trosifol® Hurricane Glazing

Specialized Applications

Trosifol® Specialized

- Trosifol® HR
- Trosifol® UV Extra Protect
- Trosifol® Natural UV
- Trosifol® XT
- SentryGlas® Natural UV
- Spallshield ® CPET
- Bird Secure

Auto/Trans-portation

Trosifol® Clear

Trosifol® Shadeband

Trosifol® Color

Trosifol® Spallshield® CPET

SentryGlas®

Trosifol® Acoustic

Trosifol® The Wedge

Recycled

Butacite® G

Best Practice

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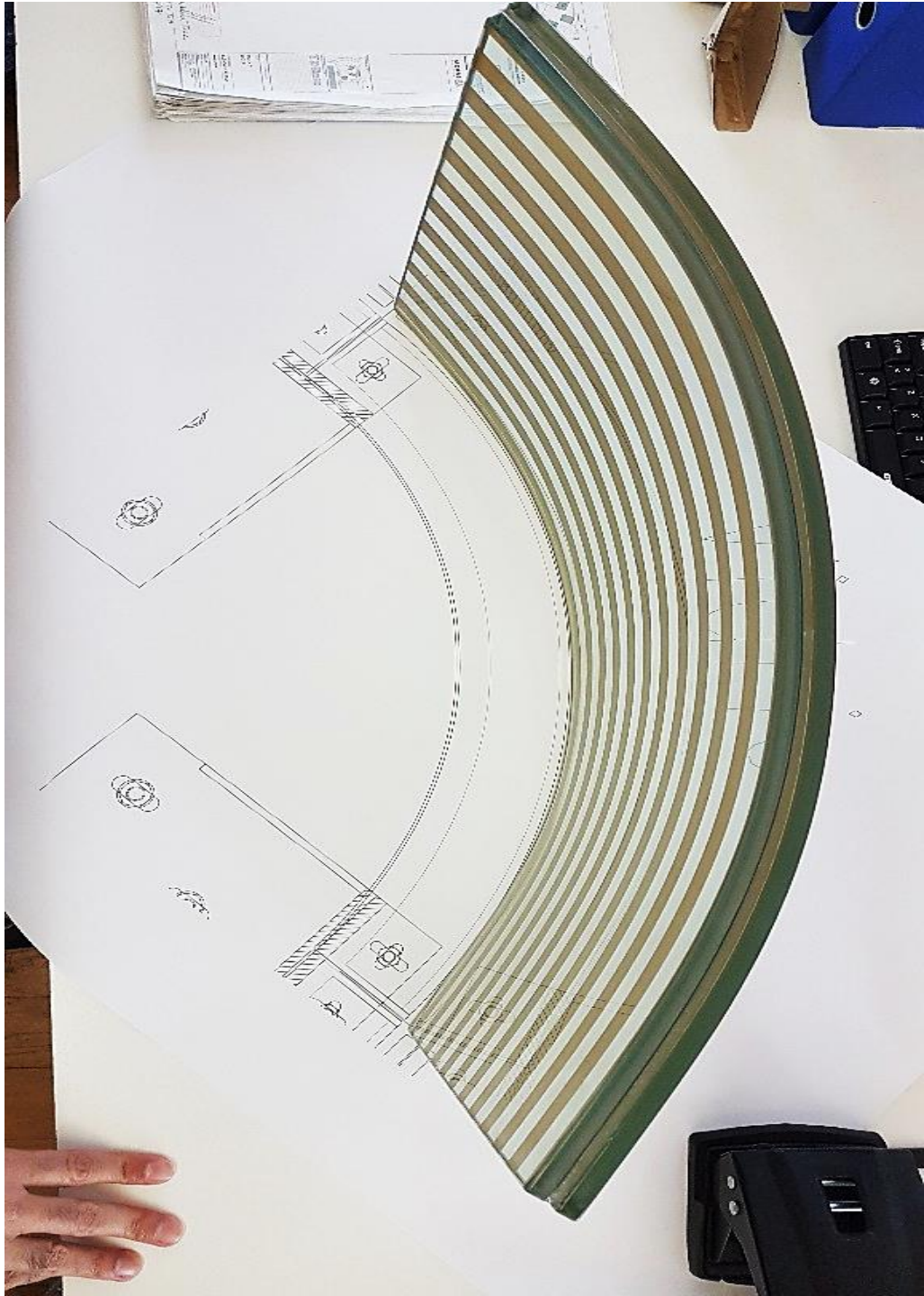
Course Description

Laminated glass is used in many different applications requiring different performance attributes. Glass makeups for structural, decorative, acoustic, security, ballistics, and safety can be tailored to achieve optimum properties. Interlayer properties that contribute to desired performance and tools to help select the appropriate interlayer will be described. Once an interlayer is selected, it must be specified properly and architectural specifications for the different interlayers will be discussed and provided.

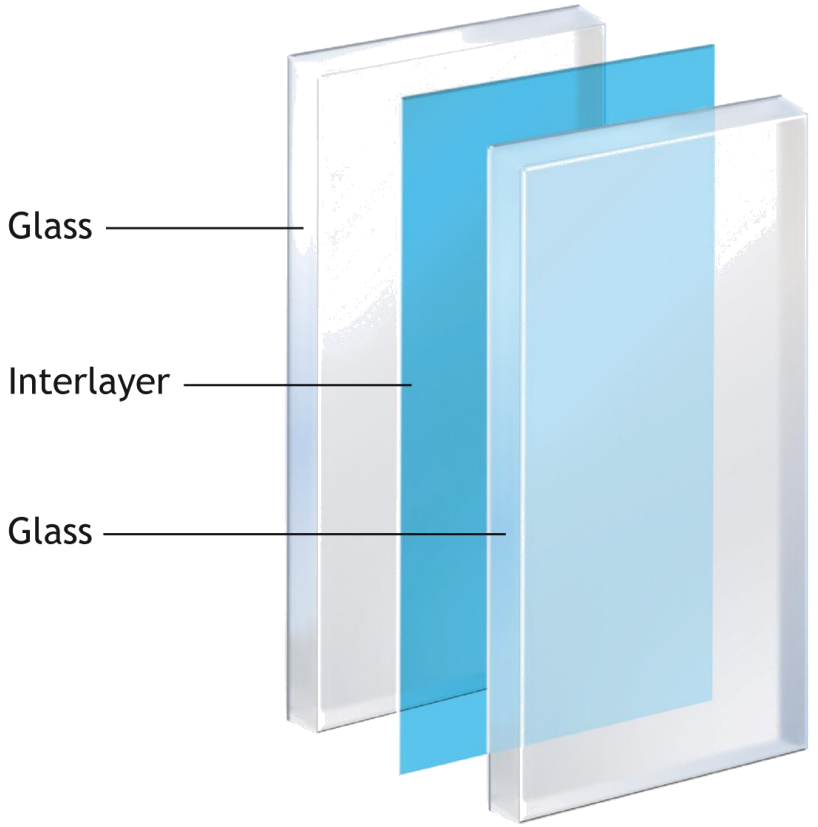
Learning Objectives

- Identify different reasons laminated glass is used.
- Understand properties of interlayers that make them best suited for specific applications.
- Review tools that can be used to select the appropriate interlayer for different applications.
- Specifying the interlayer once it is selected.



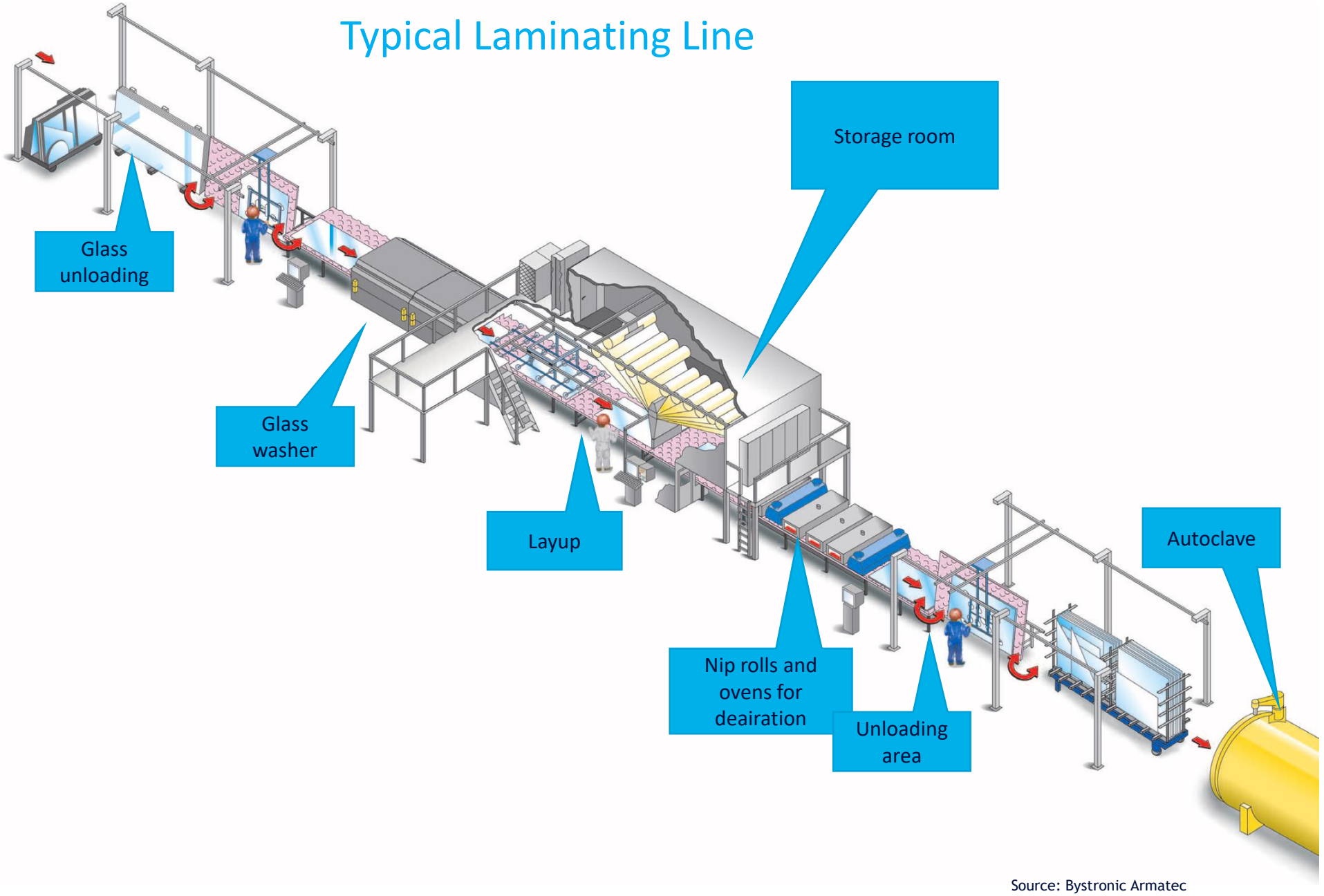
What is Laminated Glass?

