


Introduction to Laminated Glass

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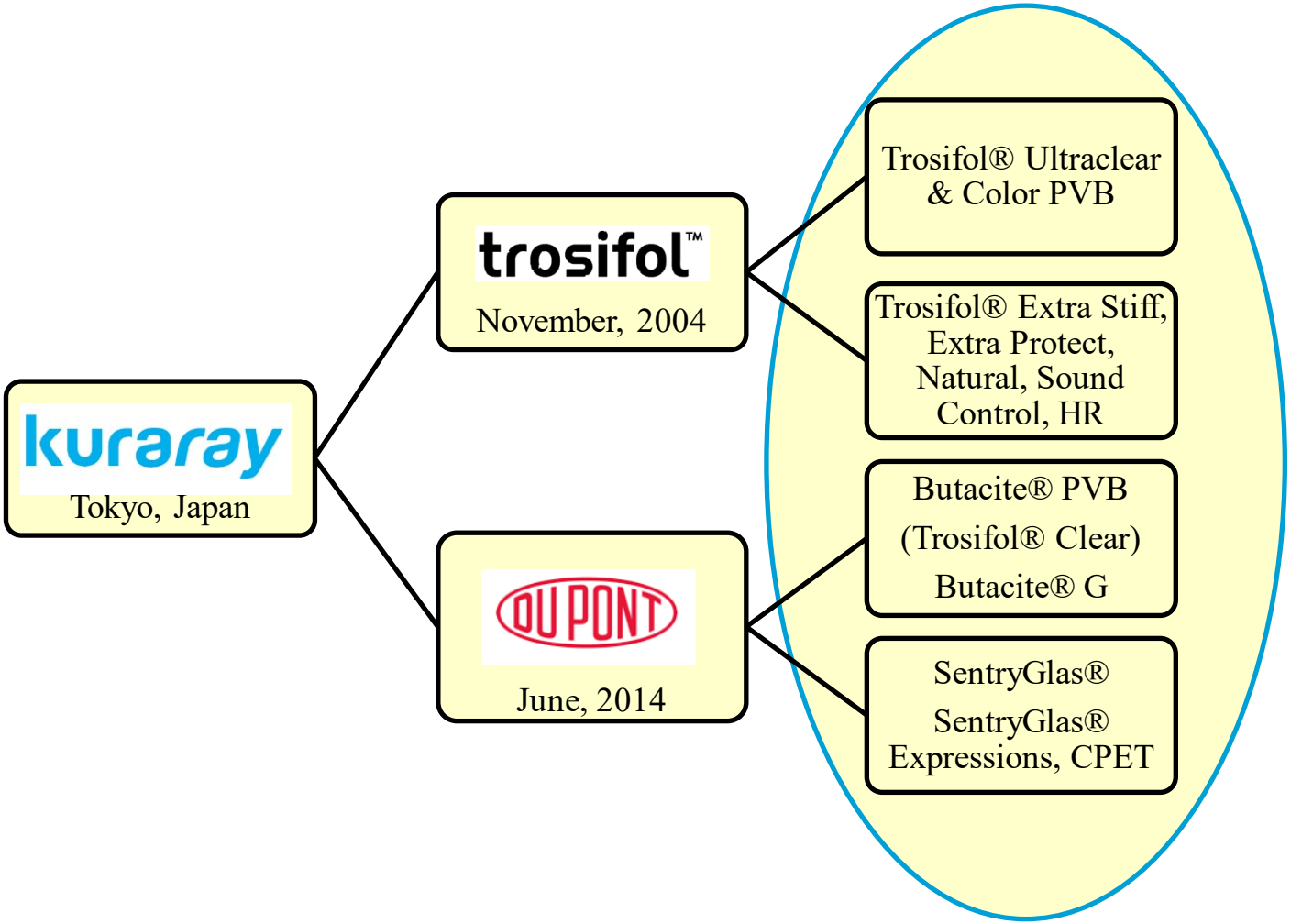
kuraray

Who is Kuraray?



Who is Kuraray?

The broadest laminated glass product portfolio in the industry

TO FIT YOUR GLAZING NEEDS

Safety	Decorative	Acoustic	Structural & Security	Specialized Application	Auto/Trans -portation	Recycled
Trosifol® Clear	Trosifol® Color	Trosifol® Sound Control	Trosifol® Structural	Trosifol® Specialized	Trosifol® Clear	Butacite® G
Trosifol® UltraClear	Trosifol® Tints	— Trosifol® SC Monolayer	— SentryGlas®	— Trosifol® HR	Trosifol® Shadeband	
	Trosifol® Black & White	— Trosifol® SC Multilayer	— SentryGlas® Natural UV	— Trosifol® UV Extra Protect	Trosifol® Color	
			— SentryGlas® Xtra™	— Trosifol® Natural UV	Trosifol® Spallshield® CPET	
			— SentryGlas® Translucent White	— Trosifol® XT	SentryGlas®	
			— Trosifol® Extra Stiff	— SentryGlas® Natural UV	Trosifol® Acoustic	
			Trosifol® Hurricane Glazing	— Spallshield ® CPET	Trosifol® The Wedge	

Kuraray = our company name, based in Japan
PVB = Trosifol®
Ionoplast = SentryGlas®, SentryGlas Plus, SGP, SG

Kuraray AIA Lunch & Learns

AIA LUNCH & LEARNS

Program Number and Title

- **KUR2004.21 Introduction to Laminated Glass**
- **KUR2008.21 Designing with Structural Laminated Glass Interlayers**
- **KUR2011.21 Enhancing Security with Laminated Glass**
- **KUR2013.21 Designing Safer Glass Railings with Laminated Glass**
- **KUR2016.21 Extraordinary Laminated Glass Projects: Designing with Structural Interlayers**
- **KUR 2017 From Vision to Realization: Challenges in the Re-development of the Seattle Space Needle**
- **KUR 2018 Designing Glazing for Wind-borne Debris Protection**
- **KUR 2019 Laminated Glass for Sound Control**

Length: 60 minutes
Credits: 1.0 learning credit
HSW: Yes

Best Practice

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Learning Objectives

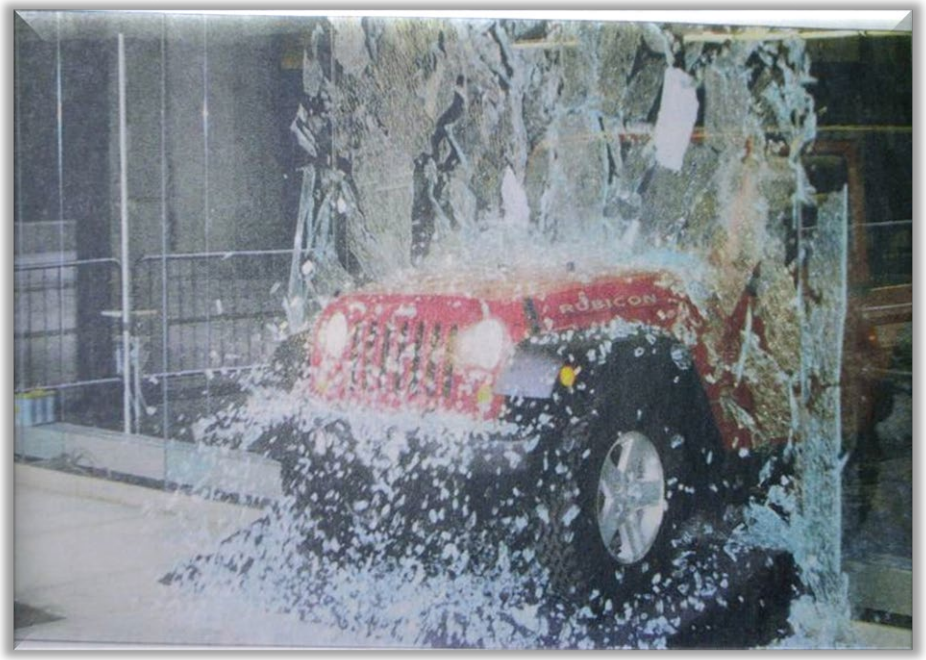
- Learn about different laminated glass interlayers and the benefits of each type of interlayer.
- Learn about how laminated glass can contribute to the safety, health, welfare and happiness of the inhabitants of the buildings (reduced noise, security and intrusion resistance & blast).
- Learn about the Miami Dade and Florida building codes and how laminated glass helps protect buildings and inhabitants from significant damage and injury during hurricanes and tornados.
- Learn about how laminated glass interlayers can be recycled to reduce environmental waste and how they protect materials inside buildings from fading and having a longer life cycle.
- See project-specific examples.

Glass is a fantastic material…

Louis Vuitton, Paris

Shanghai Tower

…but sometimes it breaks.



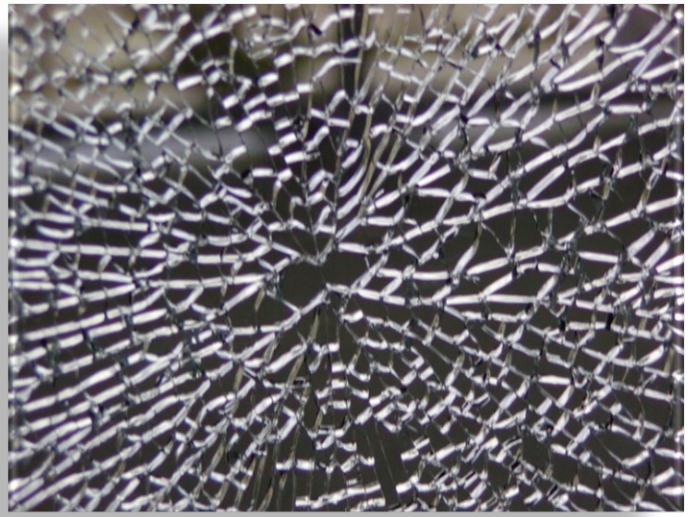
Wikipedia, building in Texas after a Tornado

Spontaneous Glass Breakage

Types of Glass

- Annealed Glass
  - Made on the float glass lines
- Heat-strengthened
  - Annealed glass is reheated and cooled to produce surface compression between 3500-7500 psi
  - 2x the mechanical strength of annealed glass

- Tempered
  - Annealed glass is reheated and rapidly cooled to produce a surface compression >10,000 psi
  - 4x the mechanical strength of annealed glass

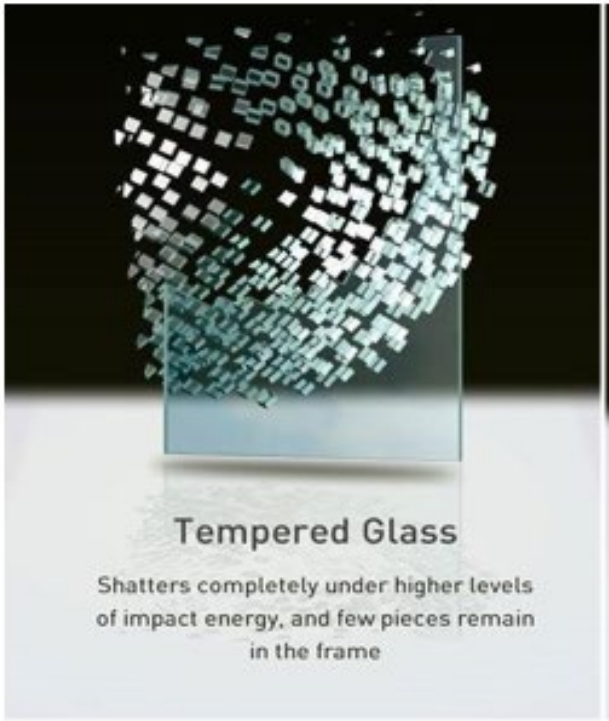


Types of Glass

From annealed glass to safety glass: Failure mode improvement

Annealed Glass

Breaks easily, producing long, sharp splinters



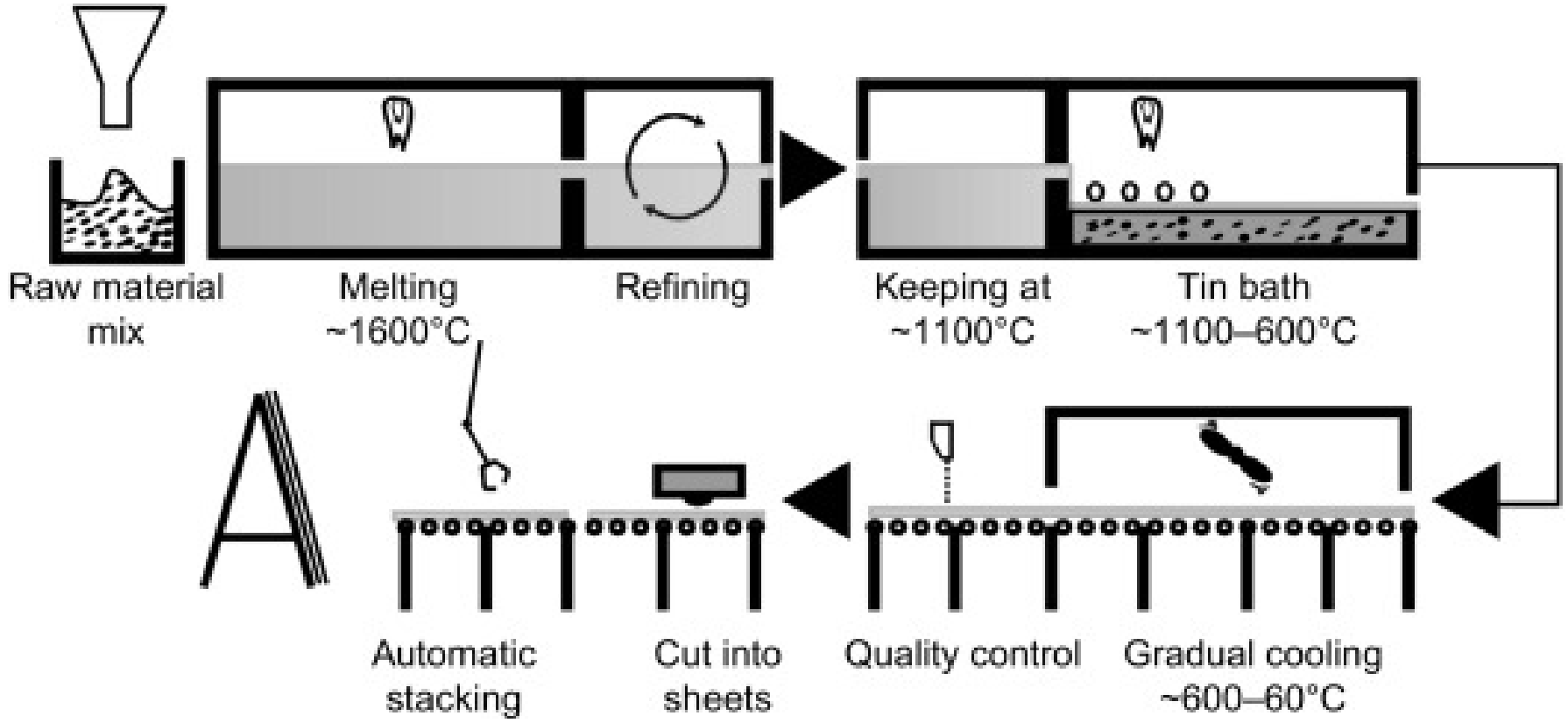
Tempered Glass

Shatters completely under higher levels of impact energy, and few pieces remain in the frame

