



Laminated Architectural Glass

▣ *Safety Glazing* ▣

National Sunroom Association

Las Vegas, Nevada – March 6, 2009



Prepared & presented by J. Schimmelpenningh

About Solutia Inc.

- World Headquarters located in St. Louis, MO
- \$2.0 Billion Chemical Company
- Saflex division is the world's largest producer of polyvinyl butyral (PVB) interlayer for laminated glass

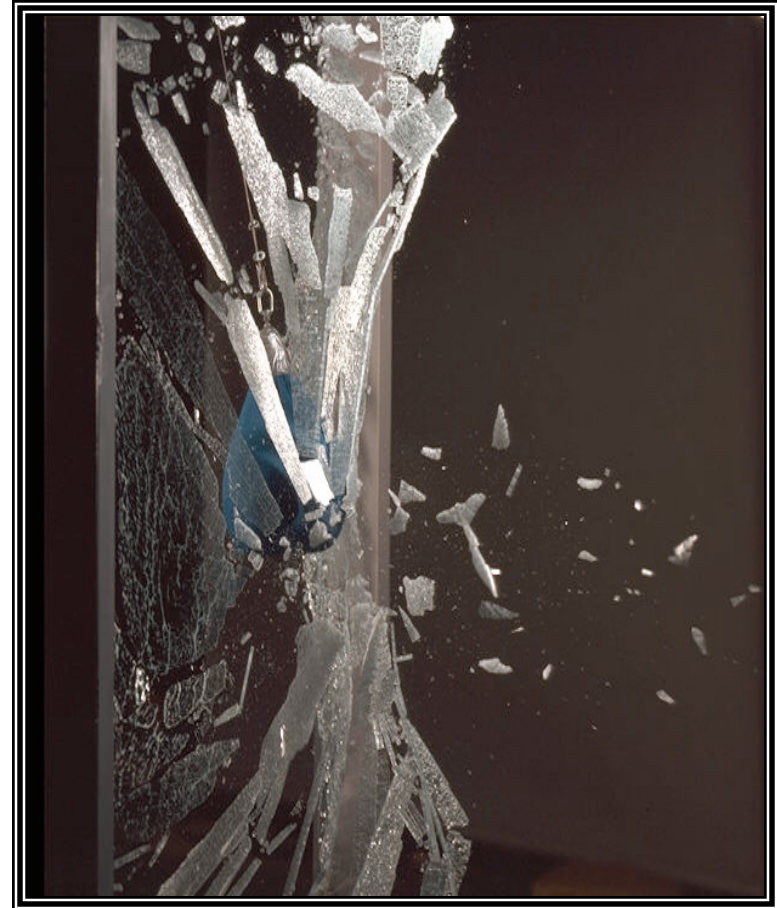


Discussion Outline

- Define Safety Glazing
- Safety Glazing Products
- Hazardous Locations
- Overhead Glazing
- Safety Glazing Applications
- Design Considerations & Other Benefits
- Questions

Safety

- Protection from cutting and piercing injuries, and fall out of glass from unintentional damages to glazing
 - Human Impact Protection
 - Hazardous Locations
 - Overhead Glazing
 - Structural
 - Railing and Balusters
 - Hurricane
 - Seismic



Regulations and Standards Overview

- CFR 16 CPSC Part 1201
 - Cat I or Cat II
- ANSI Z97.1
 - Class A, B or C
- Building Codes prescribe areas of use by defining “Hazardous Locations” and required applications