- Two or more lites of glass and one or more interlayers
- Glass retention if breakage occurs
- Types of laminated glass interlayers
    - Polyvinyl butyral (PVB)
    - Ionoplast
    - CPET (used in combination with PVB and ionoplast when spall protection is required



Typical Laminating Line

Typical Laminating Line



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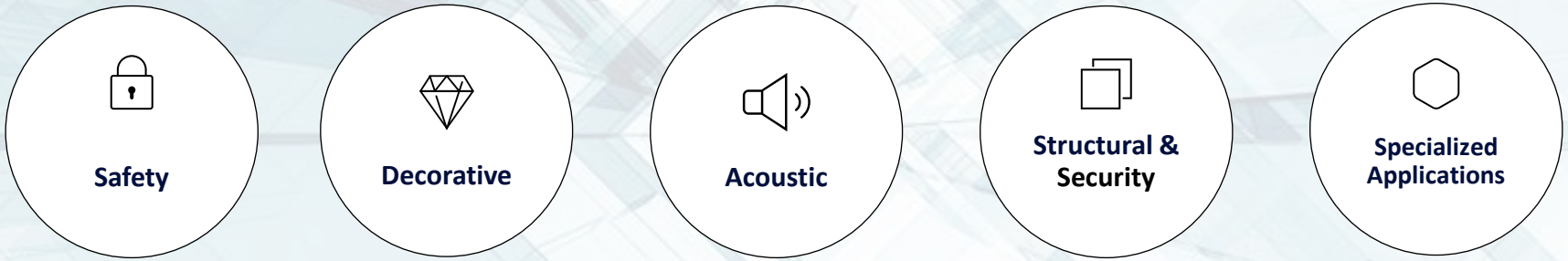
DEMAG

Reasons Laminated Glass is Used



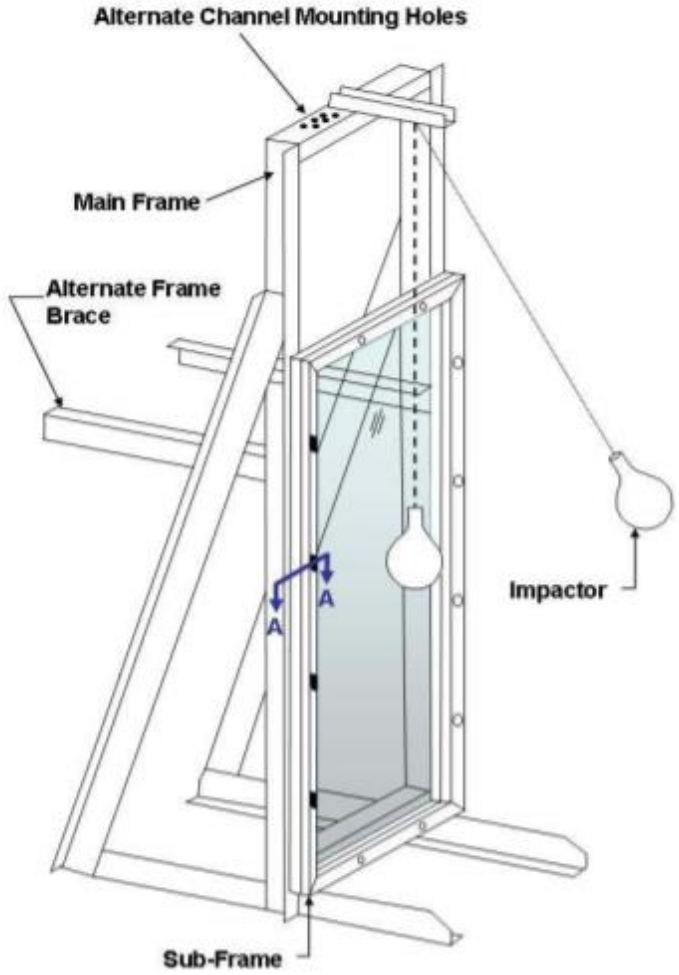
Safety

Requirements for safety glazing

- Tested to Consumer Product Safety Commission Standard 16CFR1201
- 400 foot-pound impact test
- Glass is retained

Key interlayer property for safety glazing

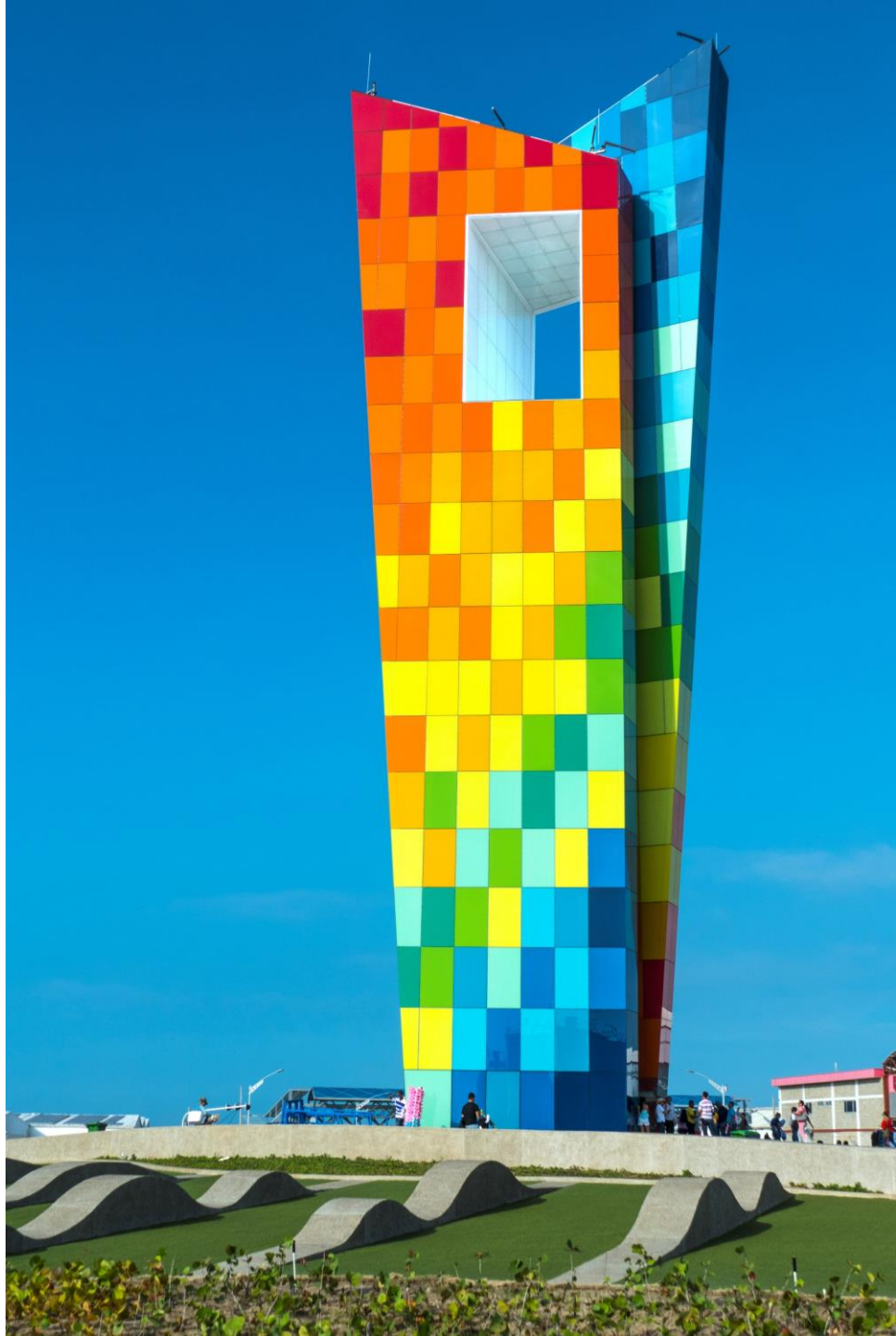
- Adhesion to glass



Note – Fully tempered glass is considered safety glazing due to breakage characteristics. It will vacate the opening upon breakage

Decorative

- Color
  - PVB has multiple colors
  - Translucent and opaque white and black
  - Ionoplast available in translucent white
- Printable
  - PVB – printable version available
  - Ionoplast – new printing technology has been developed
- Inserts
  - Fabrics, paper, wood veneer, films and other items
  - Check compatibility and adhesion
  - Bird-friendly interlayer
- Clarity
  - Ultraclear ionoplast interlayer complements low iron glass laminates
  - Special Ultraclear version of PVB available but must be specified



Color & Tints

PVB design film for colored laminated safety glass

Range of current standards colors

Brilliance of their hues

Huge diversity of possible uses

High color intensity is achieved with just a single film in the glass module; multiple layers are not necessary.