Laminated Glass

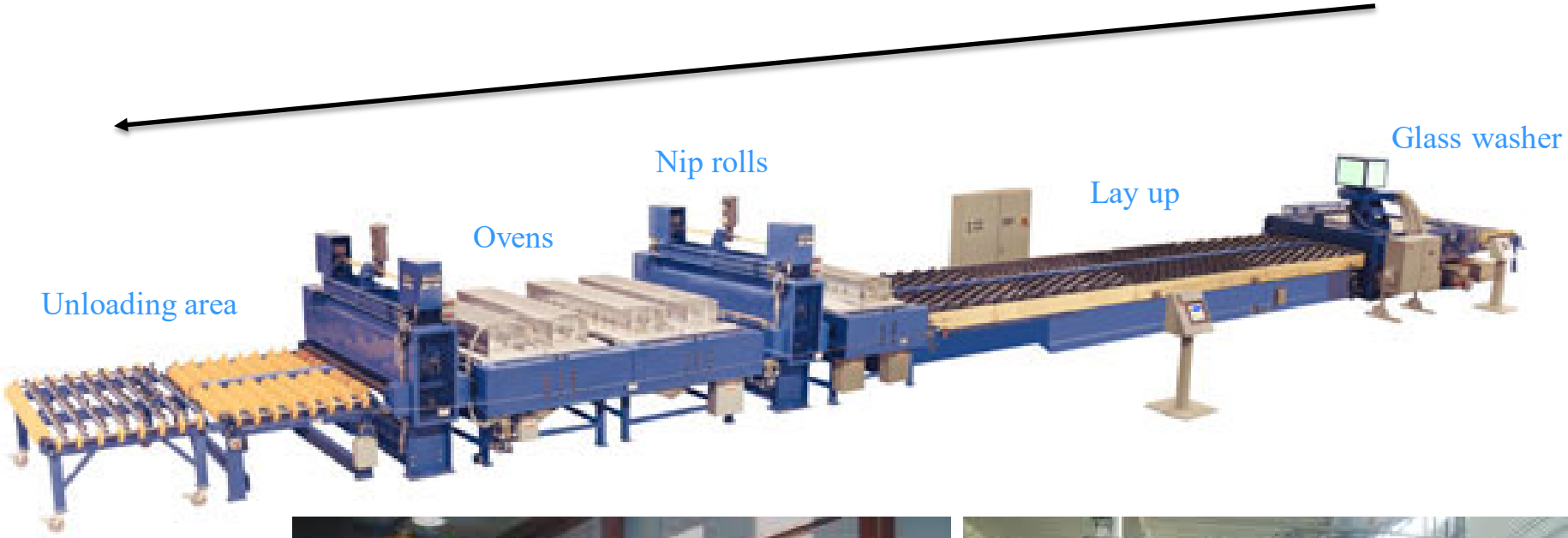
May crack under pressure, but tends to remain integral, adhering to the plastic vinyl interlayer

Typical Glass Float Glass Line



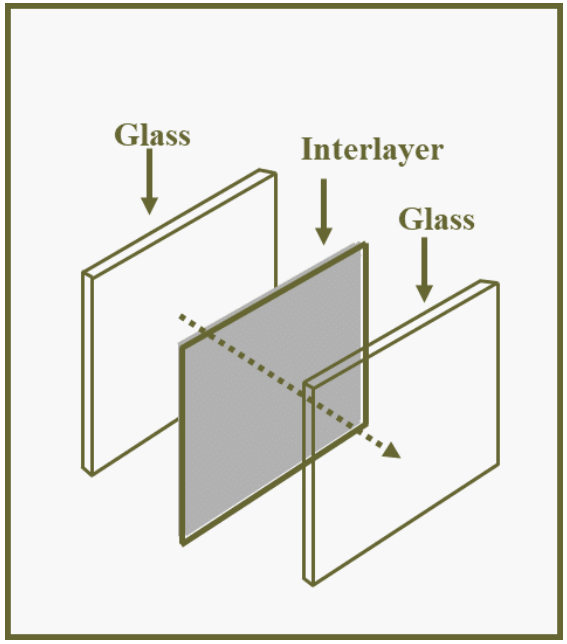
Float glass uses common glass-making raw materials, typically consisting of sand, soda ash (sodium carbonate), dolomite, limestone, and salt cake (sodium sulfate) etc.

Typical Glass Fabrication Laminating Line



What is Laminated Glass?

- Two or more lites of glass and one or more interlayers.
- Types of interlayers
  - Polyvinyl butyral (PVB)
  - Ionoplast
- Benefits
  - Safety Glass - retention if breakage occurs
  - Noise dampening
  - UV protection
  - Intrusion resistance
  - Post breakage strength



Glass for Lamination

- **Annealed Glass**
- **Curved Glass**
- **Heat Strengthened Glass**
- **Tempered Glass**
- **Chemically-Strengthened Glass**
- **Wired Glass**
- **Patterned Glass**
- **Coated Glass**
- **Mirrors**
- **Spandrel**
- **Fritted Glass**

Note: Hole-drilling and edge polishing of heat strengthened, and tempered glass must be done prior to heat treating

Trosifol PVB – Polyvinyl Butyral

History

- PVB interlayers developed in the 1930s for automotive windshields
- Laminates were designed to take a single impact
- Interlayer does not crack, craze, or degrade over time

Architectural

- Standard Clear PVB – largest volume
- Available in rolls up to 130”
- Thickness - multiple of 0.015”
  - 0.015”, 0.030”
  - 0.045”, 0.060”, 0.090”

Polyvinyl Butyral (PVB)

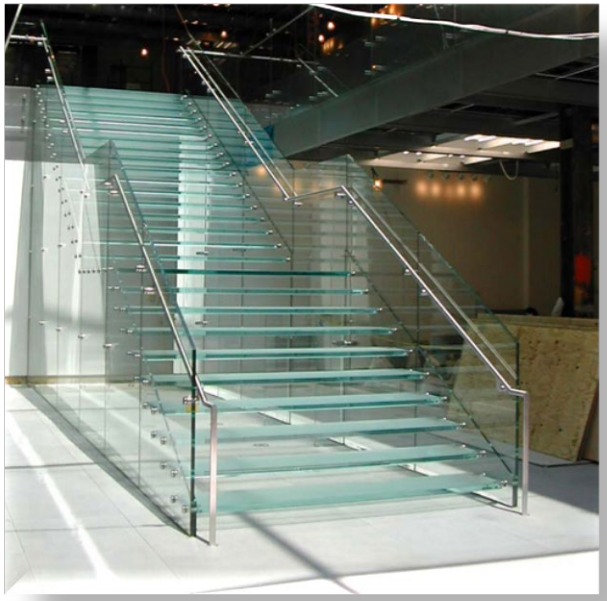
- Solid sheeting interlayer sold in rolls
- UV filtration up to 99% (prevent fabrics from fading)
- Noise reduction due to “damping” properties of interlayer
- Variety of thicknesses and colors
- Meets safety glazing standards

Colors & Tints

- **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

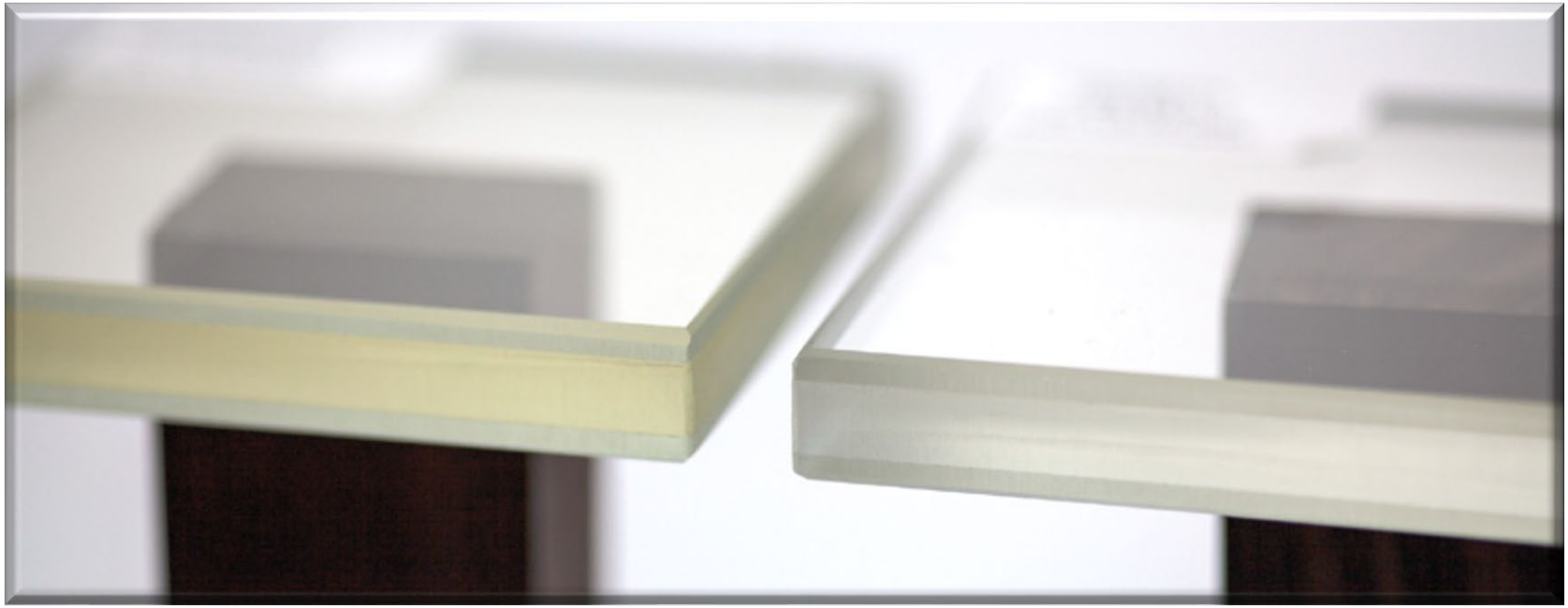
Ionoplast Interlayers

- Developed 20+ years ago for the windborne debris regions – especially for higher wind zones and larger pieces of glass (> 30 ft2).
- The most popular interlayer for structural glass applications.
- 100x stiffer & 5x more tear resistant than PVB.
- Available in clear or translucent white.
- Enhanced post breakage performance and excellent open edge stability.
- Filters up to 99% UV below 380 nm.
- Available in 130” widths, sheets and rolls



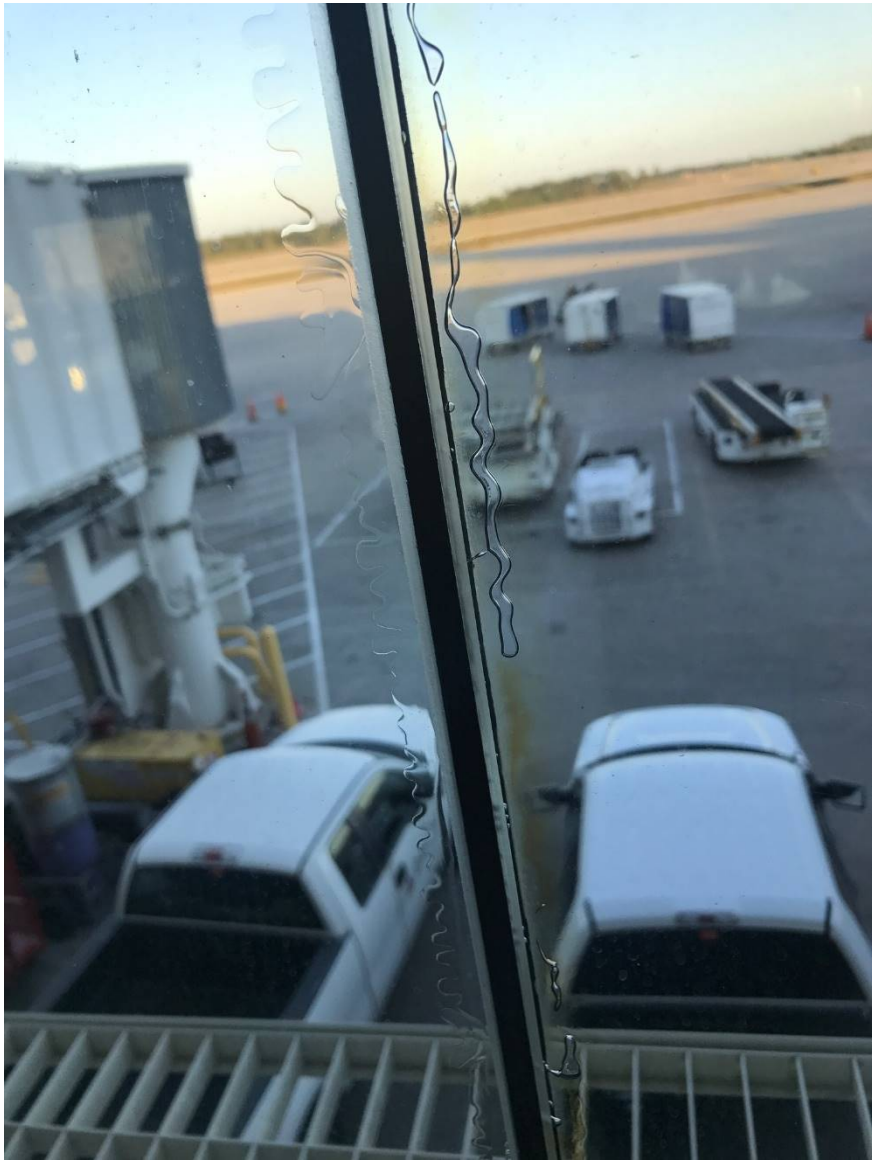
Interlayer Yellowness

- Standard clear PVB has a natural yellow tint that is noticeable with low iron glass and open edges.
- We now have a PVB that has less yellowness to be used with low-iron glass.
- Ionoplast is ultraclear and has the lowest yellowness.