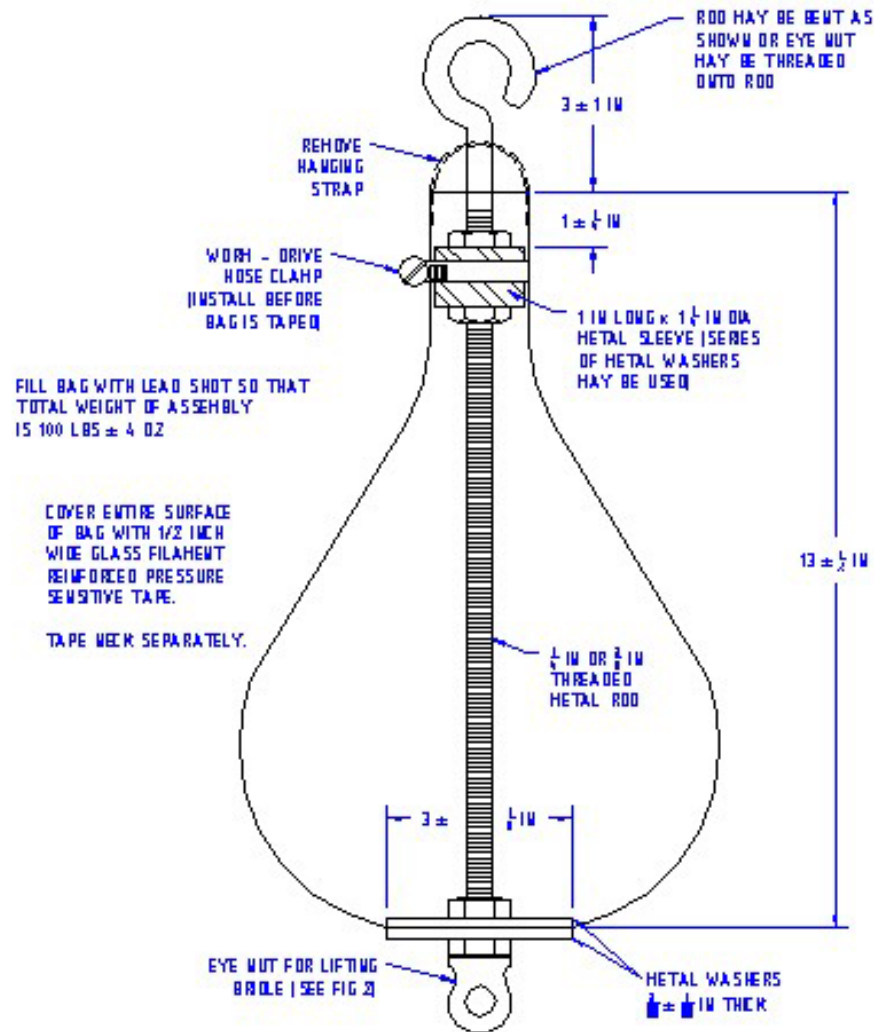
CPSC 16 CFR 1201

- Federal Safety Standard
 - Shot bag test
 - Enacted in 1977
 - Has not changed since enactment
 - Doors and Door leaves only
 - Tempered Glass, Laminated Glass
 - Wired Glass included with exemption

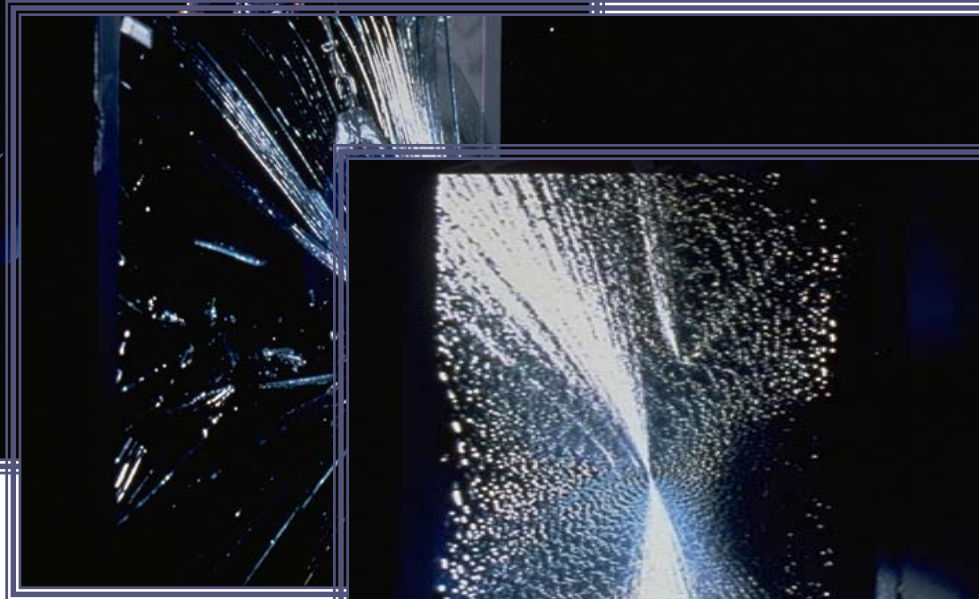
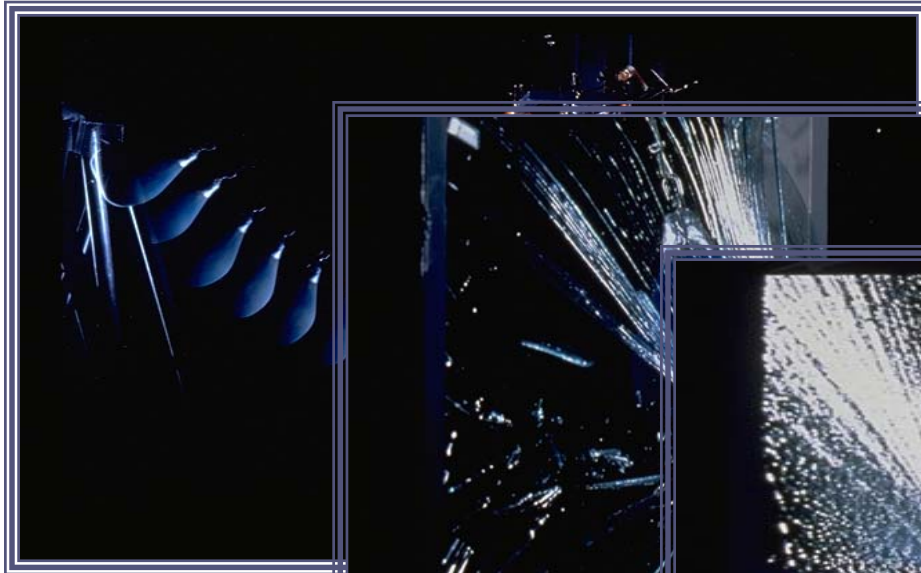
CPSC 16 CFR 1201 Test Method

- 100 lb lead shot filled punching bag
 - Pendulum test
- Two drop heights:
 - Category I = 150 ft-lb.
 - Drop height 18
 - Glass < 9 sqft
 - Category II = 400 ft-lb.
 - Drop height 48"
 - Glass > 9 sqft
- Test size: up to 34" x 76"
- Boil test required for Laminated Glass