Outstanding colorfastness: suitable for indoors and outdoors use

All Color types meet the requirements of EN ISO 12543

Trosifol® Red – Color code R30

Trosifol® Light Green – Color code G80

Trosifol® Sky Blue – Color code B54

Trosifol® Medium Blue – Color code B37

Trosifol® Violet – Color code V30

Trosifol® Shining White – Color code W17

Trosifol® Coconut White – Color Code 5131500

Trosifol® Sand White – Color code W4071

Trosifol® Translucent White – Color code W3065

Trosifol® Light Blue-Green – Color code 84073

Trosifol® Ocean Blue – Color code 74071

Trosifol® Bronze – Color code 36038

Trosifol® Medium Bronze – Color code 31052

Trosifol® Light Brown – Color code S4055

Trosifol® Medium Brown – Color code S6028

Trosifol® Grey 0.38 mm / 15 mil – Color code 66044

Trosifol® Grey 0.76 mm / 30 mil – Color code 66544

Trosifol® Asahi Grey – Color code 65042

Trosifol® Solar Grey – Color Code 1654400

SentryGlas® Translucent White – Color Code WT010

Trosifol® Diamond White – Color code W00

Trosifol® Brilliant Black– Color code S00

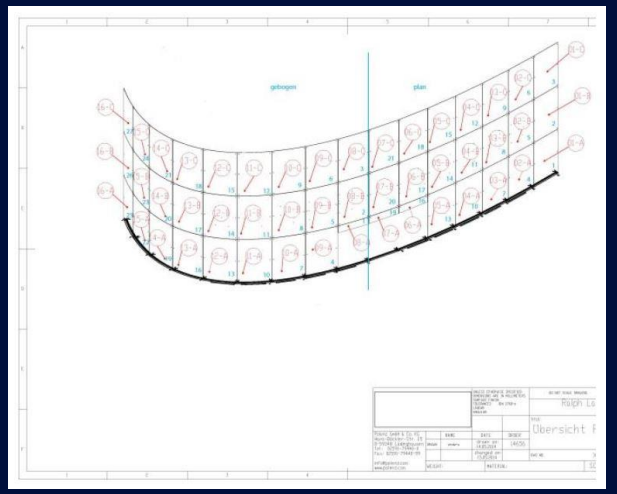
Ralph Lauren store - Port Baku Mall - Azerbaijan

Curved glass Digital printed PVB;

Architect;
Broadway Malyan

Glass Processor:
Finiglas

Printed interlayer;
PVB



Väven Cultural Centre - Sweden

Architect:
Snøhetta, White Arkitekter AB

Facade:
Seele

Laminator:
Schollglas, FiniGlas

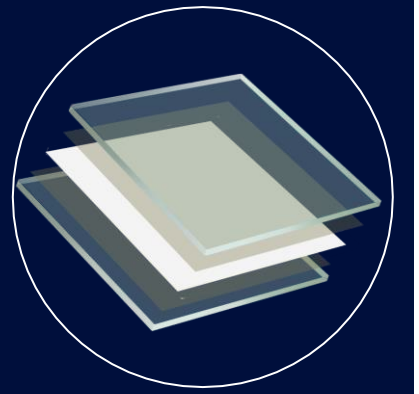
Interlayer:
Opaque White

DATEV IT Campus in Nürnberg - Combining colors

The louvers produced with a laminate of;

10 mm low-iron glass
0.38 mm Light Brown
0.76 mm Diamond White
0.38 mm Trosifol Color Light Brown
10 mm low-iron glass

Architect:
Boesel Benkert Hohberg



Aquarium of the Pacific in Long Beach, California

Architect:
EHDD

Façade Consultant:
Buro Happold

Laminator:
Pulp Studio, Inc.

Interlayer:
Ionoplast

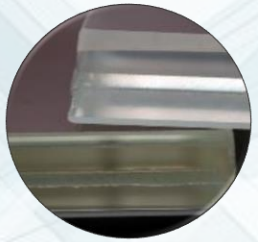
Clarity and optics

Select the right clarity of the interlayers

Ionoplast and UltraClear PVB have a low Yellowness Index

Ultra Clear PVB vs standard PVB

UltraClear PVB vs standard PVB



Yas Viceroy Hotel - Abu Dhabi

Architect:
Asymtote Architecture

Facade:
Waagner Biro

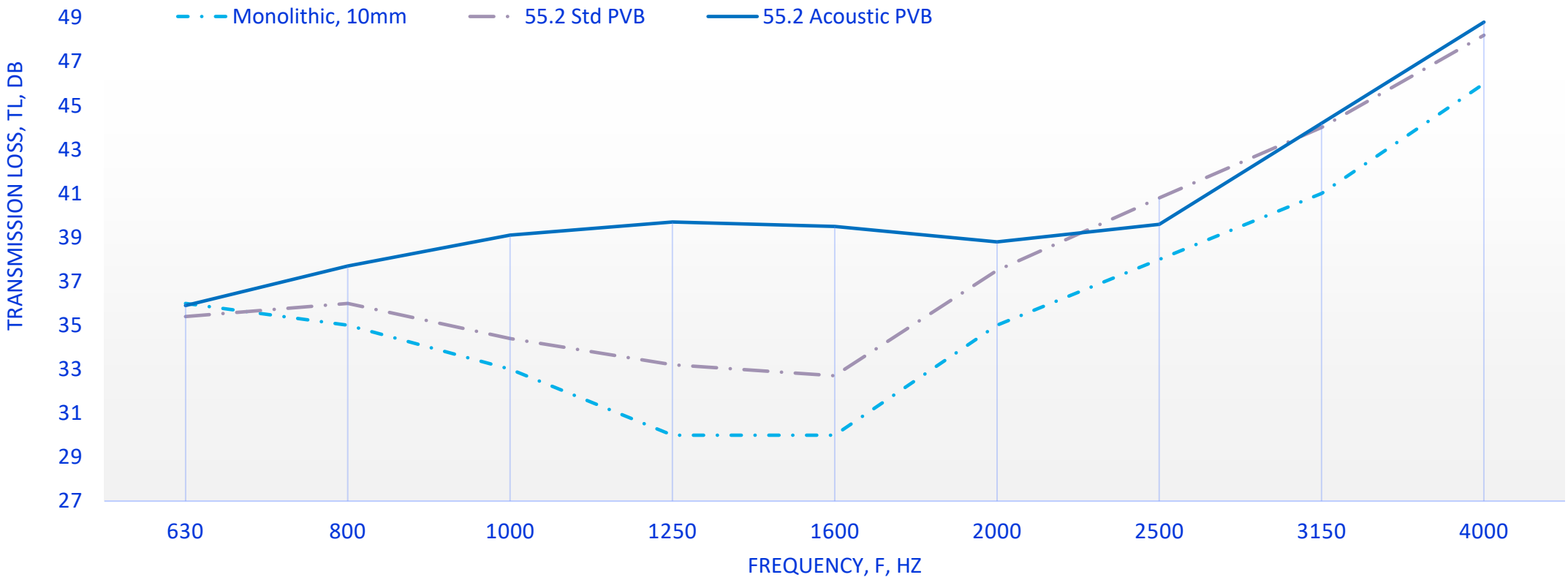
Lighting Design:
ARUP

Interlayer:
PVB Ultra Clear

Sound reduction

- Laminates reduce sound transmission over monolithic glass
- Insulating glass units with laminated glass provide superior sound attenuation
- Specially formulated PVB provides up to 3 dB improvement vs. standard PVB interlayer and 5 dB improvement vs. non-laminated glass
- Softer interlayer improves damping performance
- Sound Transmission Class (STC) and Outside/Inside Transmission Class (OITC) give overall performance of glazing

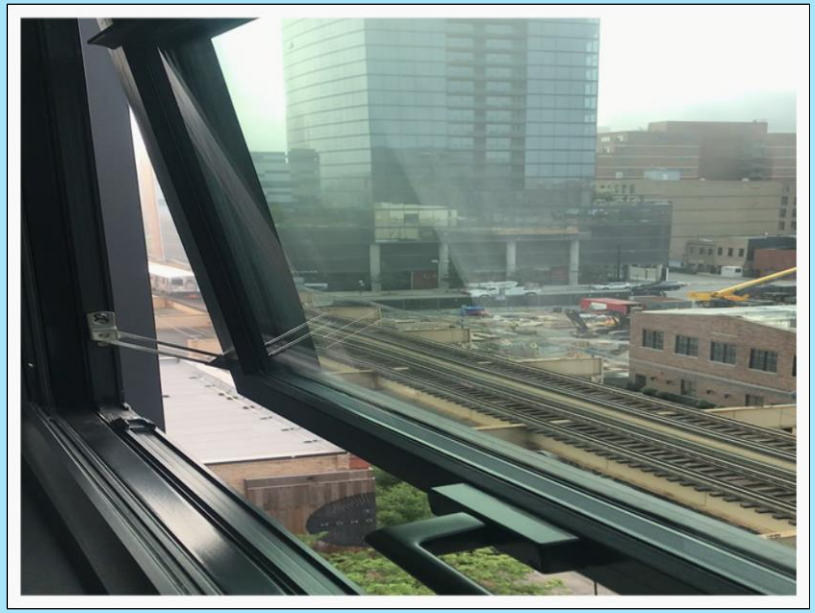
Coincidence dip comparison



Acoustic PVB delivers up to 10 dB improvement in sound reduction in this frequency range over monolithic glass.