Compatibility of Coatings, Sealants, & Frits

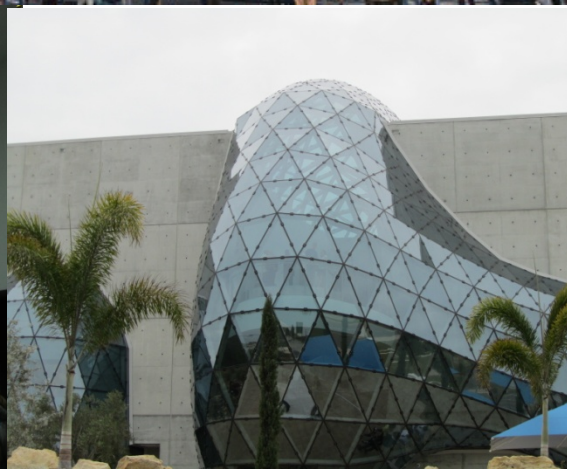
Laminated Glass Interlayers – Edge Defects



Laminated Glass Interlayers – Edge Defects

Laminated Glass Interlayers – Edge Defects

Ionoplast Laminates



Architectural Uses for Laminated Glass

Safety Glazing

- **Hazardous locations including doors, glazed panels, glazing in shower and bath enclosures**
- **Laminated glass tested to Consumer Product Safety Commission standard 16CFR 1201**
- **ANSI Z97.1 - 400 foot-pound impact test**

UV Resistance

- Additive in interlayer blocks up to 99% harmful UV rays to 380nm
- Helps to reduce fading of fabrics and other interior furnishings
- PVB's also available to provide extra protection up to 400nm and with no UV protection (for Greenhouses, aquariums, etc)

Natural UV option

- **When UV is required, ionoplast and PVB interlayers can be ordered without UV filter**
- **Especially critical for plants, some animals, aquatic life and insects**

Tropenhaus Botanical Garden, Berlin

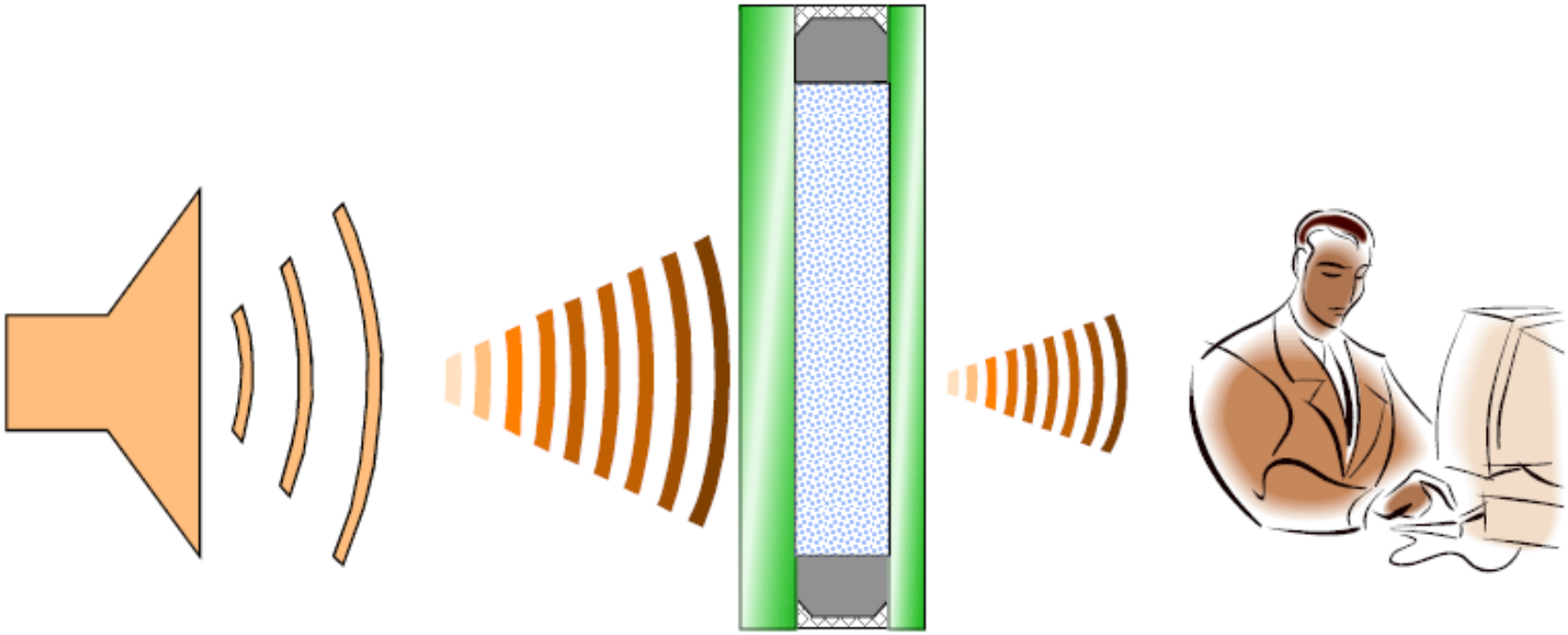
Improved Acoustic Needs

- **Noise in urban areas is increasing**
- **More people are living in cities and by highways & airports**
- **More stringent noise building codes in many metropolitan areas**
- **International Green Construction Code (IGCC) addresses acoustics**
- **LEED® credits are awarded for acoustical improvements**
- **The WELL Building Standard™ establishes requirements designed to create distraction-free, productive and comfortable indoor environments**
- **Thus, building owners and architects are asking for better acoustical control for improved occupant comfort**

**** Acoustics is now one of the main requests that we receive from architects and engineers**

What does acoustic insulation mean?

„Heights of the waves“ must be reduced quickly!



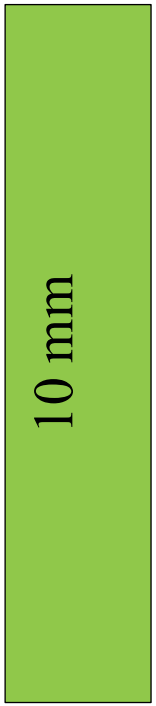
Sound Transmission Loss Factors

Factors that influence Sound Transmission Loss:

1. **Mass**
   - **Thicker glass constructions can improve acoustic glazing performance**
   - **Asymmetric glass may also help improve acoustic in some constructions**
2. **Air Space in an IGU**
   - **The larger the air space, the better the acoustics**
3. **Stiffness/Damping**
   - **Laminated glass interlayers can provide damping**
   - **The softer the interlayer, the better the sound damping**

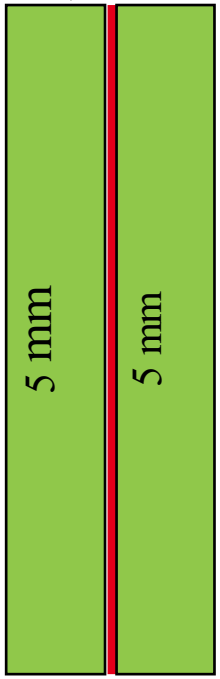
How can I achieve noise insulation with monolithic glass, reduce weight of the construction and save costs?

Monolithic glass



STC = 33

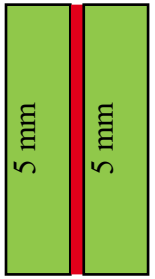
Laminated glass
0,76 mm



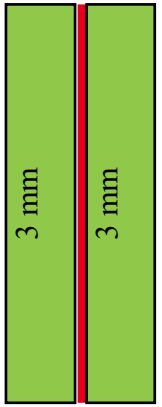
STC = 35

PVB

Acoustic laminated glass
0,76 mm



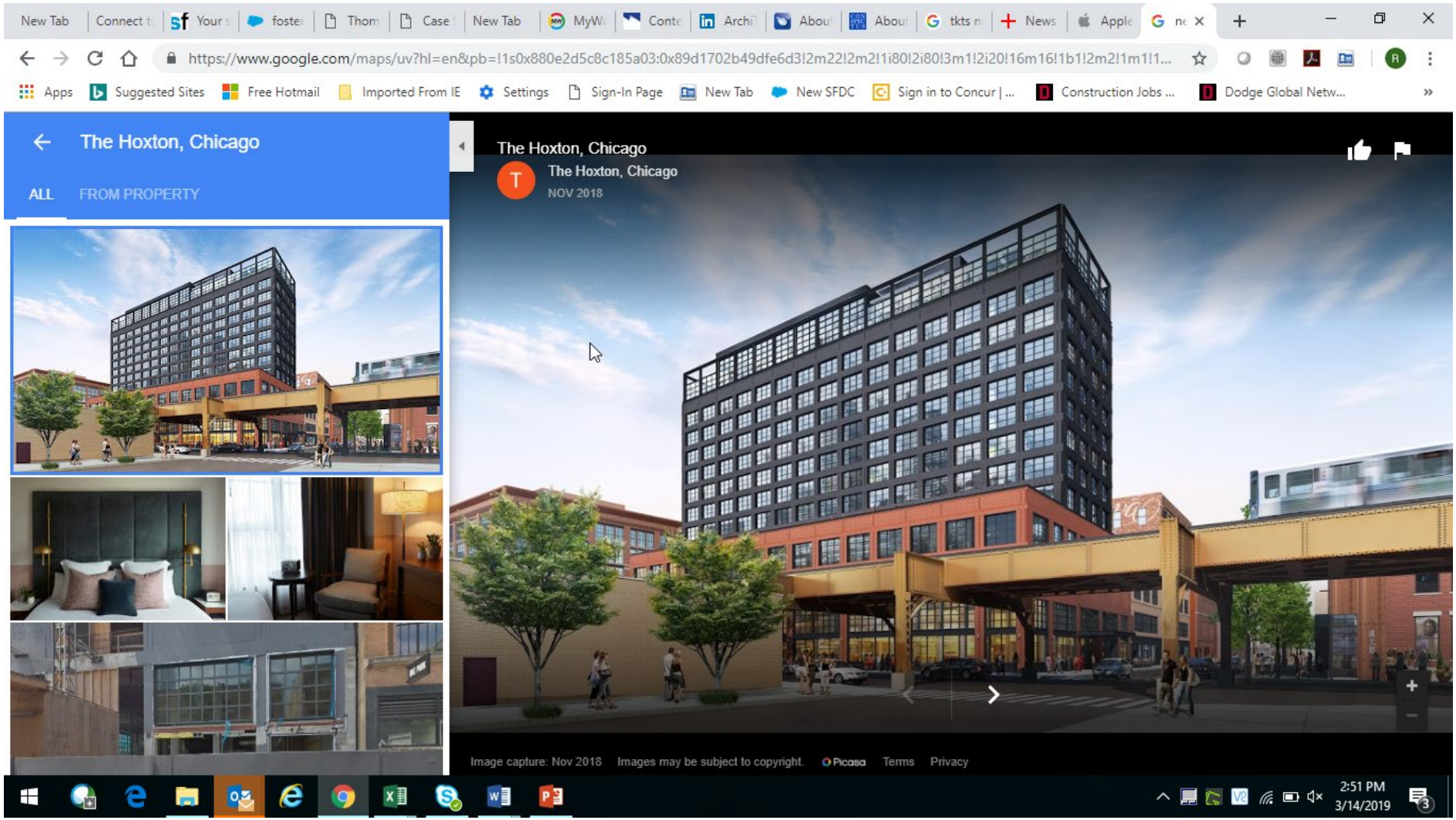
STC = 38



STC = 36

Sound Control PVB

Hoxton Hotel - 200 N Green Street, Chicago, IL



9/16” lami with acoustic PVB + 49/64 spacer + 7/16” lami with acoustic PVB.

Sound Reduction
Hoxton Hotel, Chicago
Window Open vs. Window Closed

Structural Glass

- Facades
- Skylights
- Glass roofs
- Stair treads
- Glass bridges
- Canopies
- Railings