CPSC/ANSI Shot Bag Cross Section



Human Impact Protection



Saflex

16 CFR PART 1201/ANSI Z97.1

ANSI Z97.1

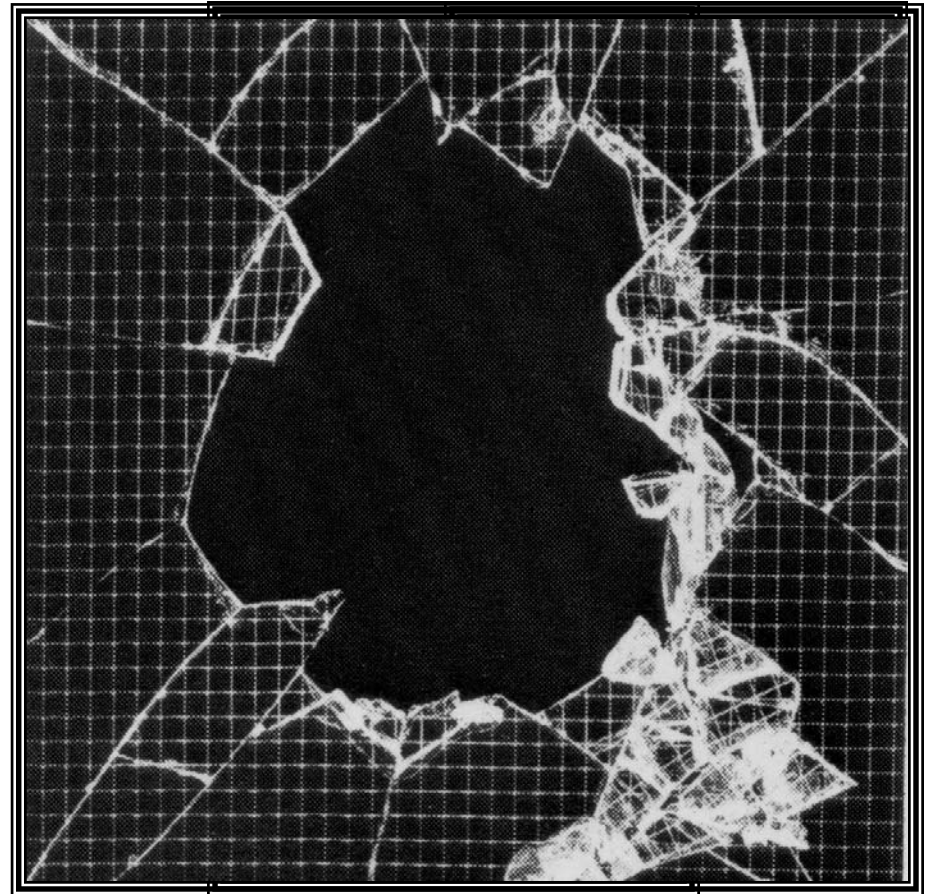
- Voluntary Safety Standard
 - Shot bag test (same impactor as CPSC 16 CFR 1201)
 - Enacted in 1964
 - Modified to meet industry changes
 - Latest Revision 2004
 - Applies to all safety glazing
 - Tempered glass
 - Laminated glass
 - Plastic glazing
 - Organic Coated Glass

ANSI Z97.1 Test Method

- 100 lb lead filled punching bag
 - Pendulum test
- Three drop heights:
 - Class C = 100 ft-lb.
 - Drop height 12”
 - Fire rated wired glass only
 - Class B = 150 ft-lb.
 - Drop height 18”
 - Glass < 9 sqft
 - Class A = 400 ft-lb.
 - Drop height 48”
 - Glass > 9 sqft
- Test size: 16 x 30 minimum up to 34” x 76”
- Boil test required for Laminated Glass
- Weathering tests required for Laminated Glass

Shot Bag Pass Fail Criteria

- 10 largest pieces (FT)
- 3" solid sphere passage for Laminated, Plastic, Organic Coated and Filmed Glass
- Modulus of Rupture for Plastics
- Pass Boil
- Pass Weathering (ANSI only)



Safety Glazing

Typical Laminated Configurations

- CPSC Cat I or ANSI Z97.1 Class B
 - “lami” glass | ≥ 0.015 ” (0.38mm) Saflex | “lami” glass
- CPSC Cat II or ANSI Z97.1 Class A
 - “lami” glass | ≥ 0.030 ” (0.76mm) Saflex | “lami” glass

GANA Ball Drop Test Method and Specification

- QC test methodology
- Correlated to
 - CPSC 16 CFR 1201 Cat II and
 - ANSI Z97.1 Class A
- Test Method
- Specification for type and pass/fail criteria

GANA Ball Drop Test



Safety Standards in Development

- ANSI Z97.1 – 2009
 - Center Punch Fragmentation
 - New weathering evaluations
 - Mode of Breakage Interpretation
- Furniture Glass Standard ASTM F15.42
 - Safety Glazing requirement for furniture
- Skylight Fall-Through standard
 - Simulates person falling on a skylight

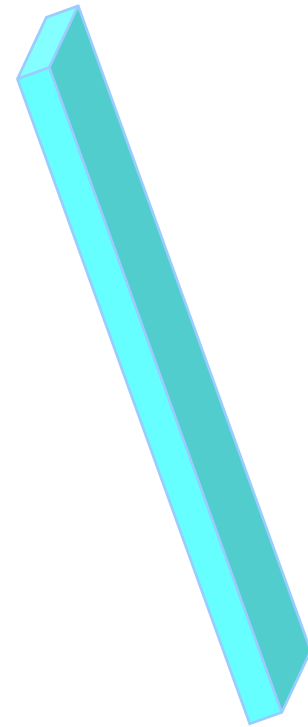


Product Descriptions

Safety Glazing

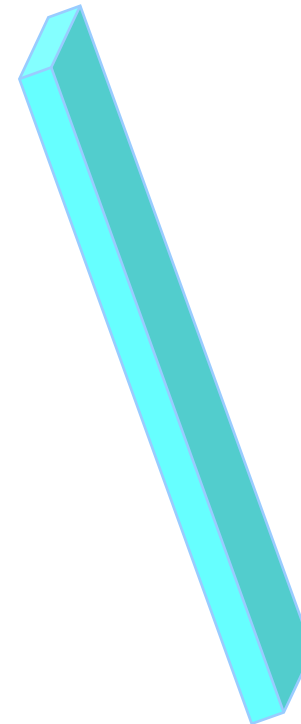
Product Descriptions

- Annealed Glass
 - Glass from float line
 - Breaks Easily
 - Dangerous Long Shards
 - Not **Safety Glazing**