Acoustic Example

Hoxton Hotel, Chicago



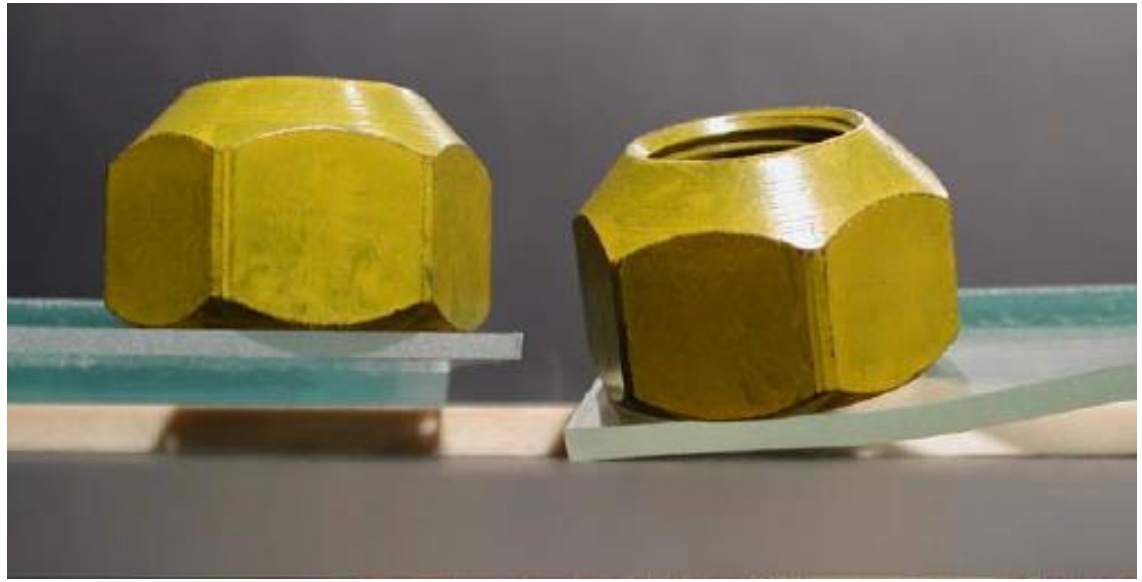
Window Open vs. Window Closed

Structural glass applications

- Facades
- Skylights
- Glass roofs
- Stair treads
- Canopies
- Railings and guards
- Glass bridges
- Floors

Special requirements for structural applications

- Stiffness
  - Ionoplast is 100 x stiffer than PVB
- Tear resistance
  - Ionoplast has 5 x the tear resistance of PVB
- Edge Stability
  - Ionoplast is more resistant to edge defects and moisture ingress than PVB



PVB Stiffness Demonstration

- Standard PVB without support of glass
- Insufficient strength to support glass load should it break

Ionoplast Interlayer Stiffness

- Ionoplast is 100x stiffer than PVB
- Can maintain load without reinforcement of glass

Edge Performance

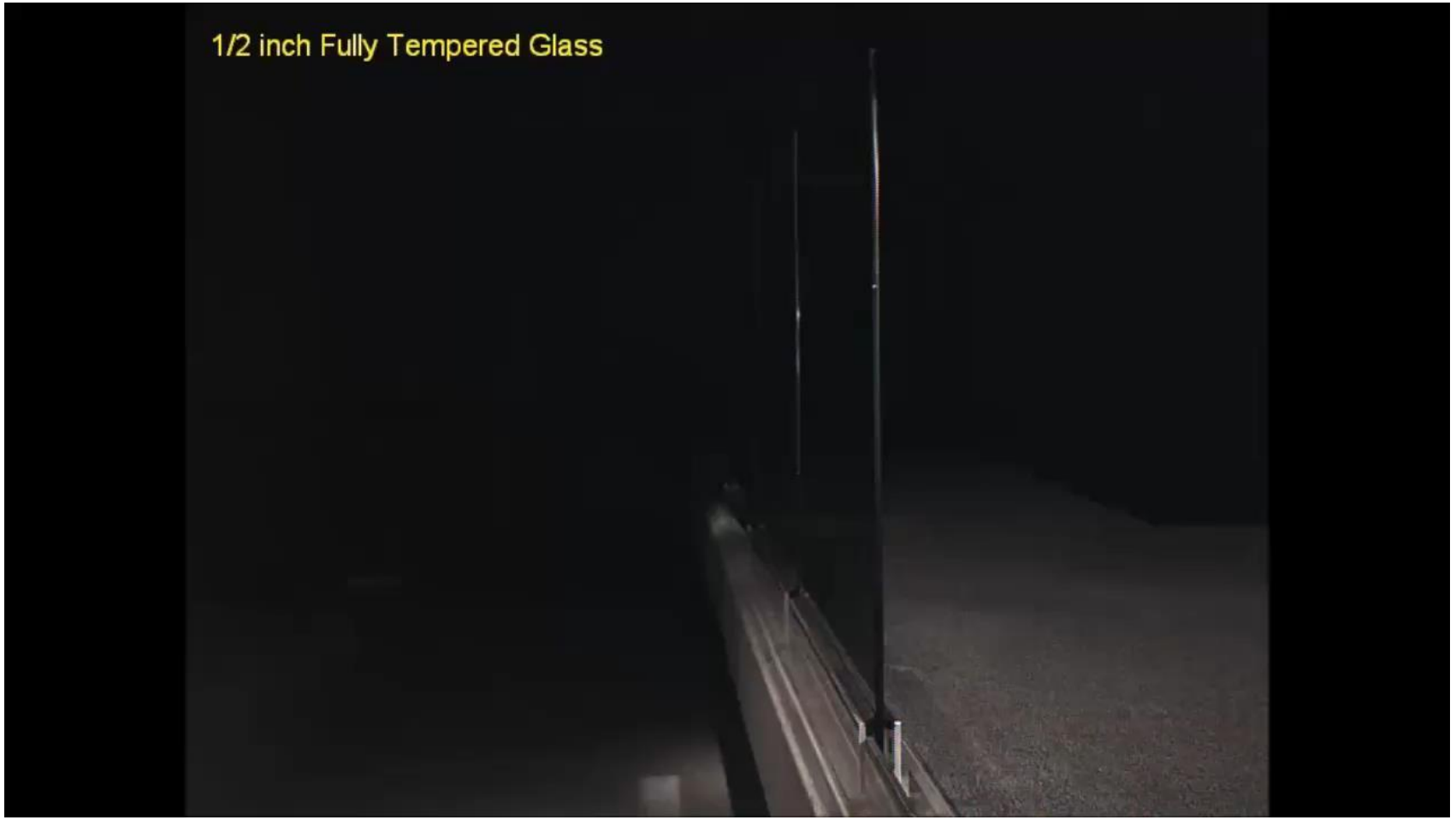
- PVB laminates are durable, but moisture sensitive
- PVB laminates may experience edge delamination due to excessive moisture exposure or processing issues
- Ionoplast laminates perform, even when edges are exposed to the elements

- Key items for specifying exposed edge
- Misalignment tolerance – Refer to ASTM C1172, Section 8.5.3
- Material compatibility – DO NOT USE cementitious grout (polyurethane OK)

Weathering tests with ionoplast laminates

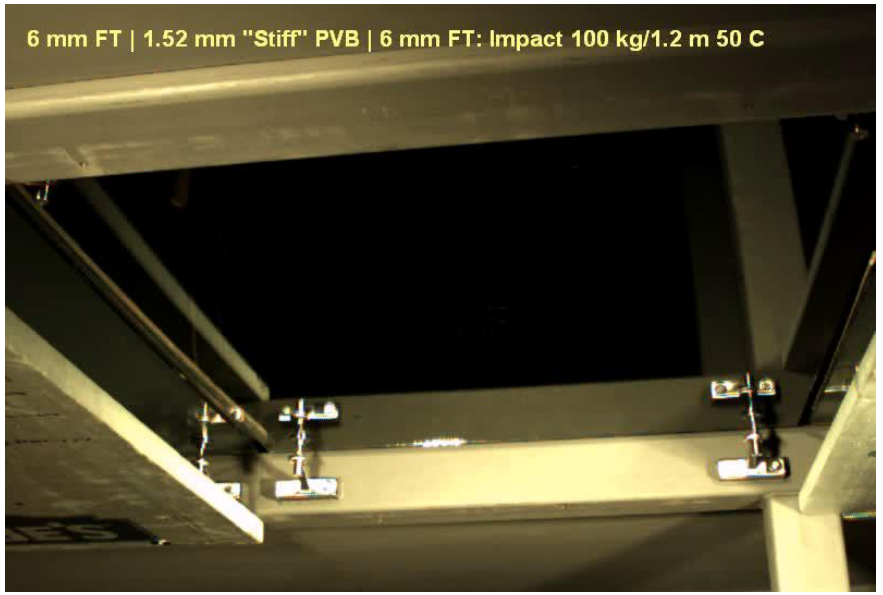
- Over 20 years of natural weathering testing
- Accelerated weathering tests
- No delamination reported

Breakage characteristics, structural railing

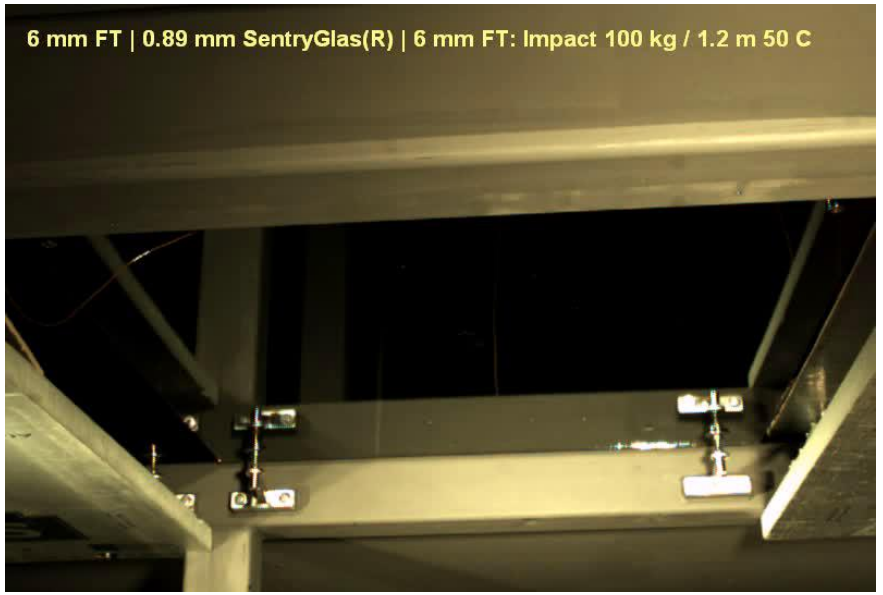


Structural canopy performance

60 mil Stiff PVB at 122F



35 mil ionoplast at 122F




PLEASE DO NOT LITTER
FOR YOUR OWN SAFETY
PLEASE DO NOT SIT ON THE DECK
PLEASE DO NOT EXTEND BEYOND
SAFETY LINES
NO TRIPOD ALLOWED