Big Glass - Retail Store

Aventura Mall

Miami, FL

Big Glass - Retail Store

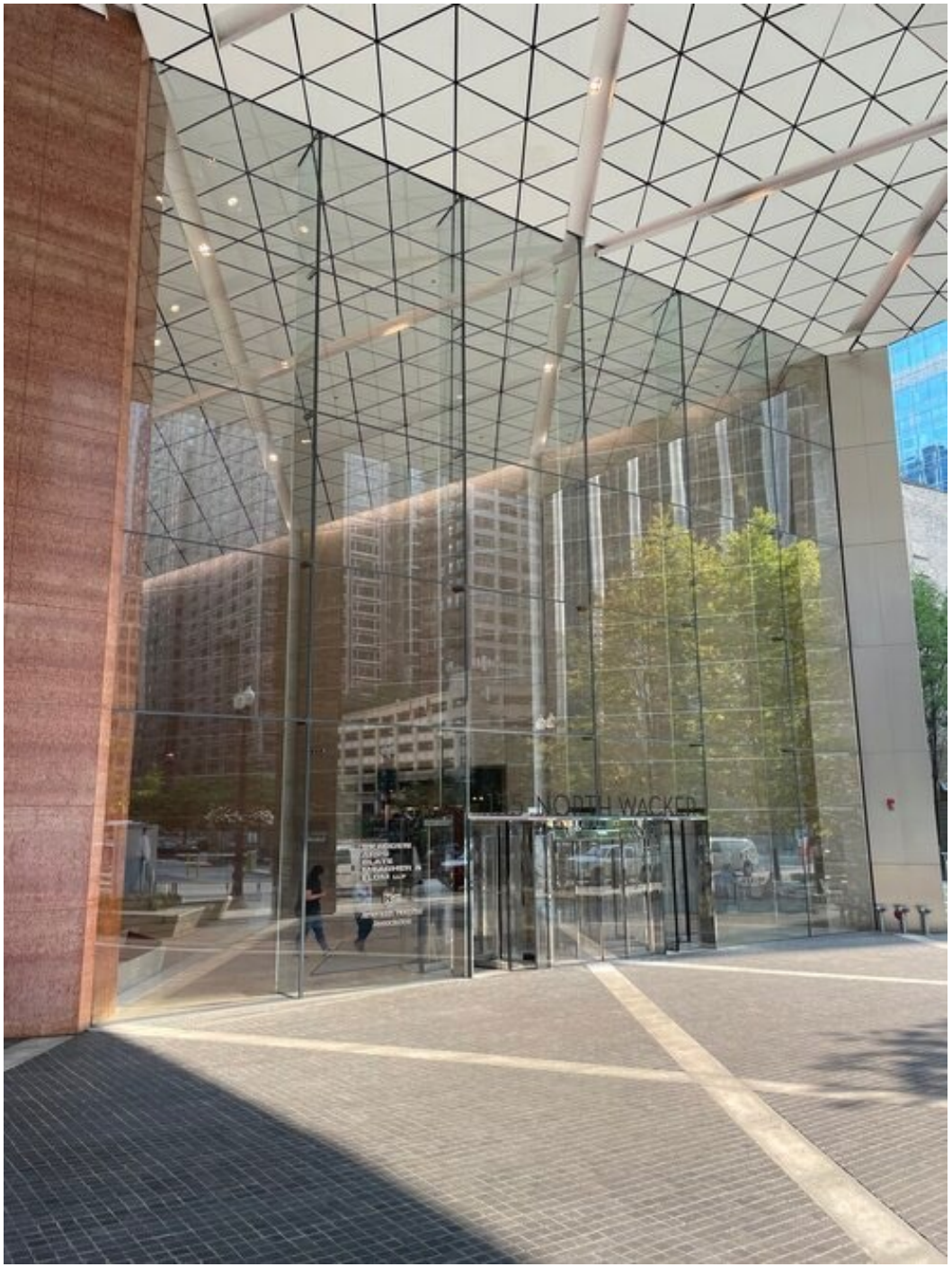
Chicago

Big Glass

- On August 6, 2021, Tianjin NorthGlass certified by the Guinness Book of World Records the world largest glass window, The unit glass window area reached 50.869 square meters.
- According to architectural firm Pelli Clarke Pelli Architects, the window belongs to Taikang Headquarters, among the tallest skyscrapers in Beijing.
- **The window measures about 547 square feet, 54 feet, 3 inches tall and 10 feet, 10 inches wide.** It consists of four layers of glass with an air space in between. The total thickness of the glass window is 2.6 inches and it weighs about 15,430 pounds.

155 N. Wacker

Chicago, IL



Facades

- Traditional & minimally supported façade systems
- Missile impact facades and storefront systems
- Cable net walls

Bolted glass facades

- **Point-supported**
- **Low iron glass curtain wall**

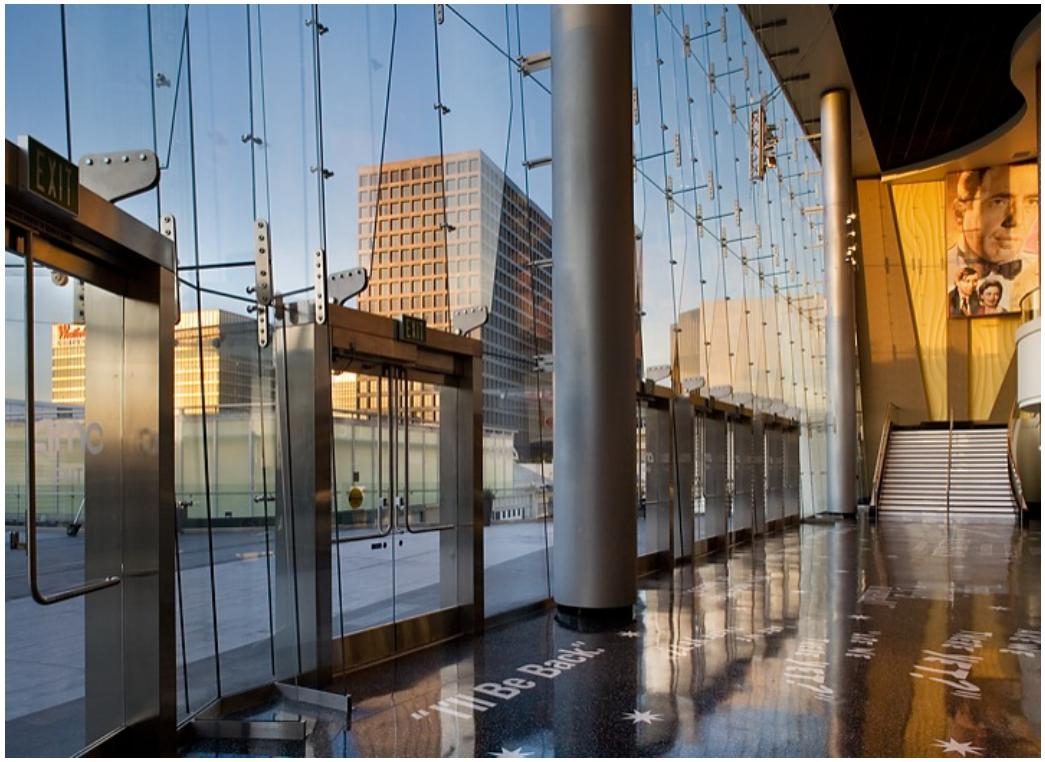
Ennead Architects, New York

Sunscreens and Rain Screens

Soka University

- **University of Baltimore Law School**

Laminated Glass Fins



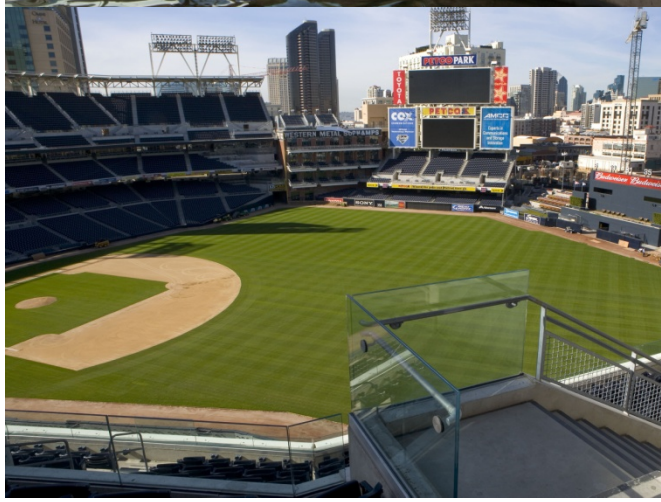
- **Interior or exterior applications**
- **Narrow profiles**
- **Edge durability**
- **Post-glass breakage safety**

Skylights

- IBC requires laminated glass with a minimum 30-mil PVB interlayer (or equivalent) to prevent glass fall out
- Skylights provide natural light
- Popular design feature in many architectural settings

Glass Railings

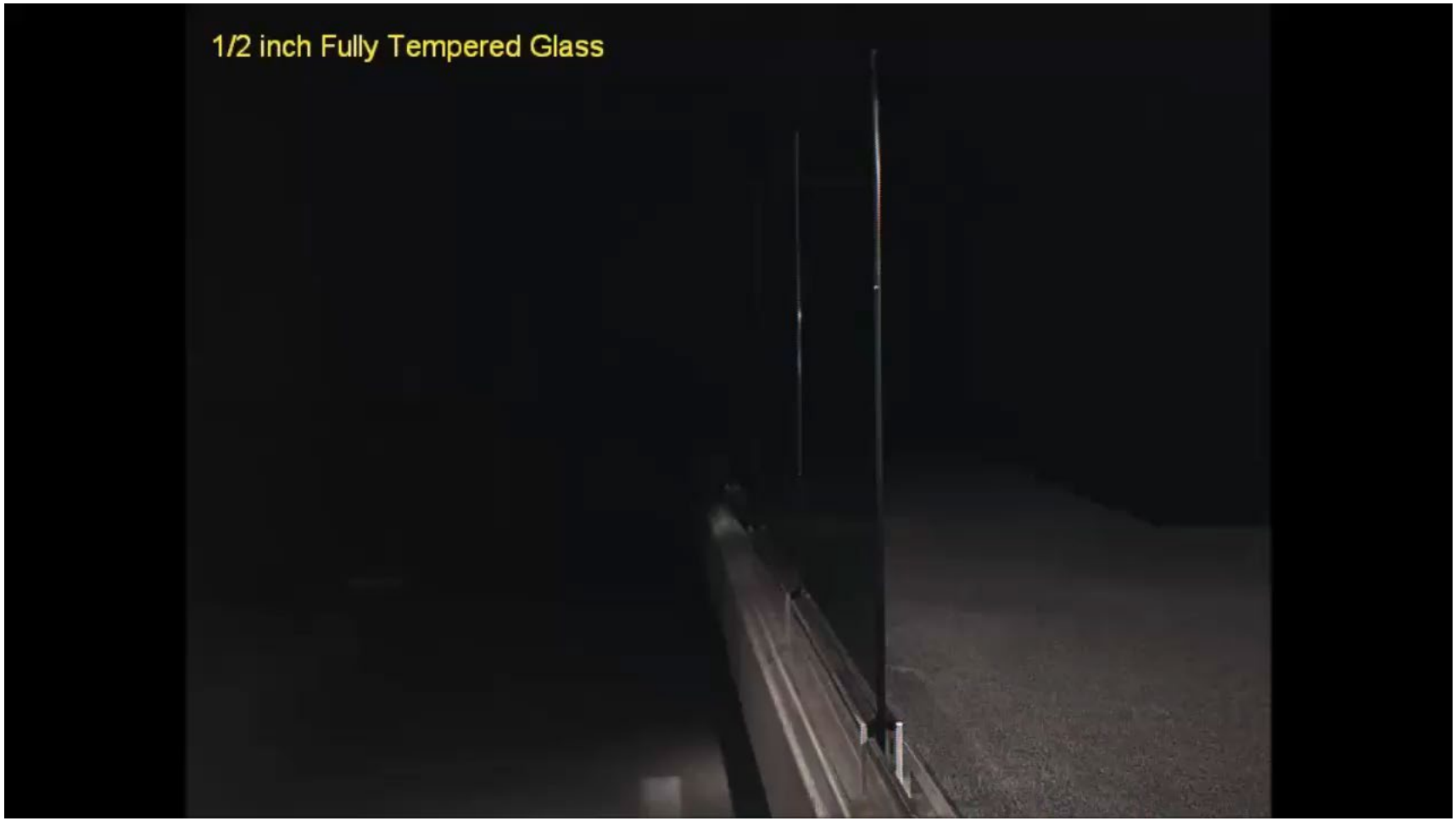
- IBC 2015 requires Heat-strengthened and tempered laminated glass
- Laminated glass provides glass retention after breakage
- Laminated glass required in windborne debris areas
- Laminated glass required for structural glass railings



Canopies

- Laminated glass provides safety from falling glass
- Translucent, colored, and decorative laminated interlayers and glass, provide variety of design choices