Product Definitions

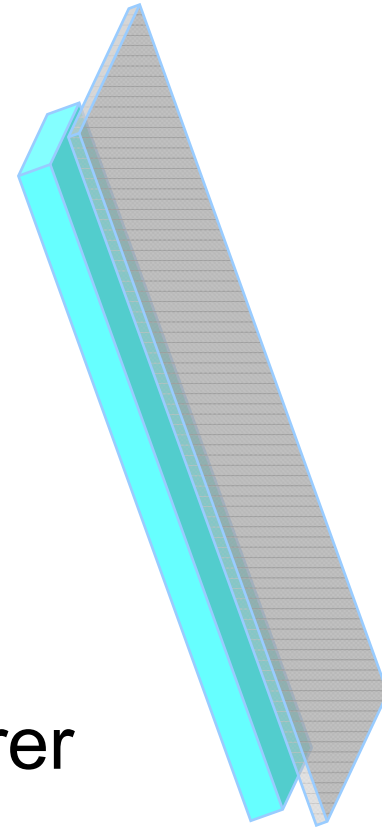
- Fabricated Glass
 - Chemically Strengthened
 - Difficult to break
 - Long dangerous shards
 - Not Safety Glazing
 - Thermally Strengthened
 - Heat Strengthened
 - Not Safety Glazing
 - Fully Tempered
 - Safety Glazing due to break pattern



Product Descriptions

Surface Applied Materials

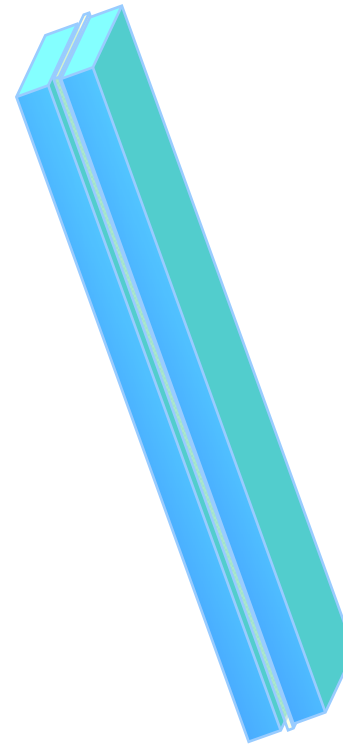
- Varied thicknesses
- Application Types
 - Daylight
 - Edge to Edge
 - Anchored
- Typically Retrofit
- Consult Glass Manufacturer regarding warranty



Product Descriptions

- **Laminated Glass**

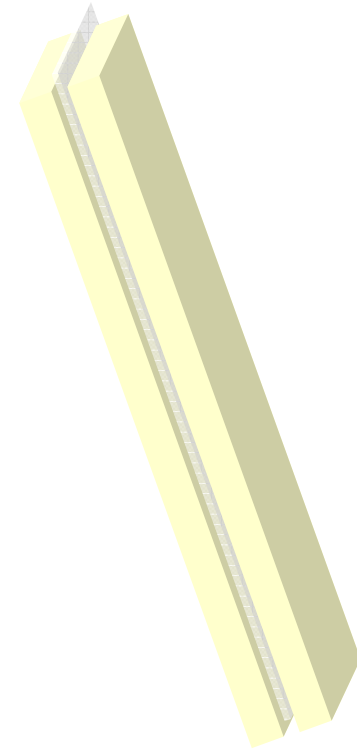
- Two or more lites of glass
- Bonded to form single lite
- Interlayer
 - “Adheres to Glass”
 - Liquid
 - Flexible Roll Form
 - Rigid Sheet
- Various Thicknesses
- Various Colors
- Retention Characteristics
- Safety Glazing



Product Descriptions

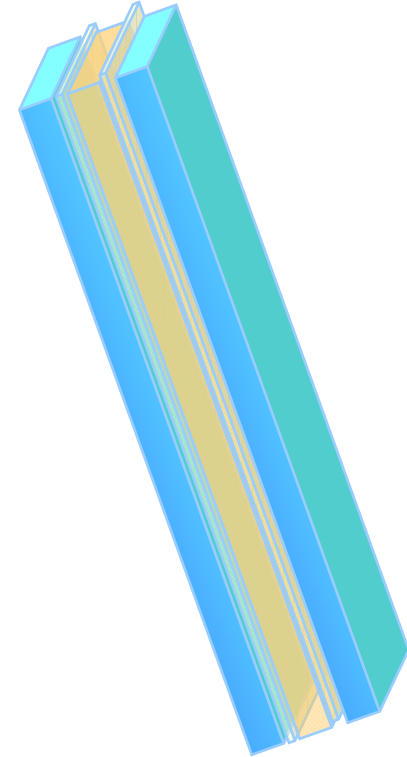
Plastic Products

- Polycarbonates
- Acrylics
- Impact Resistant
- Surface Damage Prevention
- Single layers
- Multi-ply Laminated



Product Descriptions

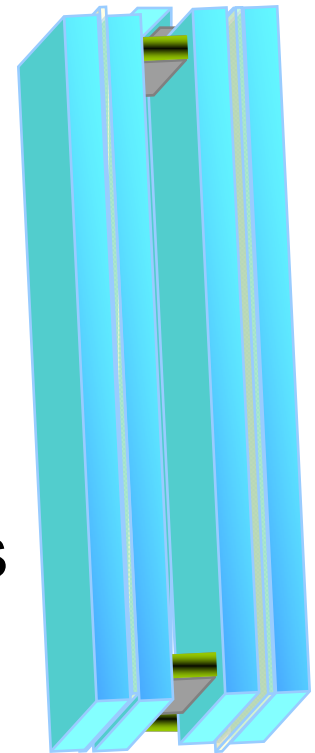
- Glass Clad Plastics
 - Plastics
 - Glass
 - Interlayers
- High Impact Strength
- Bullet Resistant
- Detention & Institutional
- Shelters