Security Glazing

Forced Entry with laminated glass

Tear strength affect on forced entry resistance

0.060” PVB

0.060” ionoplast

Enhanced Forced Entry

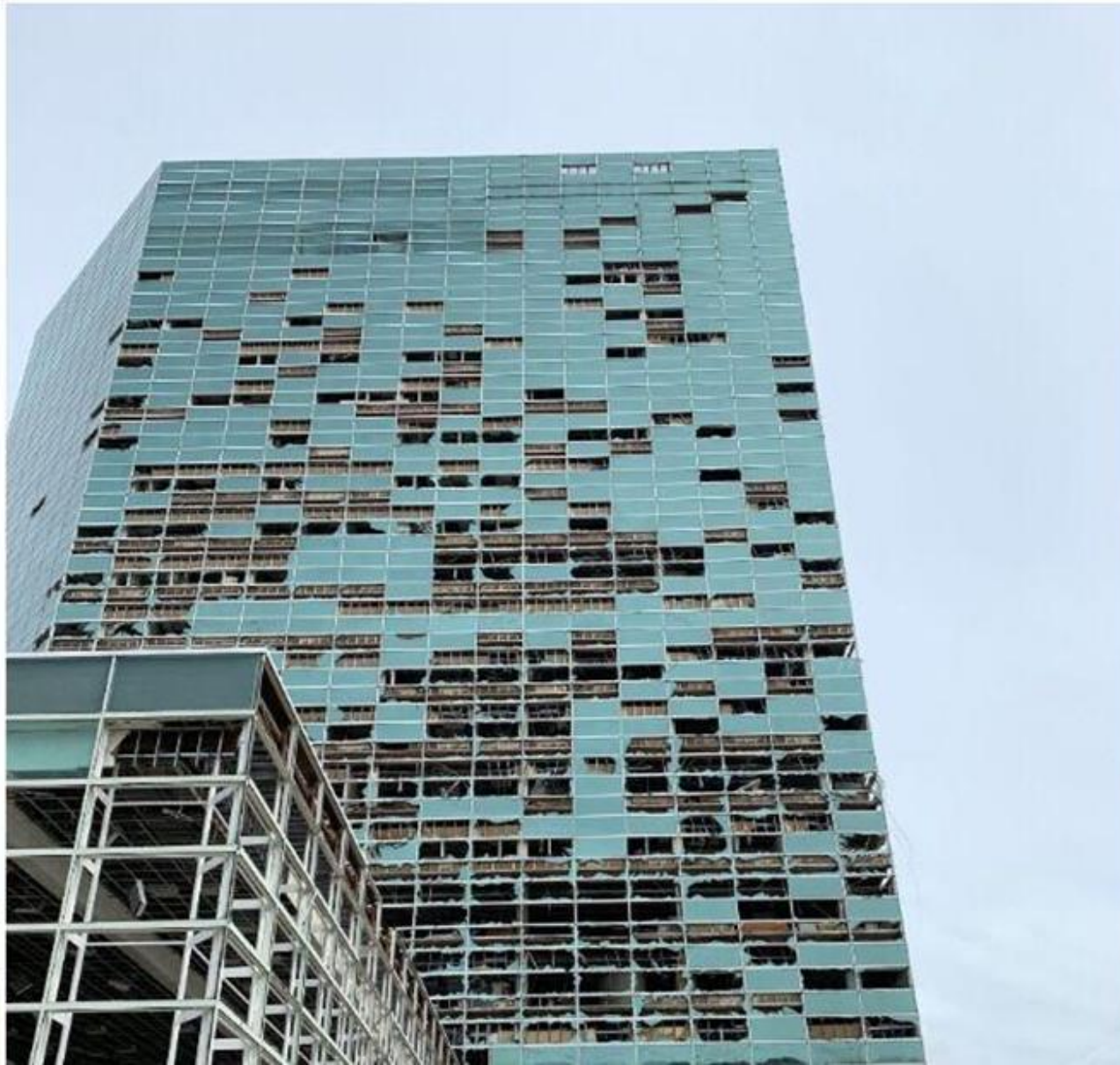
No tear after over 11 minutes of abuse

5-aa1 Test Results

HP 5-aa1 - School Security Testing		Ballistic Impact	Concentrated Assault		Forced Entry			Total Time to Failure	Notes
Interlayer	Product	5 shots 7.62mm	20 Bricks	10 Kicks	Tools 2 min*	Tools 3-1/2 min**	Sledge Hammer 6 min		
PVB	0.060”							0 sec	
	0.090”							51 sec	
	0.120”							2 min 38 sec	
	0.180”							>6 minutes	
	0.270”							11 min 30 sec	12” tear
Ionoplast	0.060”							77 sec	
	0.090							2 min. 30 sec	
	0.120”							2 min 30 sec	
	0.180”							>11min.30sec.	12” tear
	0.270”							Test ended, no failure	No openings

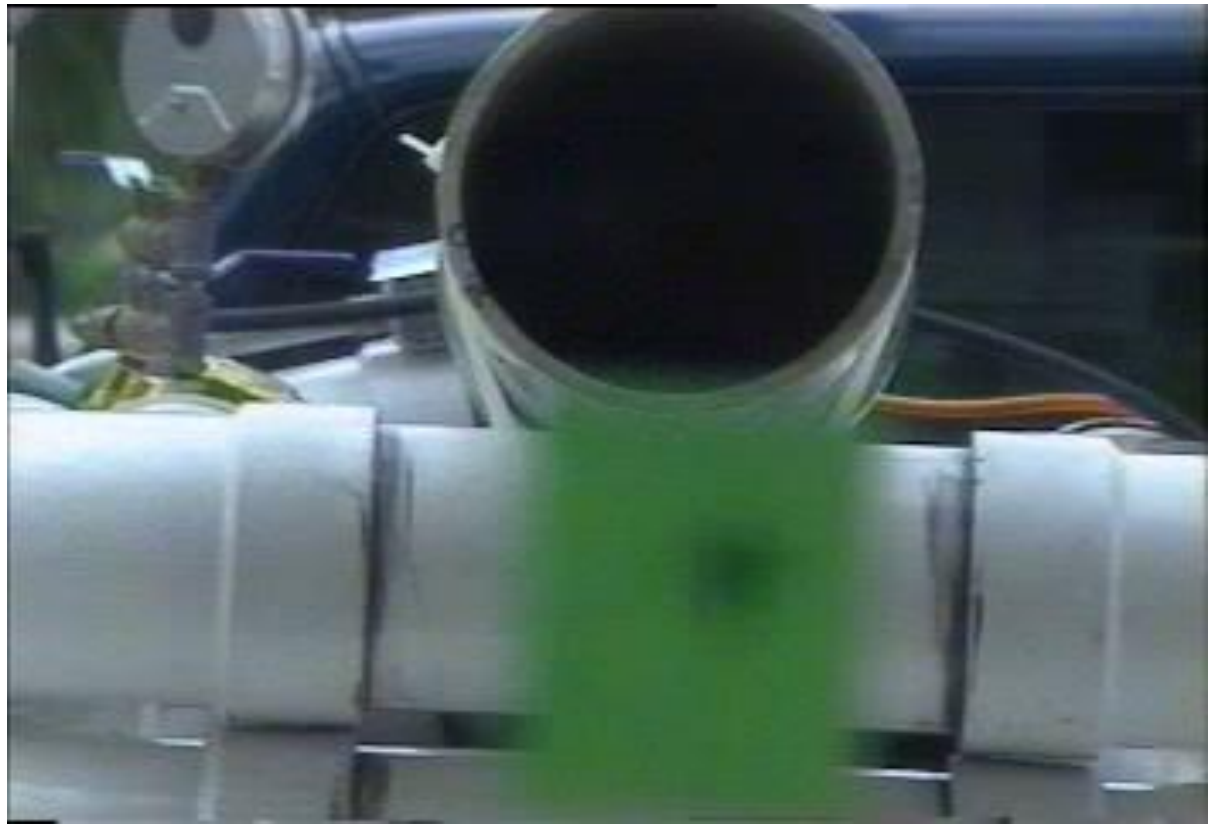
* 2 min tools - a small 2x4, claw hammer, and wrench
** 3-½ min tools – 3lb hammer and Aluminum Baseball bat
Glass used was 1/8” annealed with the designated interlayer

Hurricane Laura (2020) – Louisiana



Missile Impact

- Laminated glass resists penetration from windborne debris
- Used in large and small missile impact systems
- Protects people and property
- No need for plywood or storm shutters
- Building code compliant



Standards

- Early development by Miami-Dade County

TAS 201 Large and Small Missile impact Test Standards
TAS 202 Air, Water, & Uniform Structural Load Standards
TAS 203 Uniform Cyclic Pressure Test Standards
Notice of Acceptance (NOA)

- ASTM E1886

Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials

- ASTM E1996

Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Windborne Debris in Hurricanes

Key Differences in Test Procedures

TAS 201/203

•Only for High Velocity Wind Zone – Miami Dade & Broward County
•Large Missile - 2 impacts per specimen
•Small Missile – 3 impacts per specimen*
•Pass/ Fail – no penetration or opening larger than 1/16” x 5”
•Impact on the mullion or cross bar

* Risk category IV – essential facilities glazing above 30ft requires level D large missile impact

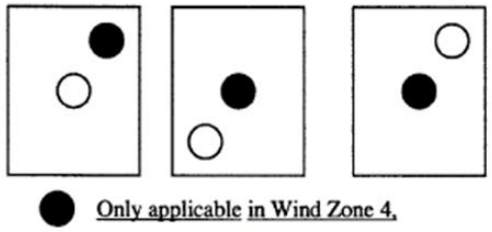


FIG. X4.1 Additional Large Missile Impact Locations in Wind Zone 4

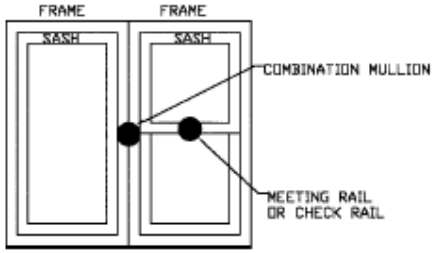


FIG. X4.3 Combination Mullion with Meeting or Check Rail

ASTM E1886/1996

•Large Missile - 1 impact per specimen
•Small Missile – 3 impacts per specimen
•Pass/Fail – no tear formed larger than 5” or wider than 1/16”, **OR** no opening through which a 3” sphere can freely pass through
•No impact of the mullion