Glass Railing Testing



Glass Railing Testing

Viewing platforms

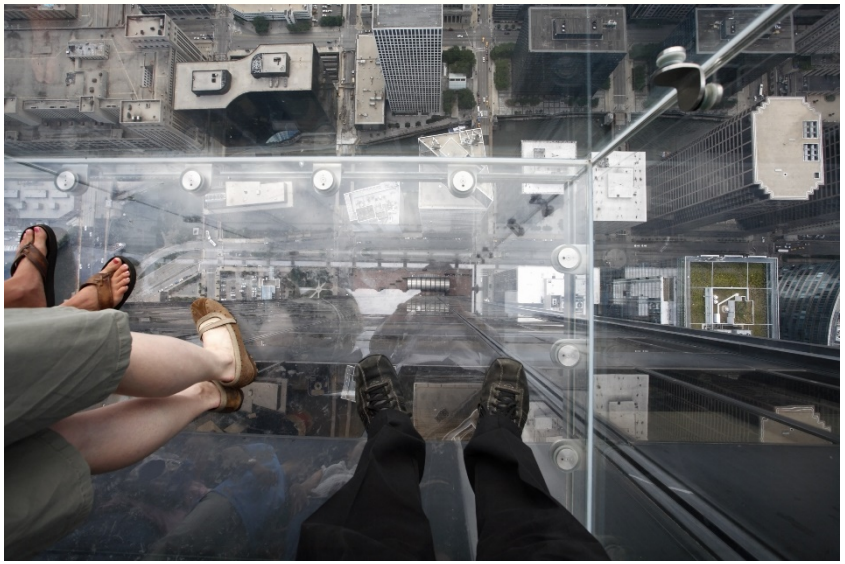
The Ledge, Chicago

Architect:
SOM

Engineer:
Read Jones Christofferson Engineering,

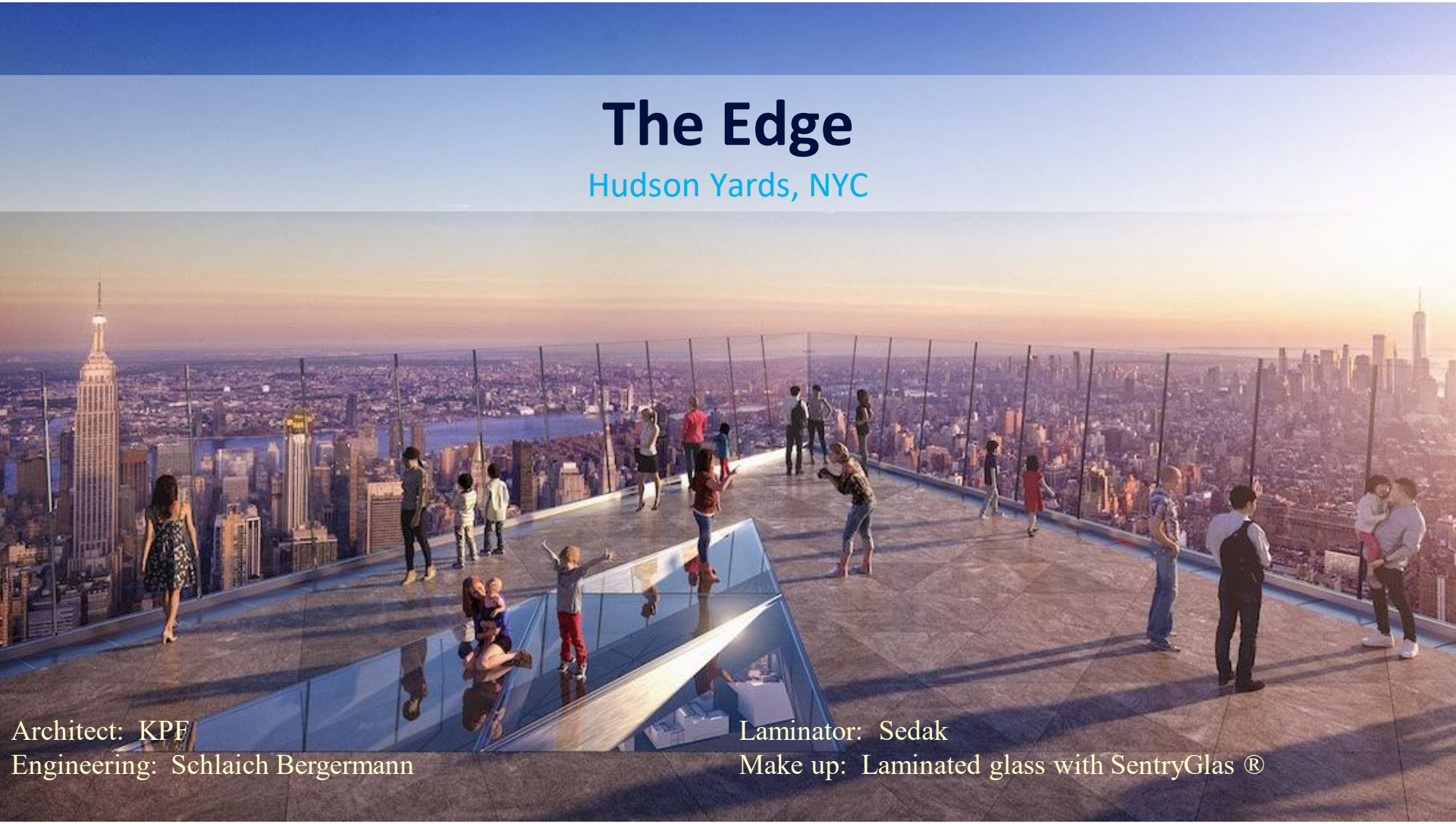
Installation:
MTH

Interlayer:
SentryGlas® 1.52 mm / 60 mil



The Edge

Hudson Yards, NYC



Architect: KPF
Engineering: Schlaich Bergermann

Laminator: Sedak
Make up: Laminated glass with SentryGlas ®

Viewing platforms

Stair Treads

Apple Store, New York

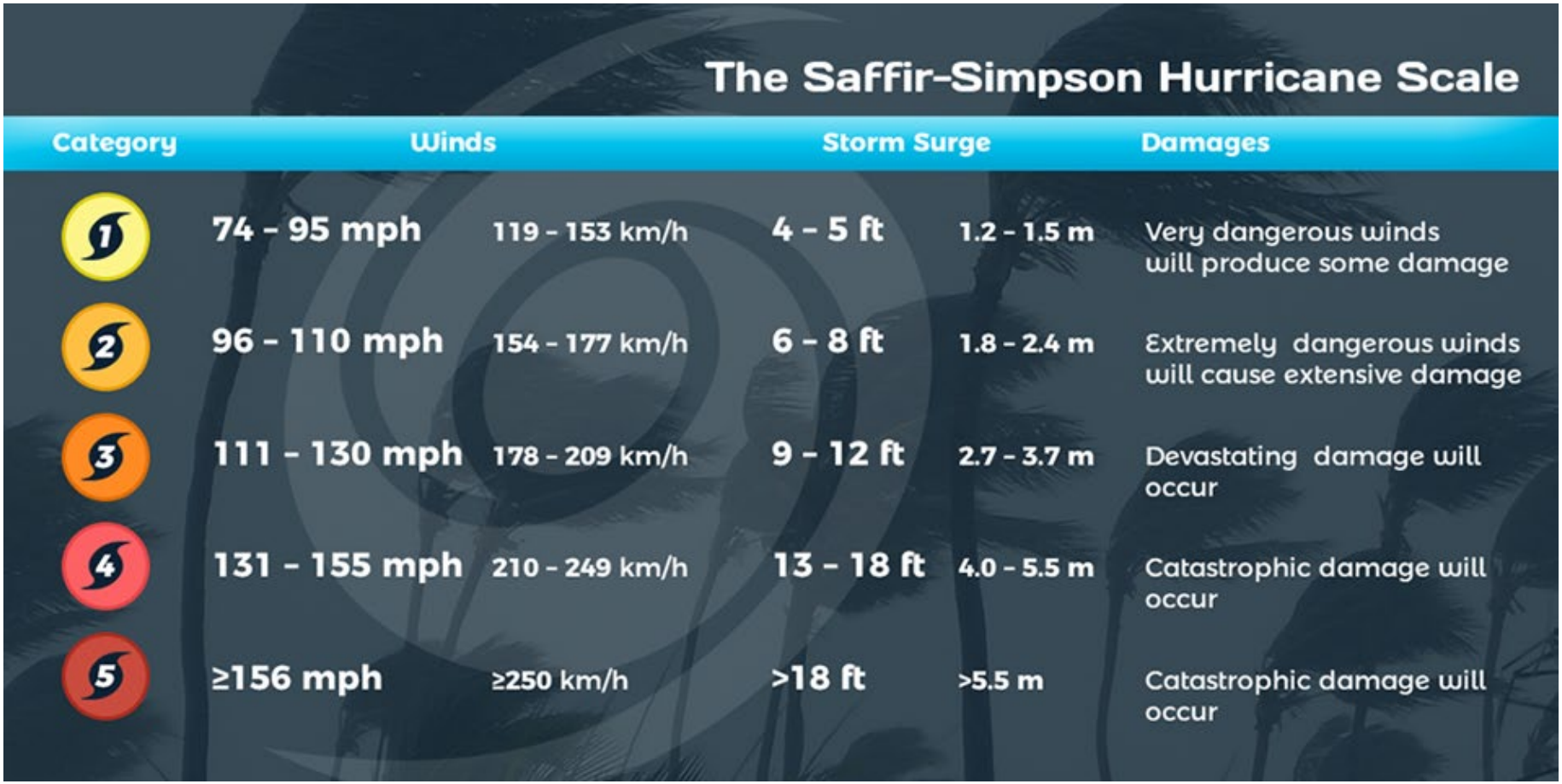
Apple® Store (Soho)

103 Prince Street

Architect: Bohlin Cywinski Jackson
Engineering: Dewhurst Macfarlane

Laminator: Sedak
Laminated stair treads and railing with SentryGlas®

Hurricane Wind Scale



Effect of Hurricane Andrew (1992)

- **Many insurance companies left the state of Florida**
- **Miami Dade County developed new performance requirements for windows, doors, storefronts, curtain walls, and skylights, as well as storm shutters based on testing**
- **Certification program adopted to qualify systems**

Hurricane Andrew aftermath

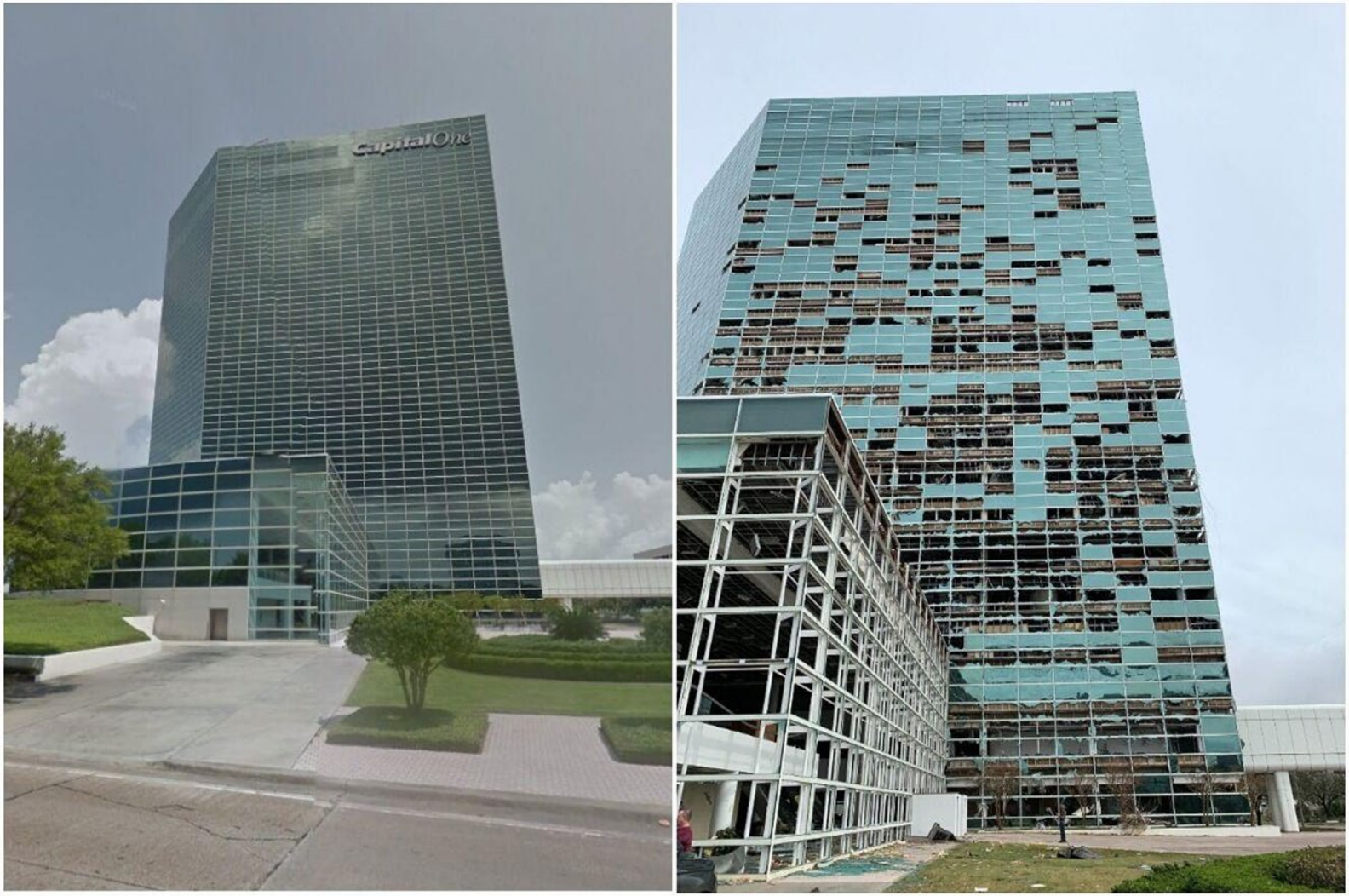
Hurricane Andrew estimated damage $26.5 billion
Hurricane Wilma estimated damage $29.4 billion
Hurricane Katrina estimated damage $135 billion
Hurricane Sandy estimated damage $32 billion

Hurricane Maria (2017) – Puerto Rico

Hurricane Michael (October, 2018) – FL Panhandle

Hurricane Michael (October, 2018) – FL Panhandle
"Home still standing" - Hurricane resilience

Hurricane Laura (2020) – Lake Charles, Louisiana Hurricane resilience



Wind speeds --- Florida Building Code

- Wind zone 1 130 mph ≤ Ultimate design wind speed < 140 mph
- Wind zone 2 140 mph ≤ UDWS < 150 mph at greater than one mile from the coastline
- Wind zone 3 150 mph ≤ UDWS <170 mph and within one mile of the coastline
- Wind zone 4 UDWS > 170 mph

* Irma had wind speeds > 200 mph

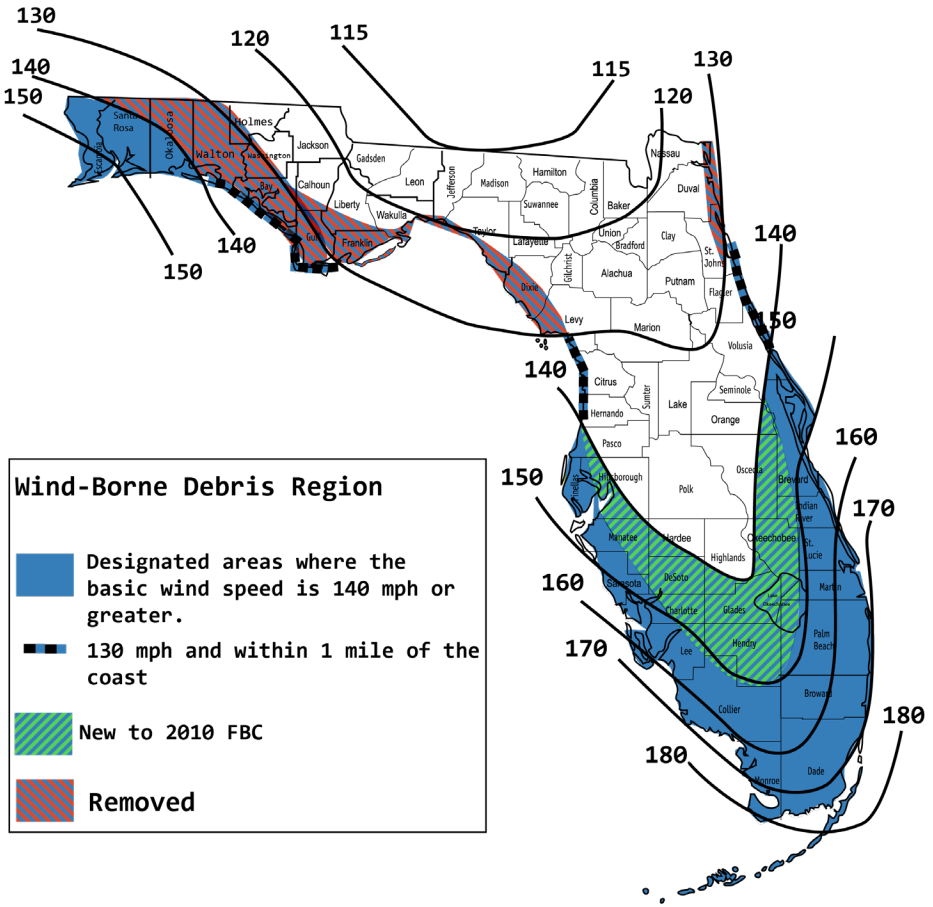


Figure 1609A Wind-Borne Debris Region, Category II and III Buildings and Structures except health care facilities