Product Descriptions

Insulating Glass Units

- Two or more lites of glass
- Insulating Space
- Thermal & Energy
- Triple IG with two Air Spaces
- Safety Glazing as one or more lites depending upon application



Safety Glazing Products

- Tempered Glass
- Plastic Glazings
- Filmed Glass
- PVB Laminates
- Polyurethane Laminates
- Ionomer Laminates
- Resin Laminates
- EVA Laminates
- Glass Clad Polycarbonate



Glazing in Hazardous Locations

Interpreted from:

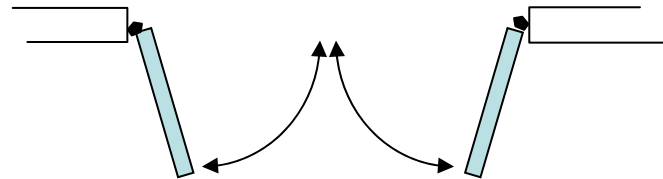
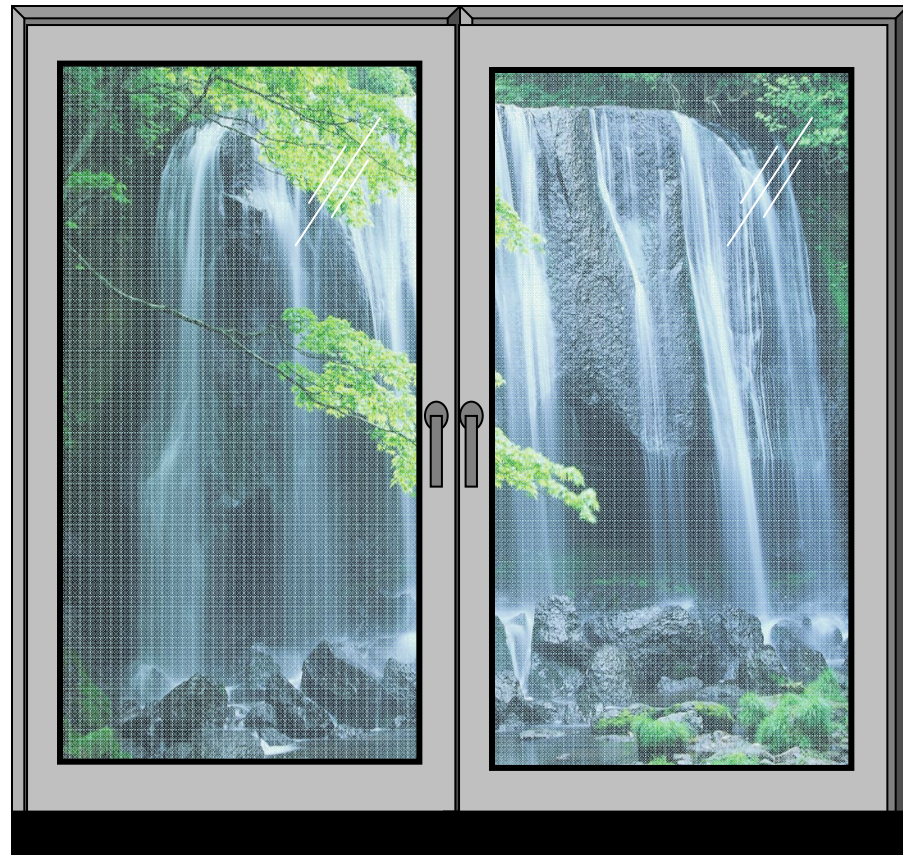
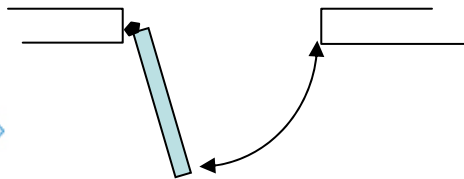
International Building Code 2006

(Section 2406.3)

International Residential Code 2006

(Section R308.4)