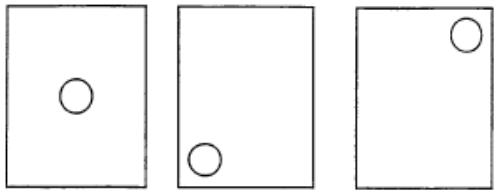


FIG. 1 Impact Locations for Large Missile Test (Each Type of Infill)

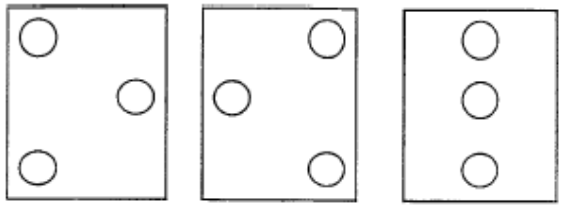


FIG. 2 Impact Locations for Small Missile Test (Each Type of Infill)

ASTM E 1996-Hurricane Missile Tests

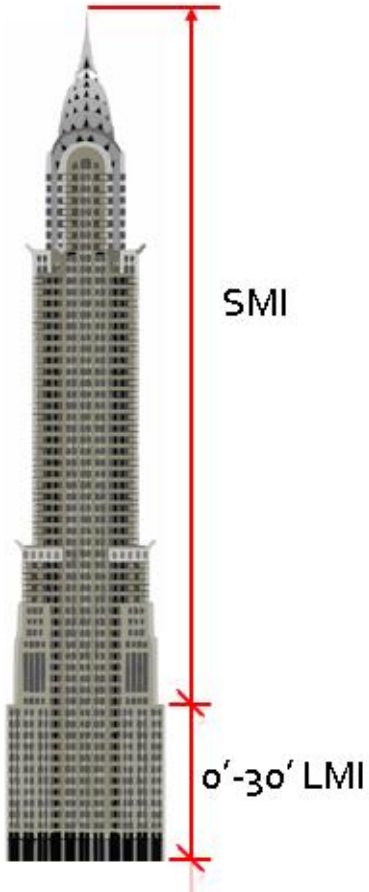
- Wind zone location?
- Location in the building-Determines LMI (large missel impact) vs SMI (small missile impact)?
- Level of protection?

TABLE 3 Description Levels

NOTE 1—For Missiles B, C, D, and E, also use Missile A for porous impact protective systems (see 8.5).

Level of Protection	Enhanced Protection (Essential Facilities)		Basic Protection		Unprotected	
Assembly Elevation	≤9.1 m (30 ft)	>9.1 m (30 ft)	≤9.1 m (30 ft)	>9.1 m (30 ft)	≤9.1 m (30 ft)	>9.1 m (30 ft)
Wind Zone 1	D	D	C	A	None	None
Wind Zone 2	D	D	C	A	None	None
Wind Zone 3	E	D	D	A	None	None

Level of Protection	Enhanced Protection (Essential Facilities)		Basic Protection		Unprotected	
Assembly Elevation	≤9.1 m (30 ft)	>9.1 m (30 ft)	≤9.1 m (30 ft)	>9.1 m (30 ft)	≤9.1 m (30 ft)	>9.1 m (30 ft)
Wind Zone 4	E	D	D	A	None	None



ASTM E1996 Basic vs Enhanced Protection

- Buildings designed as Essential Facilities require enhanced protection. These include:
  - Hospitals and health care facilities
  - Police stations, Fire rescue stations
  - Emergency shelters, Communications centers
  - Jails and detention centers
  - Buildings critical to the national defense

- Level E Impact may be required first 30 feet elevation
- Impact = 9 lb 2x4 traveling 55 mph
- 180-mil Ionoplast needed for impact

Tornado Impact Testing

- Impact test requirements are more severe than for hurricanes
- 130 mph design requirement

Impactor 15 lb. 2 x 4

Impact speed: 80 mph

- 250 mph design requirement

Impactor 15 lb. 2 x 4

Impact speed: 100 mph

Spall protection
Behavioral Health Facility

- 2,000 ft-lb impact
- 200lb dropped from 10 feet

Configuration Example
¼” Tempered
½” airspace
5/32” HS – 0.090” Ionoplast – 5/32” HS
0.030” PVB
0.007” Spallshield CPET

Pass Criteria
No holes and no sharp edges present on the interior

Other spall protection applications

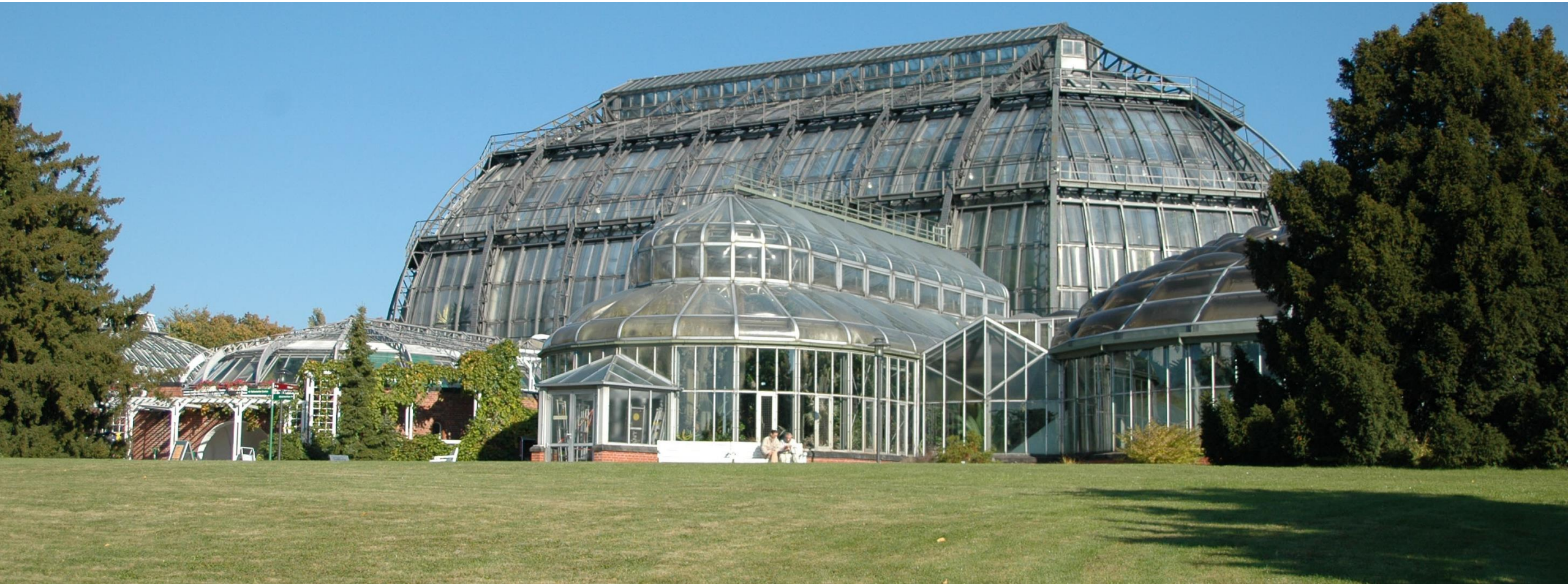
- Ballistics resistance
- Blast resistance
- Protection of valuables