Hurricane 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

Hurricane Building code requirements

- Miami Dade Building Code (Miami-Dade & Broward)
  - Issues Notices of Acceptance (NOA)
  - Reference TAS 201, 202, 203
- Florida Building Code
  - Regulates impact protection according to wind zone
  - References SSTD 12, ASTM E1886/E1996, TAS 201, 202, 203
  - Product approval program
- International Building Code regulates areas in 130 mph wind zones and higher
  - IBC references ASTM standards and determines debris missile resistance by building height
  - ASTM E1996 Standard Specification
  - ASTM E1886 Standard Test Method
  - 2009 impact resistance provisions added for exterior balustrades

Certification Programs

- Miami-Dade County
  - Systems are issued NOAs (Notices of Acceptance)
  - Interlayers are also issued NOAs based on submittal of weathering data
  - http://www.miamidade.gov/building/pc-search_app.asp
- State of Florida
  - Product Approval Program
  - https://www.floridabuilding.org/pr/pr_app_srch.aspx
- Texas Department of Insurance
  - Windstorm Product Evaluations

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

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

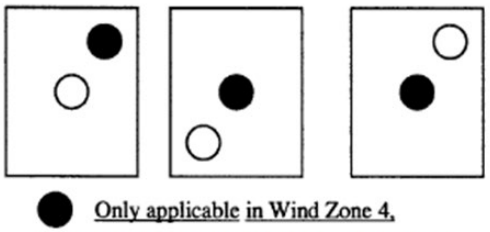


FIG. X4.1 Additional Large Missile Impact Locations in Wind Zone 4

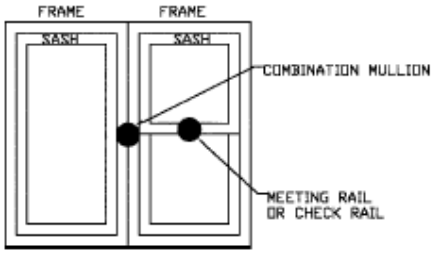


FIG. X4.3 Combination Mullion with Meeting or Check Rail

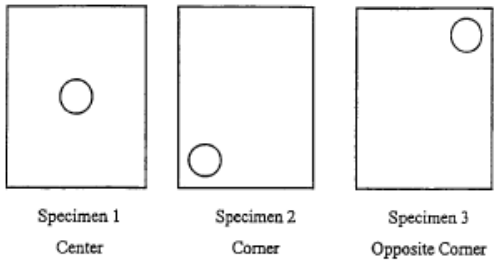


FIG. 1 Impact Locations for Large Missile Test (Each Type of Infill)

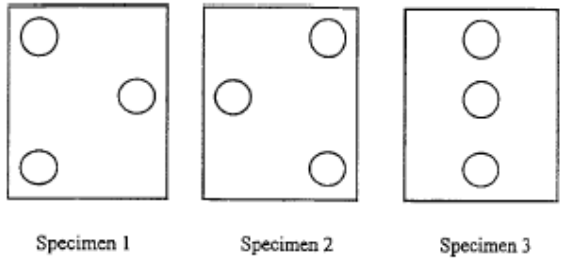


FIG. 2 Impact Locations for Small Missile Test (Each Type of Infill)

Hurricane Missile Tests

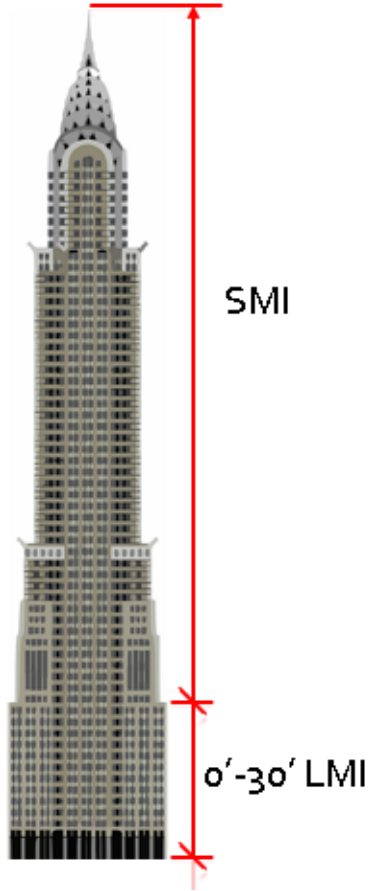
- Based on your project wind zone, use ASTM E1996 to determine the applicable missile test based on building type and location of products within the building
- The first 30’ are considered “large missile” and above that is considered “small missile”

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

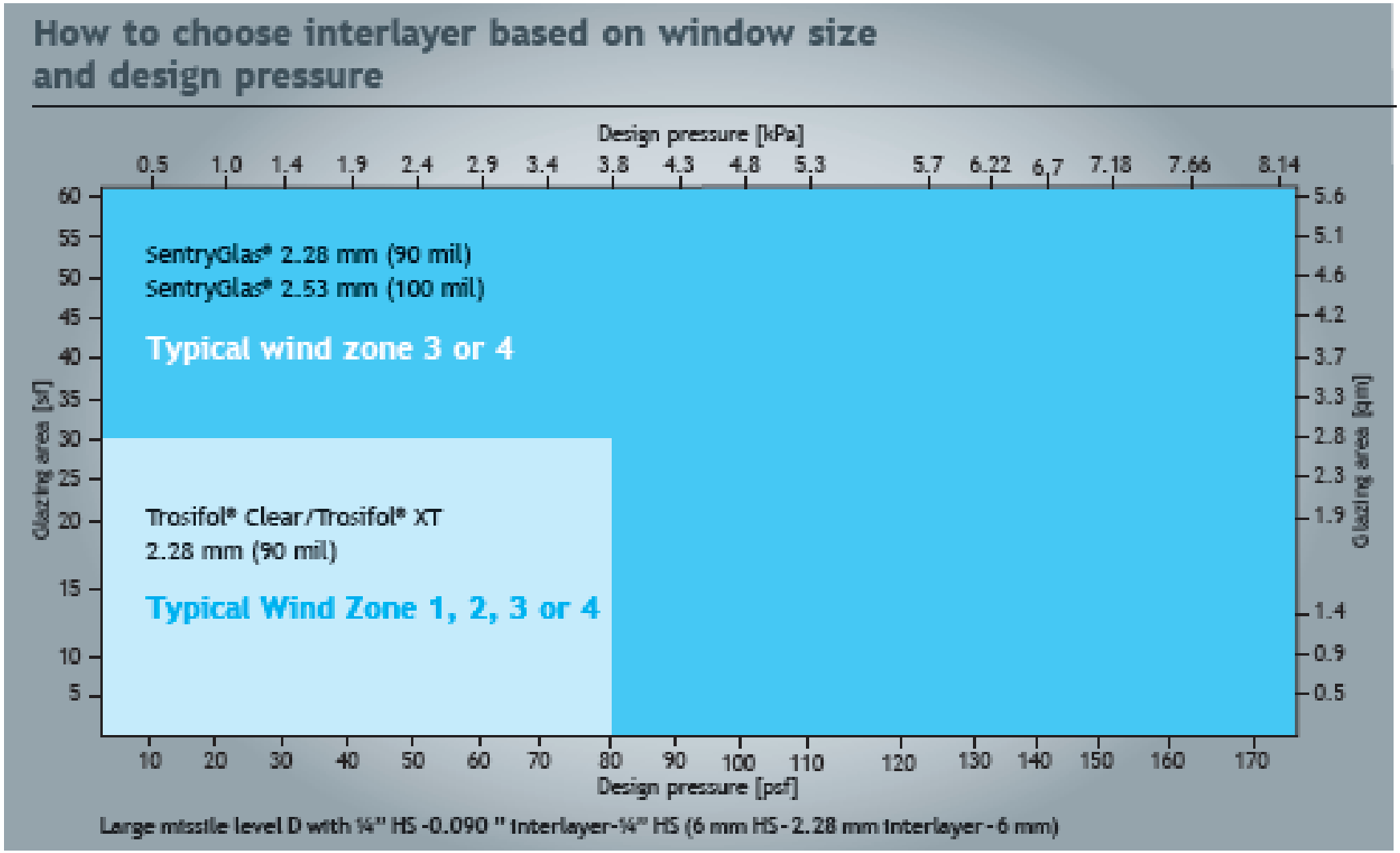


Hurricane impact missile levels

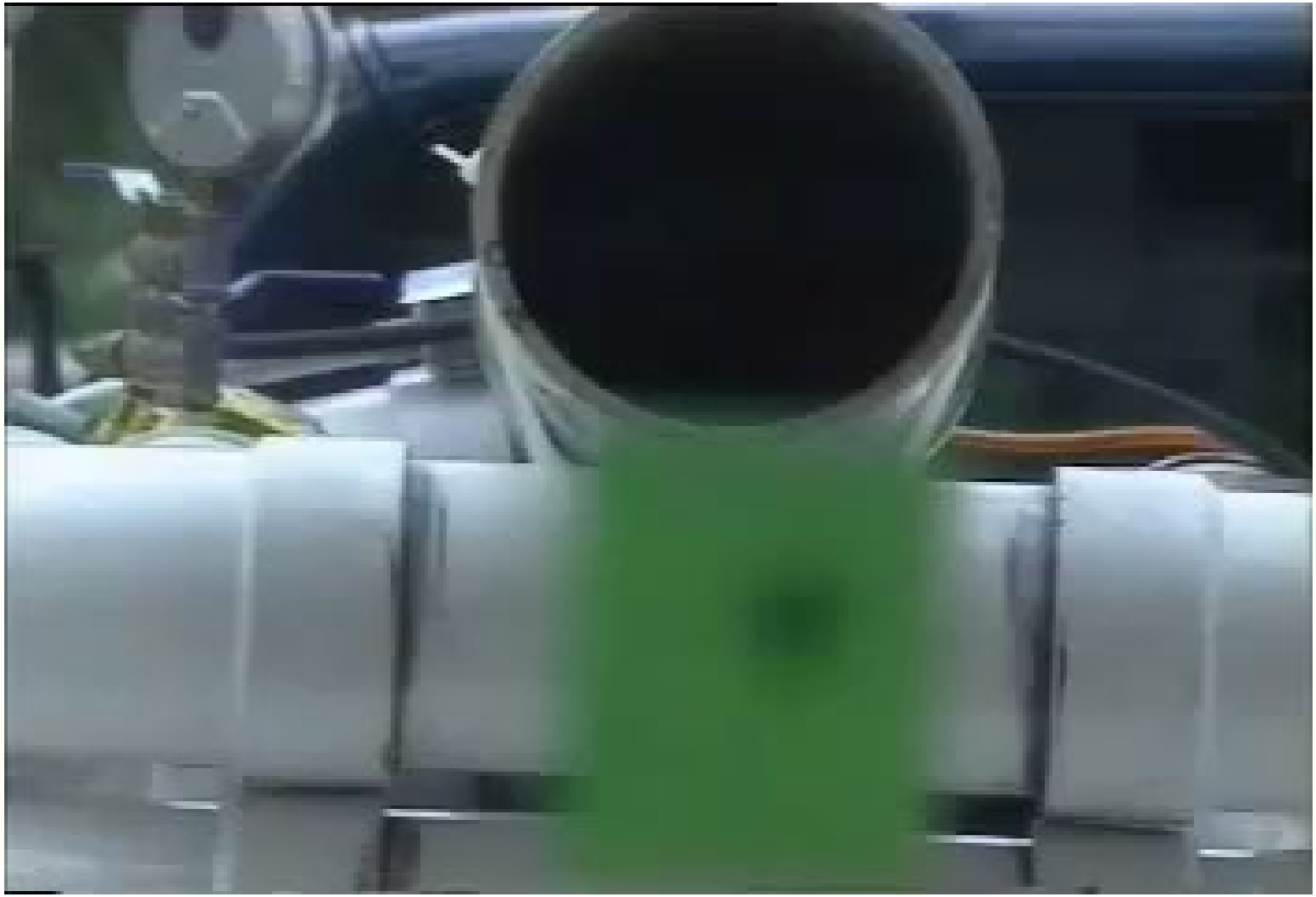
Missile Level	Missile Size	Missile Speed
Hurricane Small Missile Level A	2 g (31 grains) Steel balls	88 mph 130 f/s
Hurricane Large Missile Level B	2 lb. 2x4, 21” lumber	34 mph 50 f/s
Hurricane Large Missile Level C	4.5 lb. 2x4, 4' lumber	27 mph 50 f/s
Hurricane Large Missile Level D	9 lb. 2x4, 8' lumber	34 mph 50 f/s
Hurricane Large Missile Level E	9 lb. 2x4, 8' lumber	54.5 mph 80 f/s

Level	PVB	Ionomer
A	**¼” – 0.060” PVB- ¼”**	**¼” – 0.035” SG- ¼”**
B	**¼” – 0.060” PVB- ¼”**	**¼” – 0.035” SG- ¼”**
C	**¼” – 0.060” PVB- ¼”**	**¼” – 0.035” SG- ¼”**
D	**¼” – 0.090” PVB- ¼”**	**¼” – 0.090” SG- ¼”**
E	**N/A**	**¼” – 0.180” SG- ¼”**