Swinging Doors except Jalousies

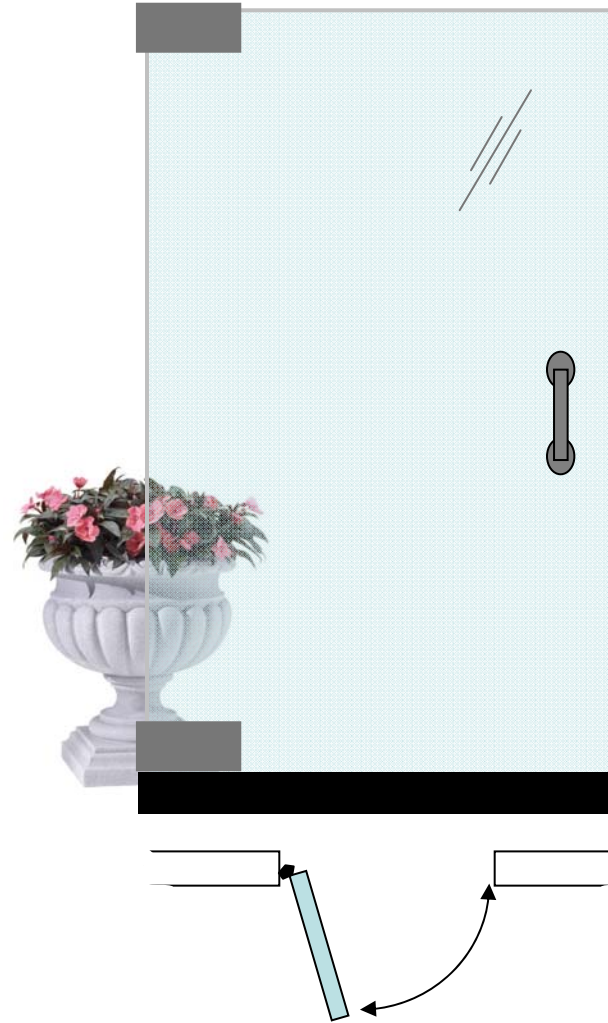
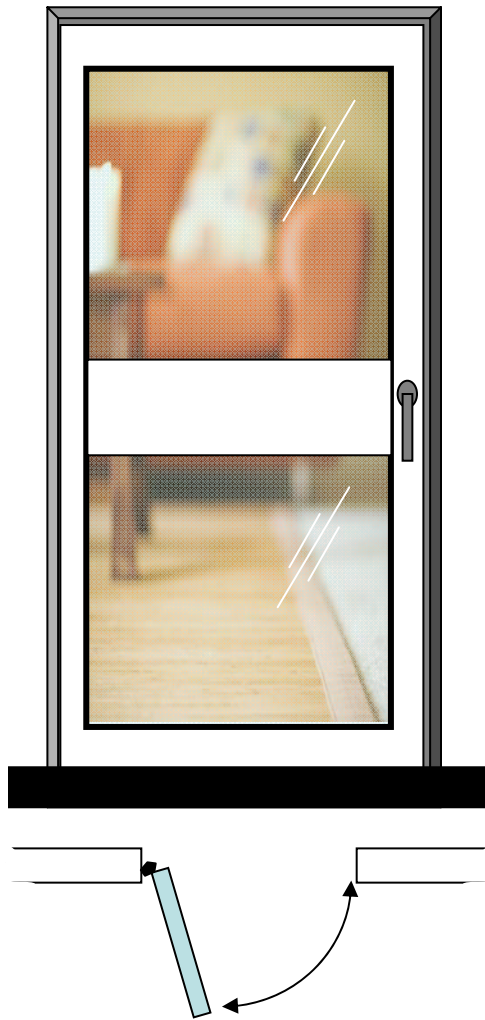


Legend

Safety

Non-Safety

Storm and Unframed Doors

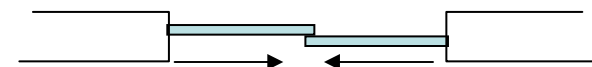
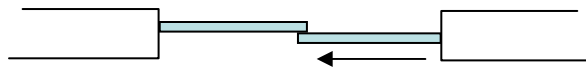
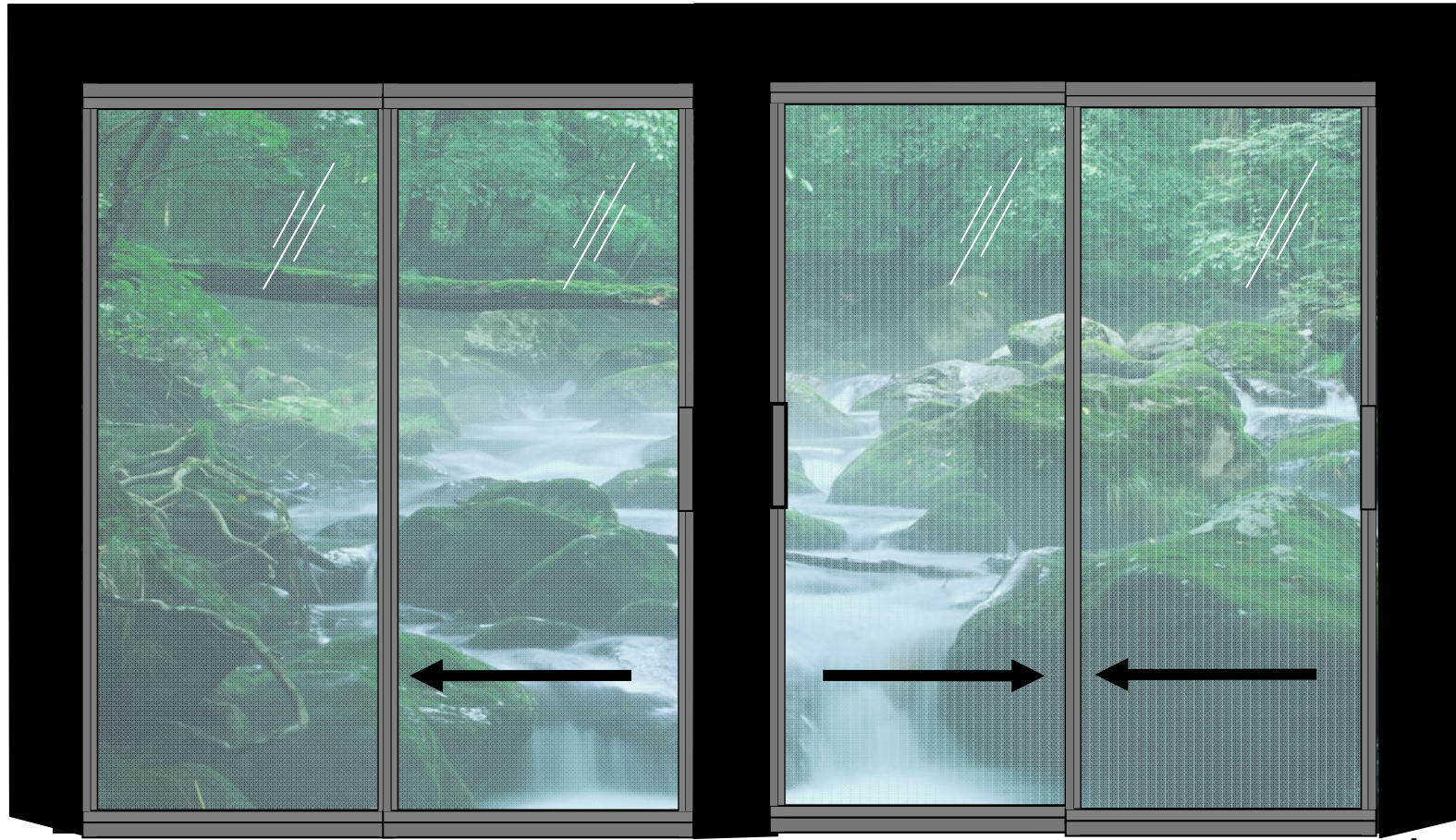