Examples
- Jails
- Embassies
- Jewelry cases

U.S. Embassy Beijing- SOM

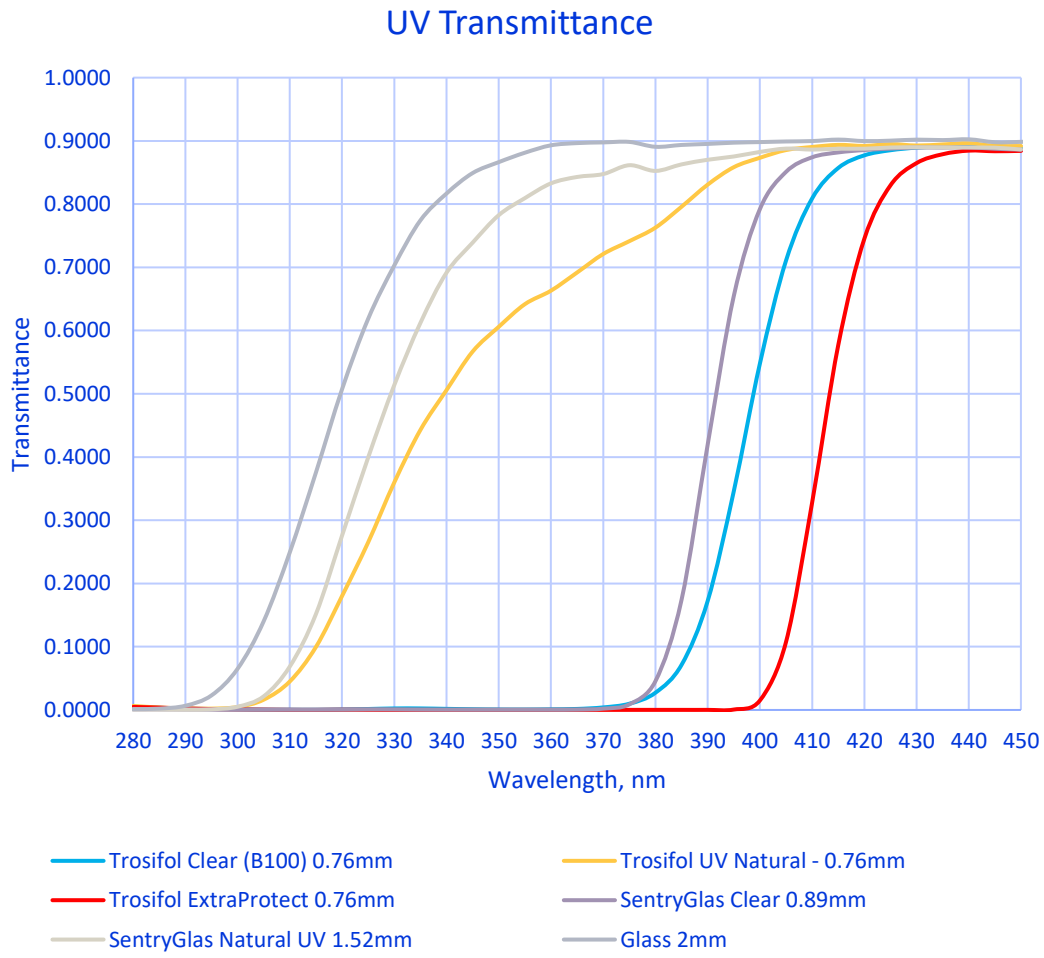
UV light

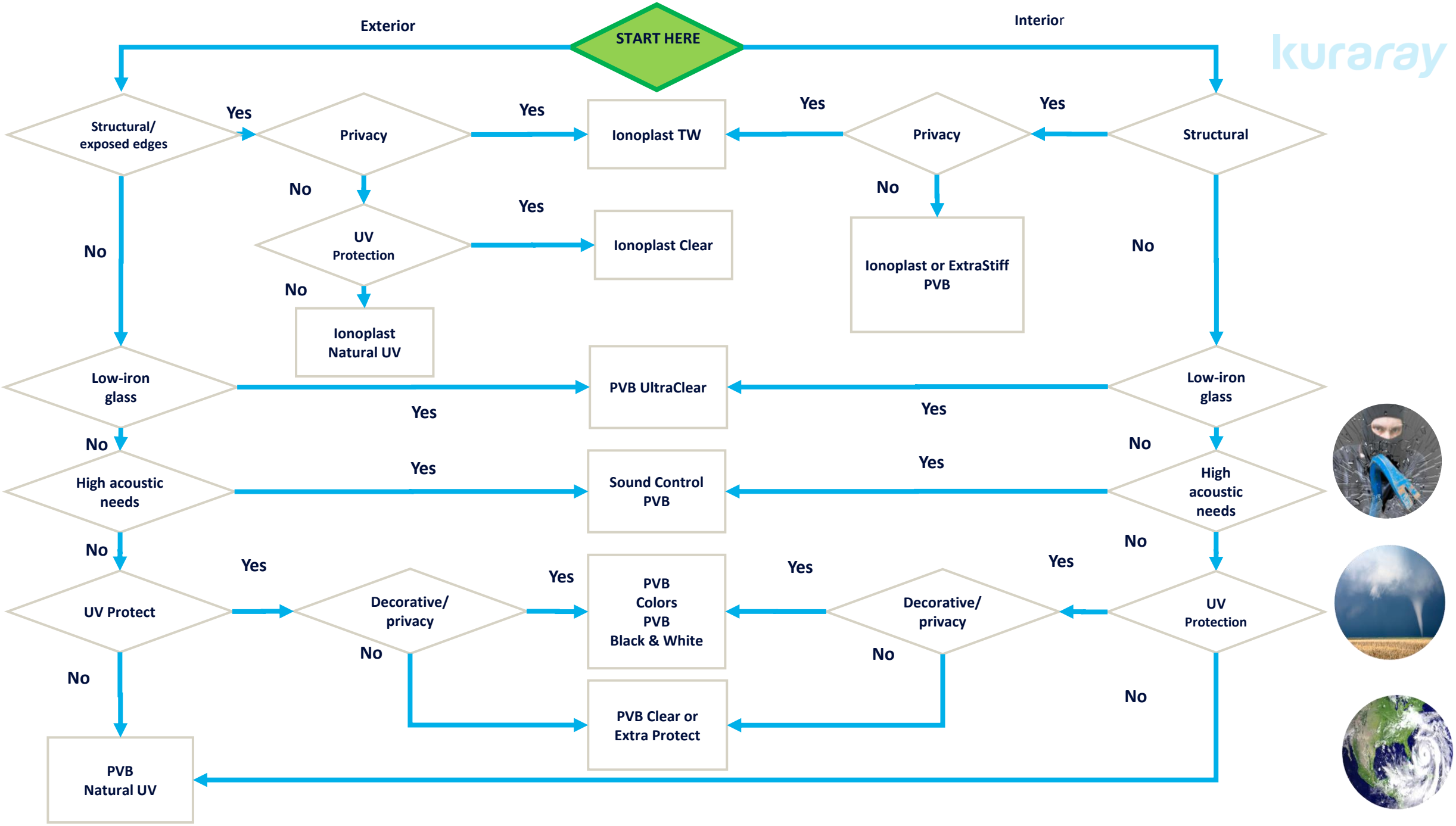
Berlin’s Tropenhaus Botanical Garden



UV Filter

- Ionoplast and PVB interlayers typically filter up to 99% harmful UV rays below 380 nm
- UV exposure contributes to fading of fabrics and furniture
- Option to order ionoplast and PVB interlayers *without* the UV filter when high transmission of UV is desirable
- Option for PVB to filter 100% UV below 400 nm




Exterior
START HERE
Interior
Structural/ exposed edges
Yes
Privacy
Yes
Ionoplast TW
Yes
Privacy
Yes
Structural
No
UV Protection
Yes
Ionoplast Clear
No
Ionoplast or ExtraStiff PVB
No
No
Ionoplast Natural UV
No
Low-iron glass
PVB UltraClear
Yes
Yes
Low-iron glass
No
No
High acoustic needs
Yes
Sound Control PVB
Yes
High acoustic needs
No
No
UV Protect
Yes
Decorative/ privacy
Yes
PVB Colors PVB Black & White
Yes
Decorative/ privacy
Yes
UV Protection
No
No
No
No
PVB Clear or Extra Protect
No
PVB Natural UV

Solution Finder

for finding the
right interlayer
for your laminated
glass application

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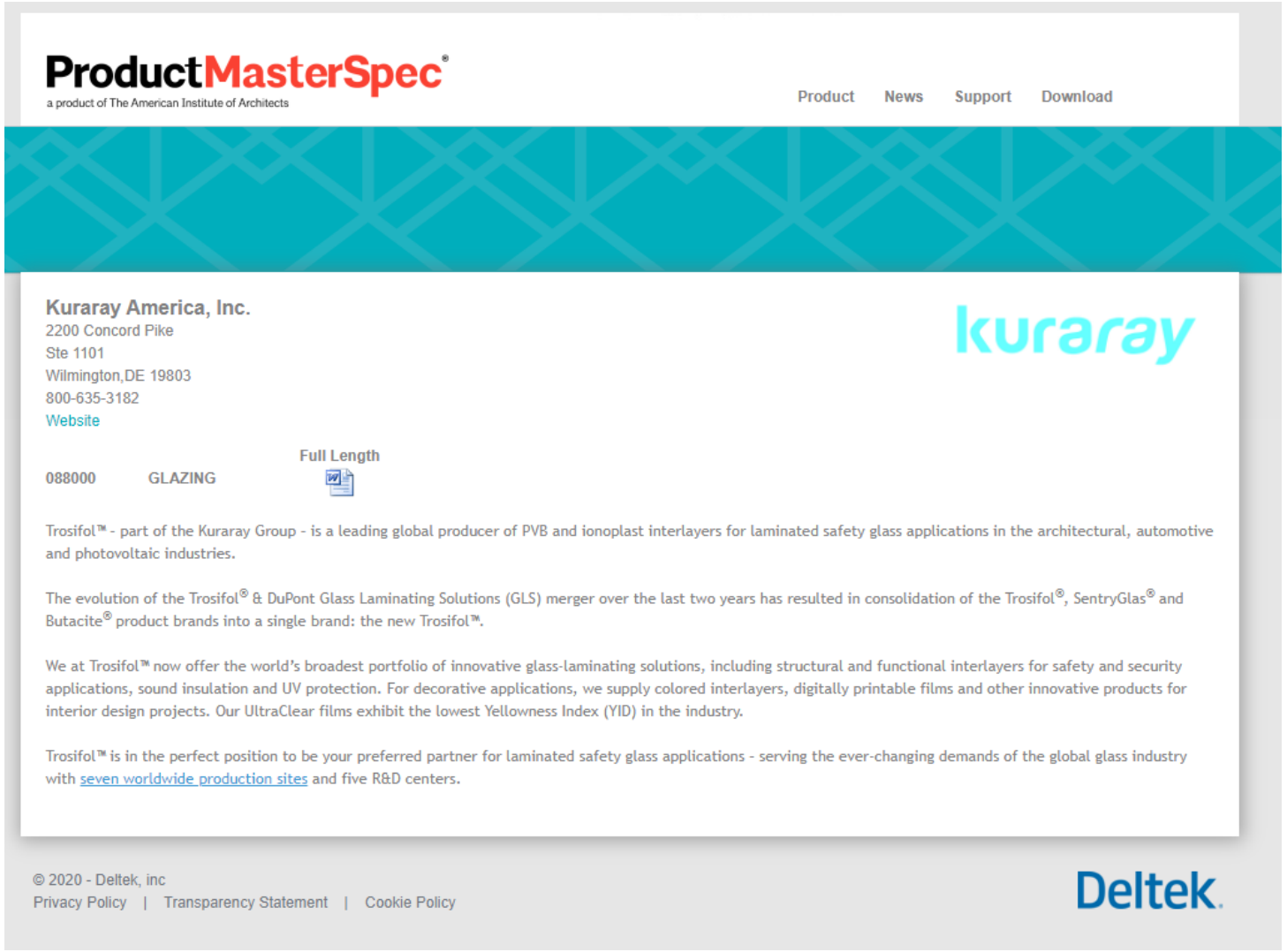
How to specify the interlayer



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088000 GLAZING Full Length

Trosifol™ - part of the Kuraray Group - is a leading global producer of PVB and ionoplast interlayers for laminated safety glass applications in the architectural, automotive and photovoltaic industries.

The evolution of the Trosifol® & DuPont Glass Laminating Solutions (GLS) merger over the last two years has resulted in consolidation of the Trosifol®, SentryGlas® and Butacite® product brands into a single brand: the new Trosifol™.

We at Trosifol™ now offer the world's broadest portfolio of innovative glass-laminating solutions, including structural and functional interlayers for safety and security applications, sound insulation and UV protection. For decorative applications, we supply colored interlayers, digitally printable films and other innovative products for interior design projects. Our UltraClear films exhibit the lowest Yellowness Index (YID) in the industry.