Hurricane Glazing Design



Large Missile Impact



Hurricane Cycling Test

Miami Dade Labeling Requirements

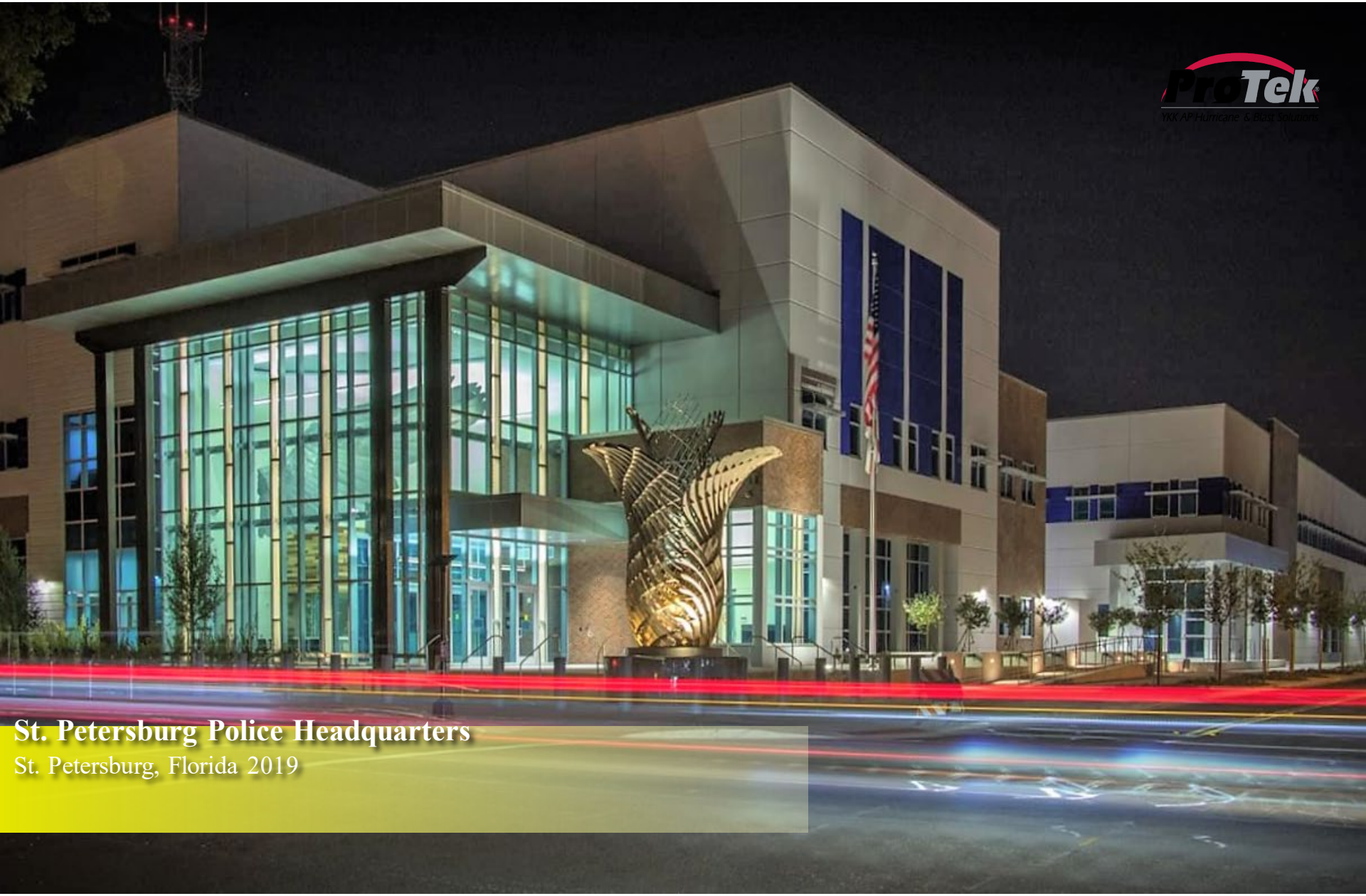
Hurricane Impact Level A & D

- Large Missile
  0.090” Ionoplast
- Small Missile
  0.060” PVB

Hurricane Level E Examples

UCCF Lake Nona Medical Center
Tavares, Florida 2019

Hurricane Level E Examples



St. Petersburg Police Headquarters
St. Petersburg, Florida 2019

Tornadoes - Federal Requirements & Codes

Federal Requirements

- **FEMA 320 – Take Shelter from the Storm**
- **FEMA 361 – Design and Construction Guidance for Community Shelters**
  - **EF5 debris protection**

Building Code Requirements

- **ICC/NSSA 500 – Design and Construction of Storm Shelters**
  - **Store shelter required in areas where the shelter design wind speed for tornadoes is 250 mph and in Group E occupancies**

Standards

- **AAMA 512-11 – Voluntary Specifications for Tornado Hazard Mitigating Fenestration Products**

F-Scale Number	3-second gust (mph)	EF-Scale Number	3-second gust (mph)
F0	45-78	EF0	65-85
F1	79-117	EF1	86-110
F2	118-161	EF2	111-135
F3	162-209	EF3	136-165
F4	210-261	EF4	166-200
F5	262-317	EF 5	Over 200

Fujita (F) Scale and the Enhanced Fujita (EF) Scale

Source: National Weather Service

Tornado vs Hurricane Testing

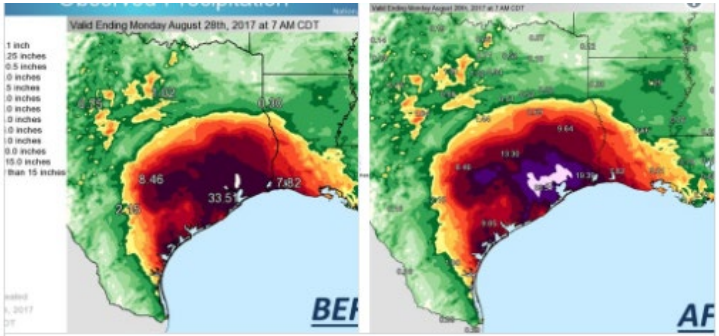
Missile Level	Missile Size	Missile Speed
Hurricane Large Missile Level D	9 lb. 2x4, 8' lumber	34 mph 50 f/s
Hurricane Large Missile Level E	9 lb. 2x4, 8' lumber	54.5 mph 80 f/s
Tornado FEMA 361 – EF2 - 130 mph	15 lb. 2x4, 12' lumber	80 mph 117 f/s
Tornado FEMA 361 – EF3 - 160 mph	15 lb. 2x4, 12' lumber	84 mph 123 f/s
Tornado FEMA 361 – EF4 - 200 mph	15 lb. 2x4, 12' lumber	90 mph 132 f/s
Tornado FEMA 361 – EF5 - 250 mph	15 lb. 2x4, 12' lumber	100 mph 147 f/s

Impact

- 2 hits per specimen (center and corner)
- Pass fail criteria
  - Perforation-component is impact by debris and the debris enters the protected space
  - Note: Perforation is different than penetration (debris does not enter the protected space)
  - Glazing remains attached to frame
  - Glass fragments or shards remain within the glazing unit
- Cycling to ASTM E1886 (if in hurricane zone)

Floods

- **Floods are the US most common natural disaster.**
- **It is emotionally and financially devastating**
- **1 inch of water in the house can cause $25,000 in damages**



NWS
@NWS

Follow

#Harvey in perspective. So much rain has fallen, we've had to update the color charts on our graphics in order to effectively map it.

9:21 AM - Aug 28, 2017

242 15,239 12,477

Flood Barrier Glazing

- Systems range from store fronts to balustrades
- Testing
  - No official test method yet
  - Testing consist of water load and impact
  - Impact – 1,000 lb floating log

Flood Barrier Glazing Test

https://www.youtube.com/watch?v=7sTvAhutC-c

Security Glazing

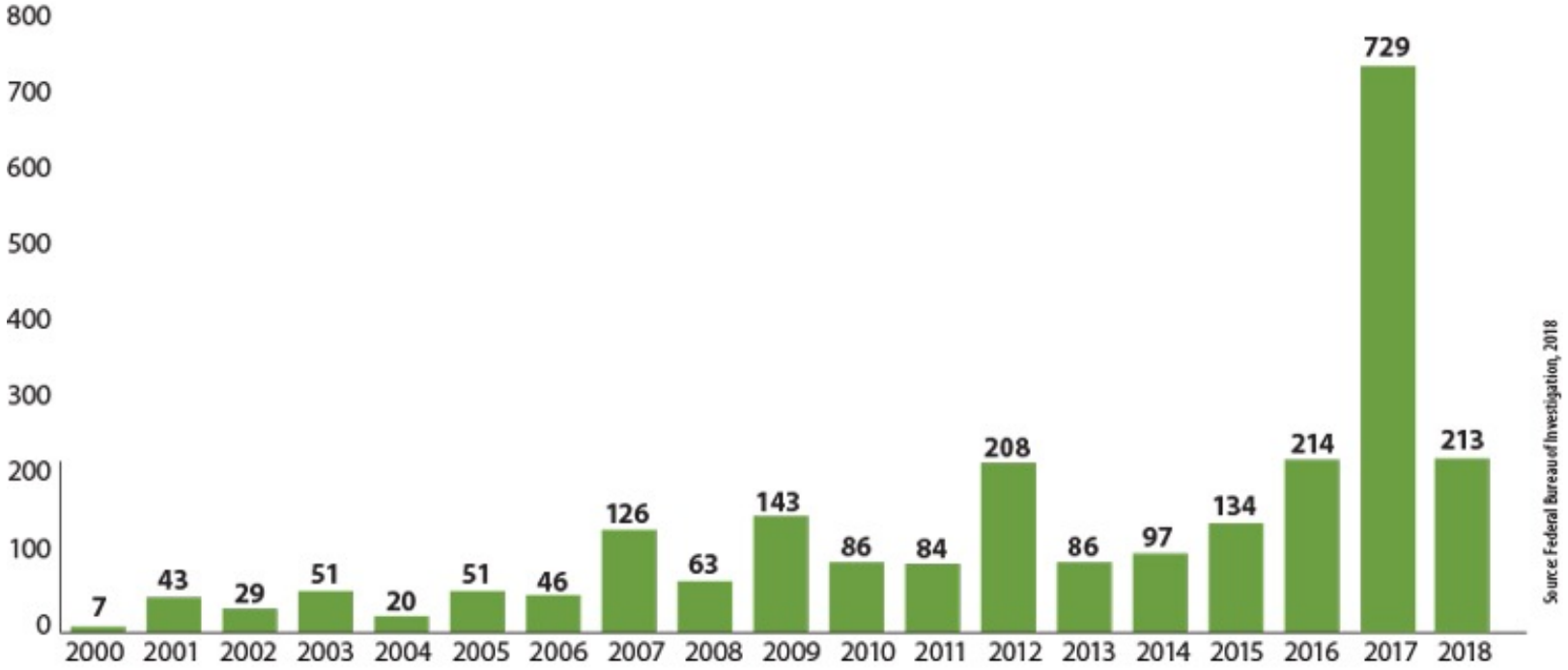
Stoneman Douglas High School
Parkland, FL 2018

- A suburb in SE Florida.
- Gunman was a 19-year-old former student at the school.
- He used an AR-15 rifle.
- Gunman pulled fire alarm to gain access to multiple victims.
- 17 dead, 17 wounded, the deadliest high school shooting in USA
- **Warnings had been made in the past regarding gunman's desire to shoot up a school**
- **The on-site police officer did not confront the gunman**

FBI Stats (2000-2018)

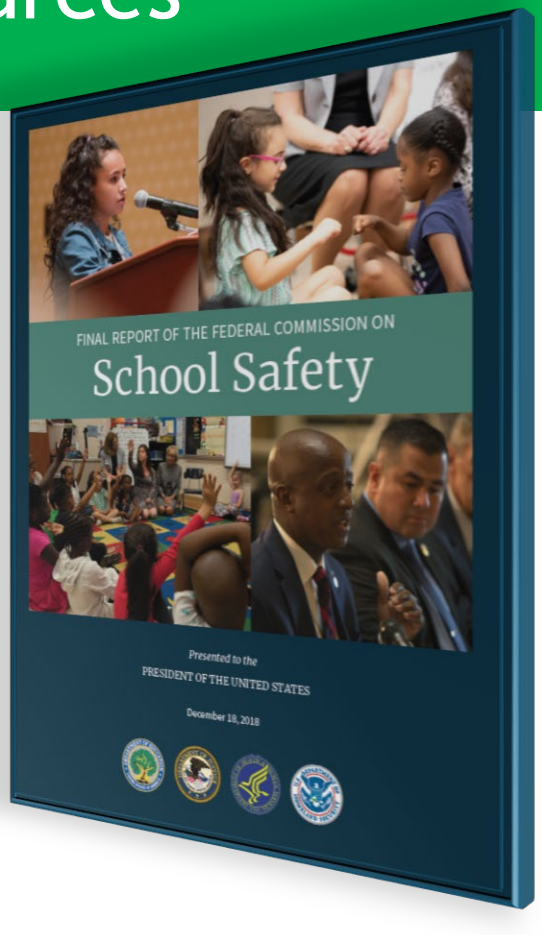
Quick Look: 277 Active Shooter Incidents in the United States Between 2000 - 2018

Casualties Per Year



School Security Additional Resources

- SchoolSafety.gov
  - https://www.schoolsafety.gov/
- US Secret Service and Dept. of Education – Threat Assessment in Schools: A Guide to Managing Threatening Situations and to Creating Safe School Climates –
  - https://www2.ed.gov/admins/lead/safety/threatassessmentguide.pdf
- US Dept. Homeland Security – K-12 School Security
  - https://www.dhs.gov/publication/k-12-school-security-guide
- US DHS & US Secret Service – Enhancing School Safety Using a Threat Assessment Model
  - https://www.secretservice.gov/data/protection/ntac/USSS_NTAC_Enhancing_School_Safety_Guide_7.11.18.pdf
- Final Report of the Federal Commission on School Safety
  - https://www2.ed.gov/documents/school-safety/school-safety-report.pdf



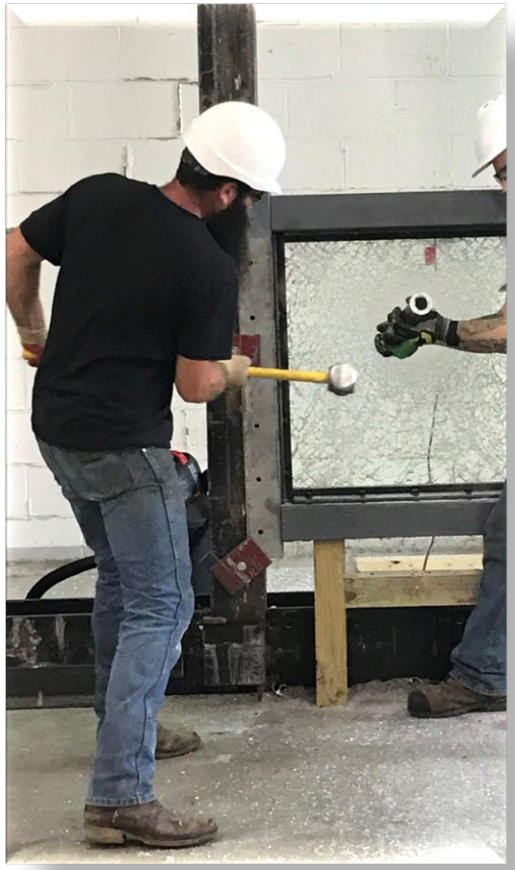
Just a few of the many documents!

Forced Entry Standards

ASTM F1233 - *Standard Test Method for Security Glazing Materials and Systems*

Sequence	Test Implements	Impacts	Minutes	Class Achieved
1	Ball Peen Hammer	10		1.0
2	Ball Peen Hammer	10		1.1
3	1-1/2” Diameter Pipe	25		1.2
4	Extinguisher, CO2		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

First 11 of 41 sequences!