Legend

Safety

Non-Safety

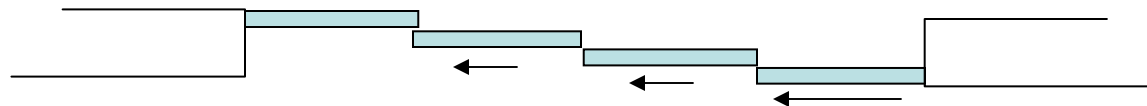
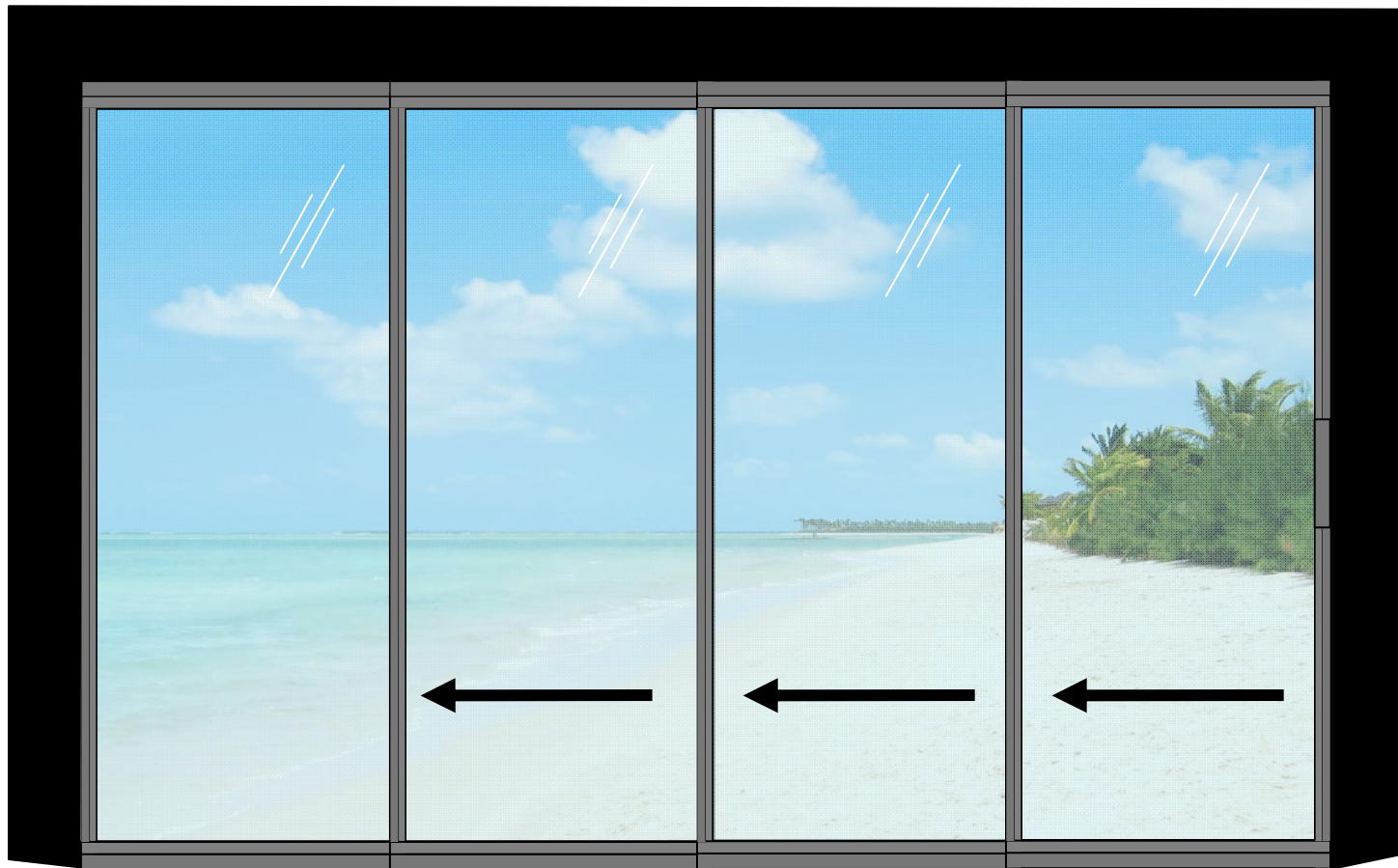
Fixed and Sliding Door Assemblies