Trosifol™ is in the perfect position to be your preferred partner for laminated safety glass applications - serving the ever-changing demands of the global glass industry with seven worldwide production sites and five R&D centers.

Deltek

Safety glazing specification

A. Glass Type [**GL-<#>**]: Clear laminated glass with two plies of [**annealed**] [**heat-strengthened**] [**fully tempered**] float glass.

1. Basis-of-Design Product: Kuraray America, Inc.; Trosifol Clear.
2. Minimum Thickness of Each Glass Ply: [**3 mm**] [**4 mm**] [**5 mm**] [**6 mm**] [**As indicated**] <**Insert thickness designation**>.
3. PVB Interlayer Thickness: [**0.030 inch (0.76 mm)**] [**0.060 inch (1.52 mm)**] [**0.090 inch (2.29 mm)**].
4. Safety glazing required.

B. Glass Type [**GL-<#>**]: Clear laminated glass with two plies of [**ultraclear annealed**] [**ultraclear heat-strengthened**] [**ultraclear fully tempered**] float glass and ultraclear PVB interlayer.

1. Basis-of-Design Product: Kuraray America, Inc.; Trosifol UltraClear**.**
2. Minimum Thickness of Each Glass Ply: [**3 mm**] [**4 mm**] [**5 mm**] [**6 mm**] [**As indicated**] <**Insert thickness designation**>.
3. PVB Interlayer Thickness: [**0.030 inch (0.76 mm)**] [**0.060 inch (1.52 mm)**] [**0.090 inch (2.29 mm)**].
4. Safety glazing required.

C. Glass Type [**GL-<#>**]: Clear laminated glass with two plies of [**ultraclear annealed**] [**ultraclear heat-strengthened**] [**ultraclear fully tempered**] and ultra-clear ionoplast interlayer.

1. Basis-of-Design Product: Kuraray America, Inc.; [**SentryGlas Ionoplast**] [**SentryGlas Xtra (SGX) Ionoplast**] interlayer
2. Minimum Thickness of Each Glass Ply: [**3 mm**] [**4 mm**] [**5 mm**] [**6 mm**] [**As indicated**] <**Insert thickness designation**>.
3. Ionoplast Interlayer Thickness: [**0.035 inch (0.89 mm)**] [**0.060 inch (1.52 mm)**] [**0.090 inch (2.29 mm)**].
4. Safety glazing required.

Safety glazing examples

Office area – Doors and bottom panels must be safety glazing
Decorative used for writing surface

Shower doors

Structural specification

A. Glass Type [**GL-<#>**] Structural: Clear laminated glass with two plies of [**annealed**] [**heat-strengthened**] [**fully tempered**] [**ultraclear annealed**] [**ultraclear heat-strengthened**] [**ultraclear fully tempered**] float glass and structural interlayer.

1. Basis-of-Design Product: Kuraray America, Inc.; [**SentryGlas Ionoplast**] [**SentryGlas Xtra (SGX) Ionoplast**] [**Trosifol Extra Stiff PVB**].
2. Color: Ultraclear.
3. Minimum Thickness of Each Glass Ply: [**3 mm**] [**4 mm**] [**5 mm**] [**6 mm**] [**As indicated**] <**Insert thickness designation**>.

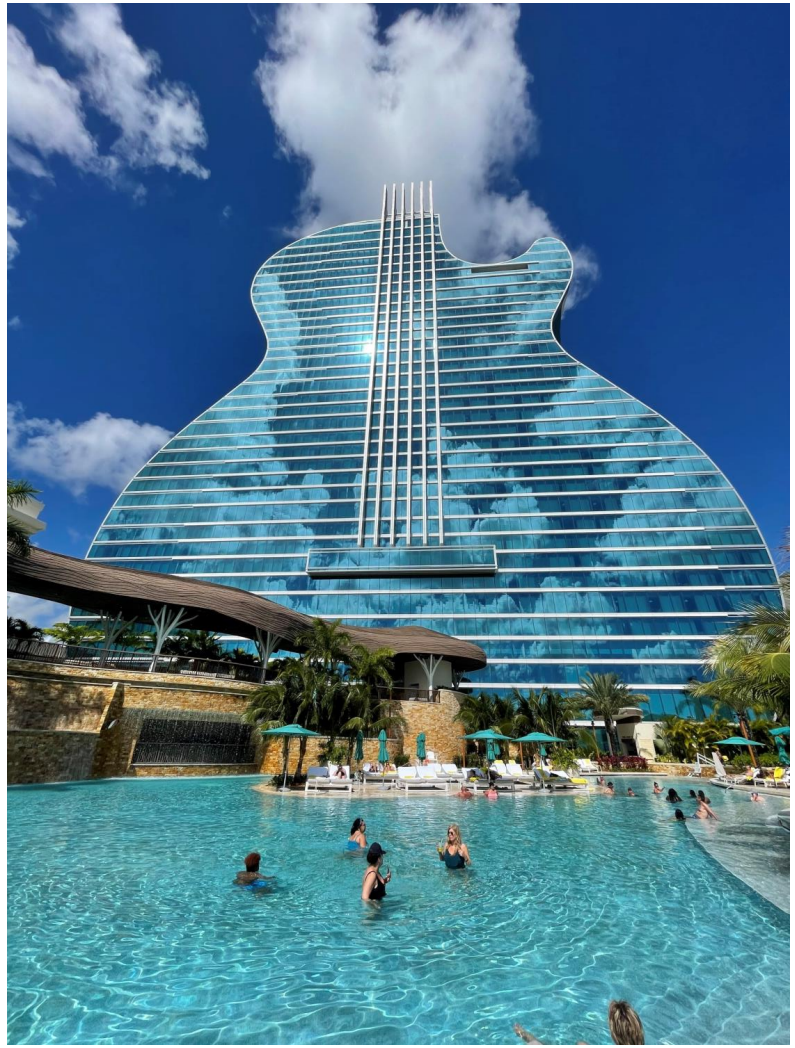
4. Interlayer Thickness: [**0.030 inch (0.76 mm)**] [**0.035 inch (0.89 mm)**] [**0.060 inch (1.52 mm)**] [**0.090 inch (2.29 mm)**].
5. Safety glazing required.

Hurricane specification

A. Glass Type [**GL-<#>**] Hurricane: Clear laminated glass with two plies of [**annealed**] [**heat-strengthened**] [**fully tempered**] float glass and interlayer.

1. Basis-of-Design Product: Kuraray America, Inc.; [**SentryGlas Ionoplast**] [**SentryGlas Xtra (SGX) Ionoplast**] [**Trosifol Clear PVB**]. [**Trosifol Ultraclear PVB**].
2. Minimum Thickness of Each Glass Ply: [**3 mm**] [**4 mm**] [**5 mm**] [**6 mm**] [**As indicated**] <**Insert thickness designation**>.
3. Interlayer Thickness: [**0.030 inch (0.76 mm)**] [**0.035 inch (0.89 mm)**] [**0.060 inch (1.52 mm)**] [**0.090 inch (2.29 mm)**] [**0.180 inch (4.58 mm)**].
4. Safety glazing required.

Hurricane examples



Seminole Hard Rock Hotel and Casino
Hollywood, FL

Wilkie D. Ferguson Federal Courthouse
Miami, FL

Acoustic specification

A. Glass Type [**GL-<#>**] Acoustic: Clear laminated glass with two plies of [**annealed**] [**heat-strengthened**] [**fully tempered**] float glass and interlayer.

1. Basis-of-Design Product: Kuraray America, Inc.; [**Trosifol PVB**] [**Trosifol SC Sound Control**].
2. Color: As selected by Architect from manufacturer's full range of standard colors.
3. Minimum Thickness of Each Glass Ply: [**3 mm**] [**4 mm**] [**5 mm**] [**6 mm**] [**As indicated**] <**Insert thickness designation**>.
4. PVB Interlayer Thickness: [**0.030 inch (0.76 mm)**] [**0.060 inch (1.52 mm)**] [**0.090 inch (2.29 mm)**].
5. Sound Transmission Class (STC): Not less than [**STC indicated in a schedule**] [**36**] [**39**] [**40**] [**41**] [**42**] [**43**] [**44**] [**46**] [**48**] [**49**] [**51**].

Acoustic Examples with sound control interlayer

Pierhouse, Brooklyn, NY

Hoxton Hotel, Chicago

Decorative specification

I. Glass Type [GL-<#>]: Tinted laminated glass with two plies of clear [annealed] [heat-strengthened] [fully tempered] float glass and tinted interlayer.

1. Basis-of-Design Product: Kuraray America, Inc.; Trosifol Colors.
2. Minimum Thickness of Each Glass Ply: [3 mm] [4 mm] [5 mm] [6 mm] [As indicated] <Insert thickness designation>.
3. Interlayer Thickness: [0.030 inch (0.76 mm)] [0.060 inch (1.52 mm)] [0.090 inch (2.29 mm)].
4. Interlayer Color: [Brilliant Black] [Diamond White] [Light Green] [Medium Blue] [Red] [Sand White] [Shining White] [Sky Blue] [Translucent White] [Violet] <Insert color>.
5. Winter Nighttime U-Factor: <Insert value> maximum.
6. Summer Daytime U-Factor: <Insert value> maximum.
7. Visible Light Transmittance: <Insert number> percent minimum.
8. Solar Heat Gain Coefficient: <Insert value> maximum.
9. Safety glazing required.

Decorative examples

Corporate HQ – decorative fins

Store interior

Conclusions

- Laminated glass is used for a wide variety of applications including safety glazing, structural applications, acoustics, decorative and security applications.
- Different properties of interlayers make choosing the appropriate interlayer critical in optimizing glass performance.
- PVB is a good choice for safety glazing, acoustics, and high UV protection.
- Ionoplast is excellent for structural, security, and natural threat protection.
- A new tool is available to aid in the selection of the appropriate interlayer.
- Product MasterSpec® files are available for use. Specifications are also available through BSD.

Thank you.

Keep updated – Laminated Glass News

www.trosifol.com

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Questions?

This concludes the American Institute of Architects
Continuing Education Systems Program

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