Forced Entry + Ballistics

Test 5-aa1 – *Certification Standards for Retrofitting and Reinforcing of Standard Commercial Entry Systems, Windows and Glazing*

5-aa1			
Sequence	Test Implements	Impacts	Pass
1	Shot 0.762 Round	5	✓
2	Bricks	20	✓
3	Kicks with Steel Toe	10	✓
4	Tools Set #1	2 min	✓
5	Tool Set #2	3- ½ min	✓
6	Sledge Hammer	6 min	✓

Forced Entry + Ballistics
(0.060” PVB vs. 0.180” Ionoplast)

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	0.60”							0 sec	
	0.90”							51 sec	
	0.120”							2 min 38 sec	
	0.180”							6 min 43 sec	
	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”							11 min. 30 sec	12” tear
	0.270”							11 min. 30 sec.	No openings

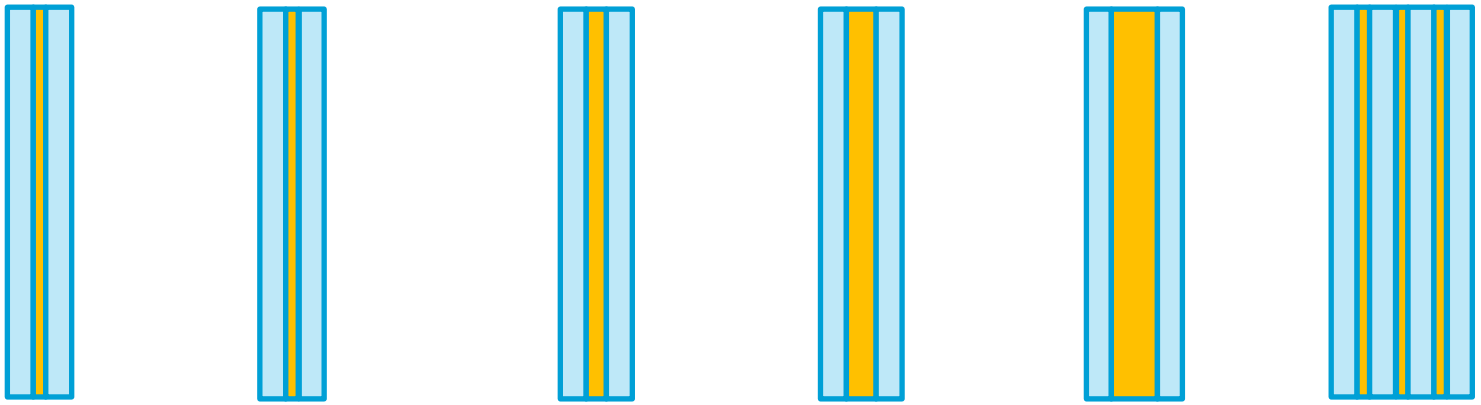
* 2 min tools - a small 2x4, claw hammer, and wrench

** 3-½ min tools – 3lb hammer and Aluminum Baseball bat

Security Glazing

Level	Safety	Burglary	Enhanced	Forced Entry	Forced Entry + Ballistics*	Ballistic Protection
Delay Time	0 - 1 min	0 - 1 min	1 - 3 min	3 – 6 min	6 - 12 min	> 12 min
Example of Configuration	Glass 0.035” Ionoplast or 0.030” PVB Glass	Glass 0.035” Ionoplast or 0.060” PVB Glass	Glass 0.060” Ionoplast or 0.090” PVB Glass	Glass 0.180” Ionoplast or 0.270” PVB Glass	Glass 0.270” Ionoplast Glass	Glass 0.060” Ionoplast Glass 0.060” Ionoplast Glass 0.060” Ionoplast Glass

***** Forced Entry + Ballistics will allow the bullet to penetrate, but the glazing will remain in the frame preventing access



Ballistic Standards

UL 752

- 8 performance levels
- Testing on 12”x12”
- No penetration
- No Spall

Other Standards

- NIJ 0108.01
- ASTM F1233
- EN 1063

UL 752 Ballistics Levels

Level	UL 752 - Ammunition	Grain	Velocity (fps)	# Shots
1	**9mm** Full Metal Copper Jacket with Lead Core	124	1175-1293	3
2	**.357 Magnum** Jacketed lead Soft Point	158	1250-1375	3
3	**.44 Magnum** Lead Semi-Wadcutter Gas Checked	240	1350-1485	3
4	**.30 Caliber Rifle** Lead Core Soft Point	180	2450-2794	1
5	**7.62mm Rifle** Lead Core Full Metal Copper Jacket, Military Ball	150	2750-3025	1
6	**9mm** Full Metal Copper Jacket with Lead Core	124	1400-1540	5
7	**5.56mm Rifle** Full Metal Copper Jacket with Lead Core	55	3080-3388	5
8	**7.62mm Rifle** Lead Core Full Metal Copper Jacket, Military Ball	150	2750-3025	5

Recycled Interlayers

- Kuraray uses recycled interlayers from our customers, and we have a 100% recycled PVB Interlayer.
- There are not many post consumer recycled interlayers available yet due to the complexity of removing the glass from the interlayers. We are hopeful, with new technology, there will be post consumer recycled interlayers available in the near future.

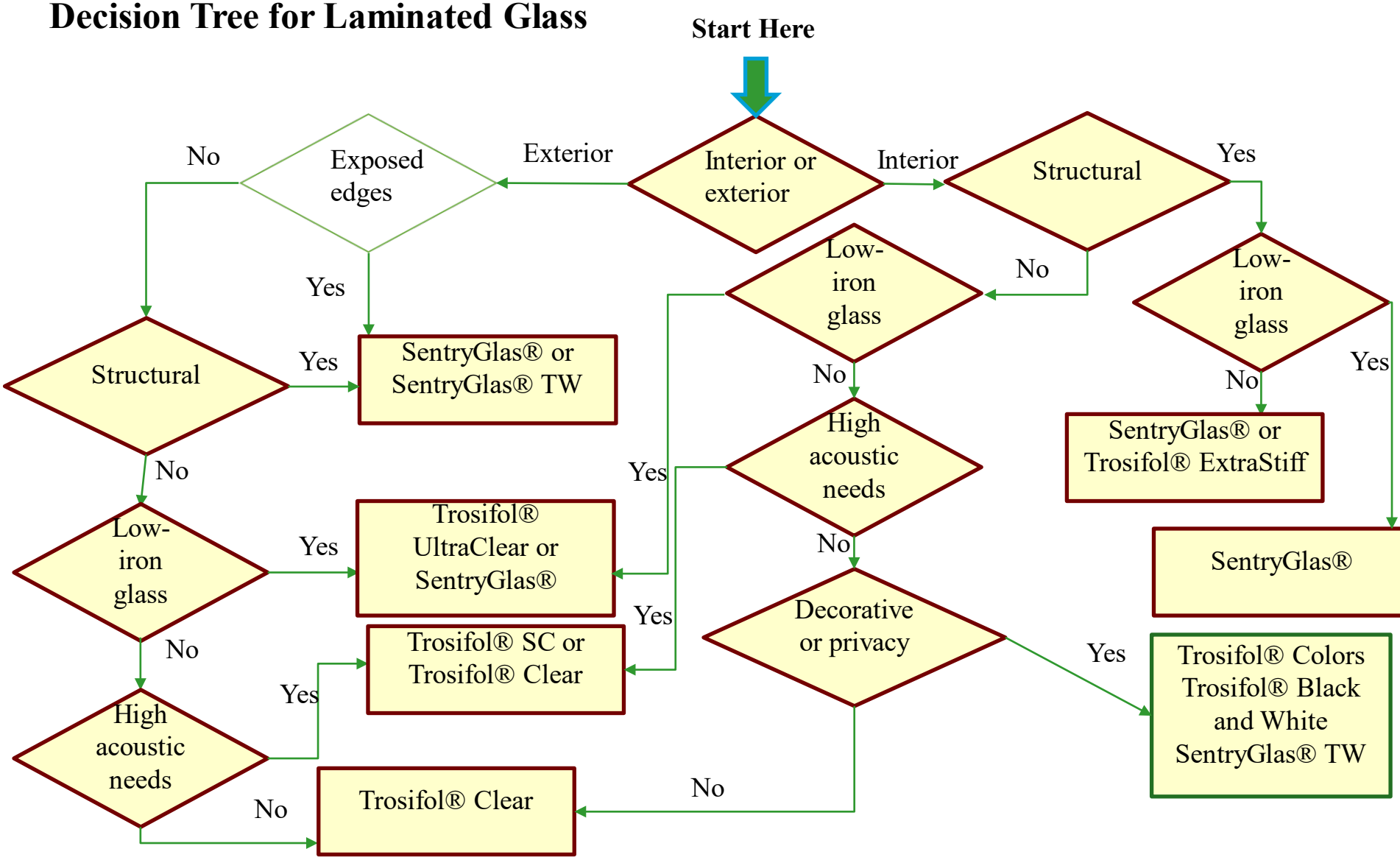
Conclusion

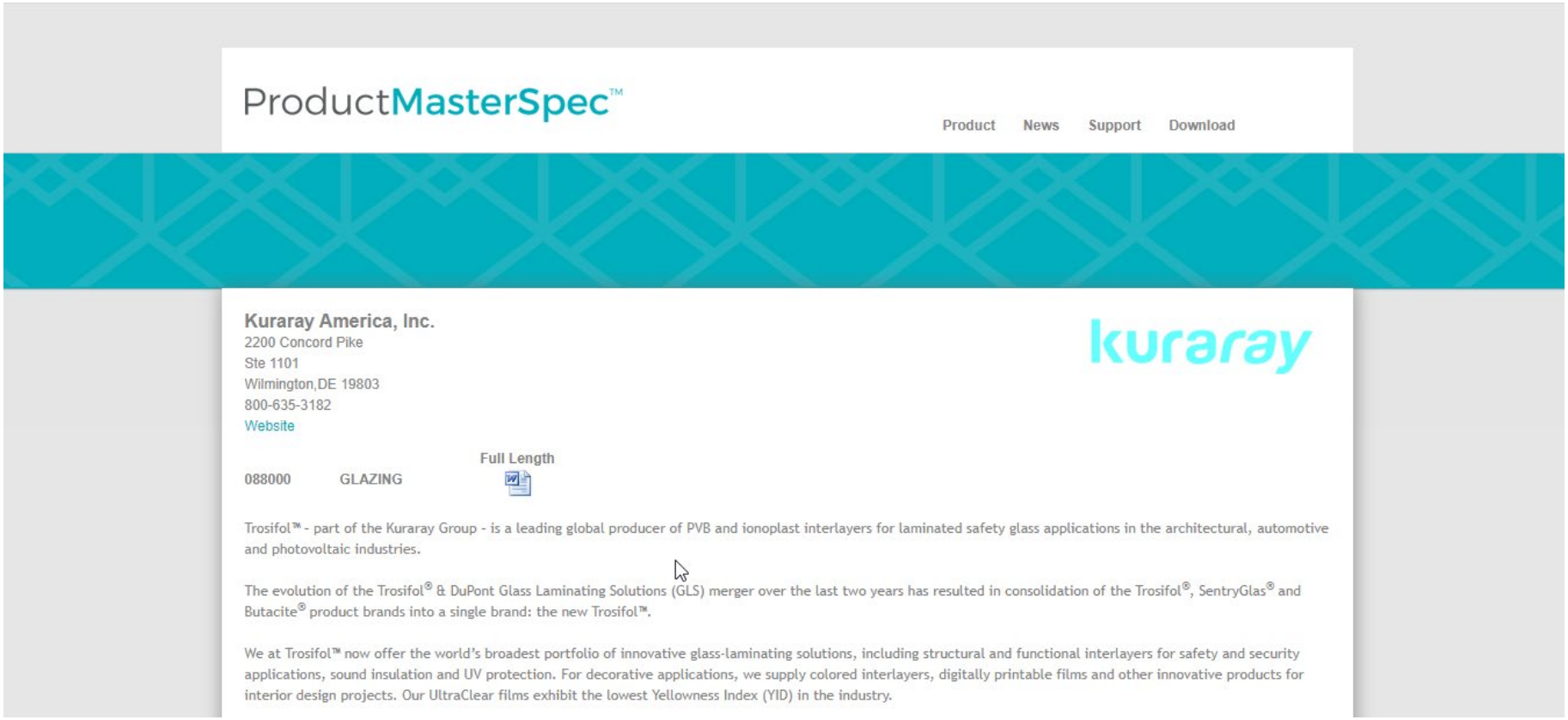
- **There are two main types of laminated glass interlayers – PVB and Ionoplast. Both interlayers offer safety and design versatility.**

- **Laminated glass contributes to the safety, health, welfare and happiness of the inhabitants of the buildings, including hurricanes, tornados, blast, reduced noise, security and intrusion resistance and UV protection.**

- **Ionoplast interlayers are especially suited for structural designs, including bolted glass façade and railings, laminated glass floors, stair treads, skylights and canopies and open edge applications.**

Decision Tree for Laminated Glass





Also available in BSD Speclink

Thank you.

Questions?

This concludes the American Institute of Architects
Continuing Education Systems Program

Ron Hull, P.E., CDT®, AIA

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941-769-4279

Office of Mental Health New York

Trosifol Business

Behavior Health Facilities

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” Trosifol PVB
0.007” Spallshield CPET

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

How can Trosifol support you

Consultancy services

Finite Element Analysis (SJ Mepla, SG Calc…)

- Effective thickness method (ASTM E1300-09)
- Thermal breakage

Windows glass design

Bomb blast performance

- Wingard suite of tools (ARA)

Thermal and energy performance

- Lawrence-Berkeley National Labs (LBNL), optics, window, therm

Test design support

- Miami Dade County…

Laminated glass expertise

Interlayer advice and selection

Kuraray Network of Laminators: glass fabricators capabilities

Glass and lamination training

Building codes monitoring

Technical support and standard tests (Adhesion…)

New applications development and tests

Global technical support team with 3 technical labs in Korea, Germany and USA

Online tools

Trosifol® Strength of glass calculator

- Technical design guide for structural engineers
- list of compatible sealants
- Library of technical papers and test reports
- List of glazing systems tested for hurricane glazing

Trosifol® WinSlt

- Calculation of light and energy tranmission

Trosifol® GlasGlobal

- Static calculation according DIN 18008 and ASTM E.1300
- Taking into account the coupling effect of Trosifol® Extra Stiff and SentryGlas®

Trosifol® SoundLab

- This is a database for determining sound insulation values for glass constructions fabricated using Trosifol® products.

Laminated Glass News (Newsletter)