Legend

Safety
Non-Safety

Panels in Sliding Door Assemblies



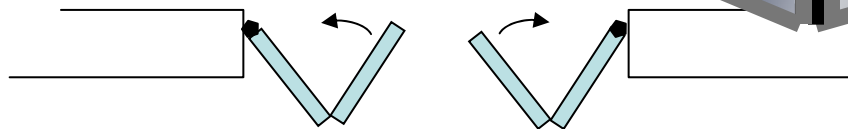
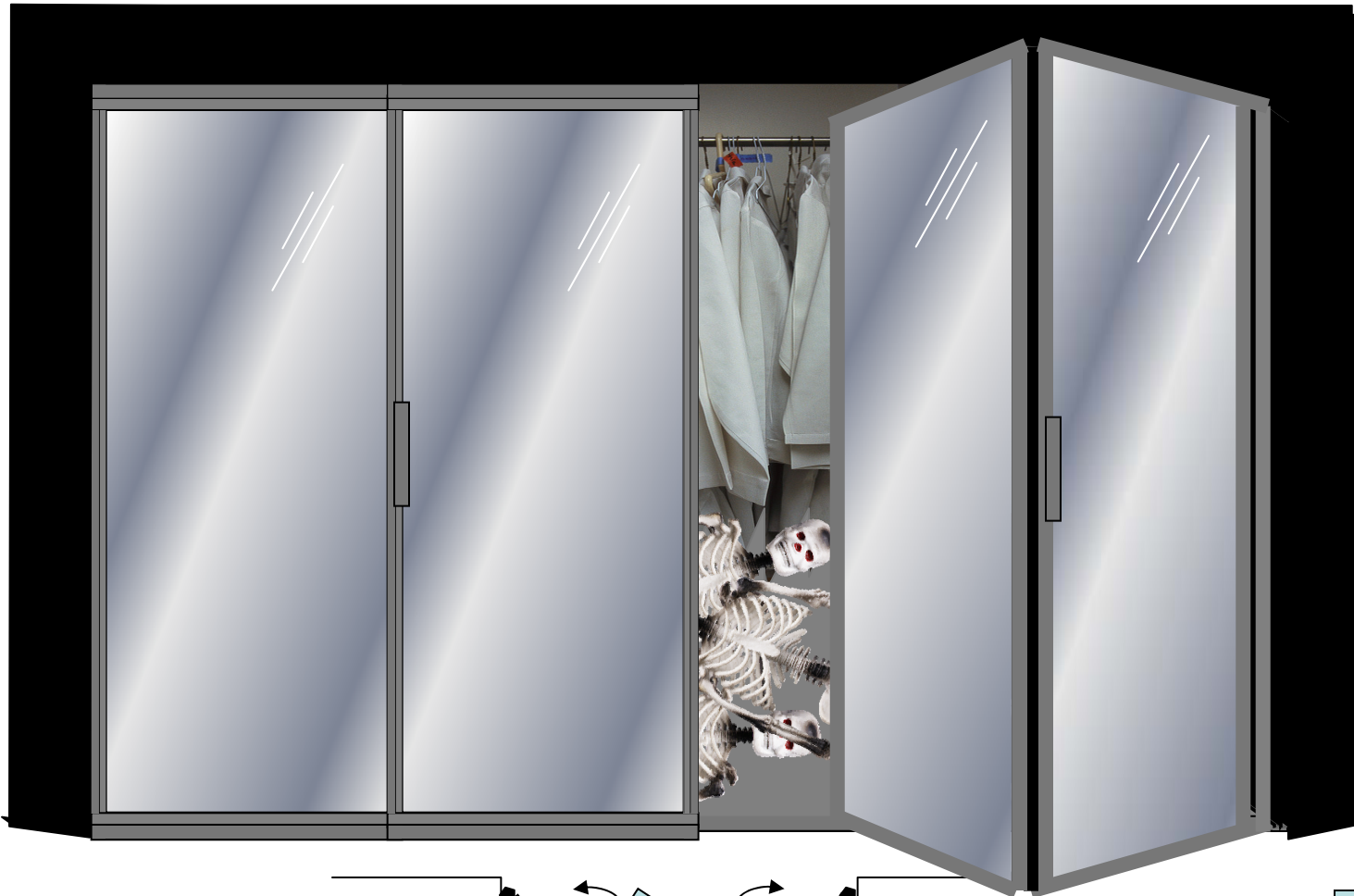
Legend

Safety

Non-Safety



Panels in Bi-Fold Door Assemblies



Legend

Safety

Non-Safety

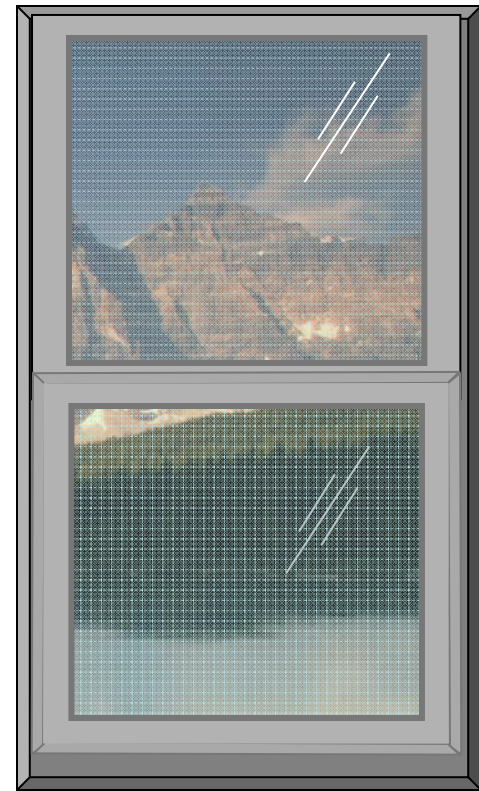
Fixed or Operable Panels



Area >9 ft²
(0.84 m²)

<18 in (46 cm)
Above floor

> 36 in
(91 cm)

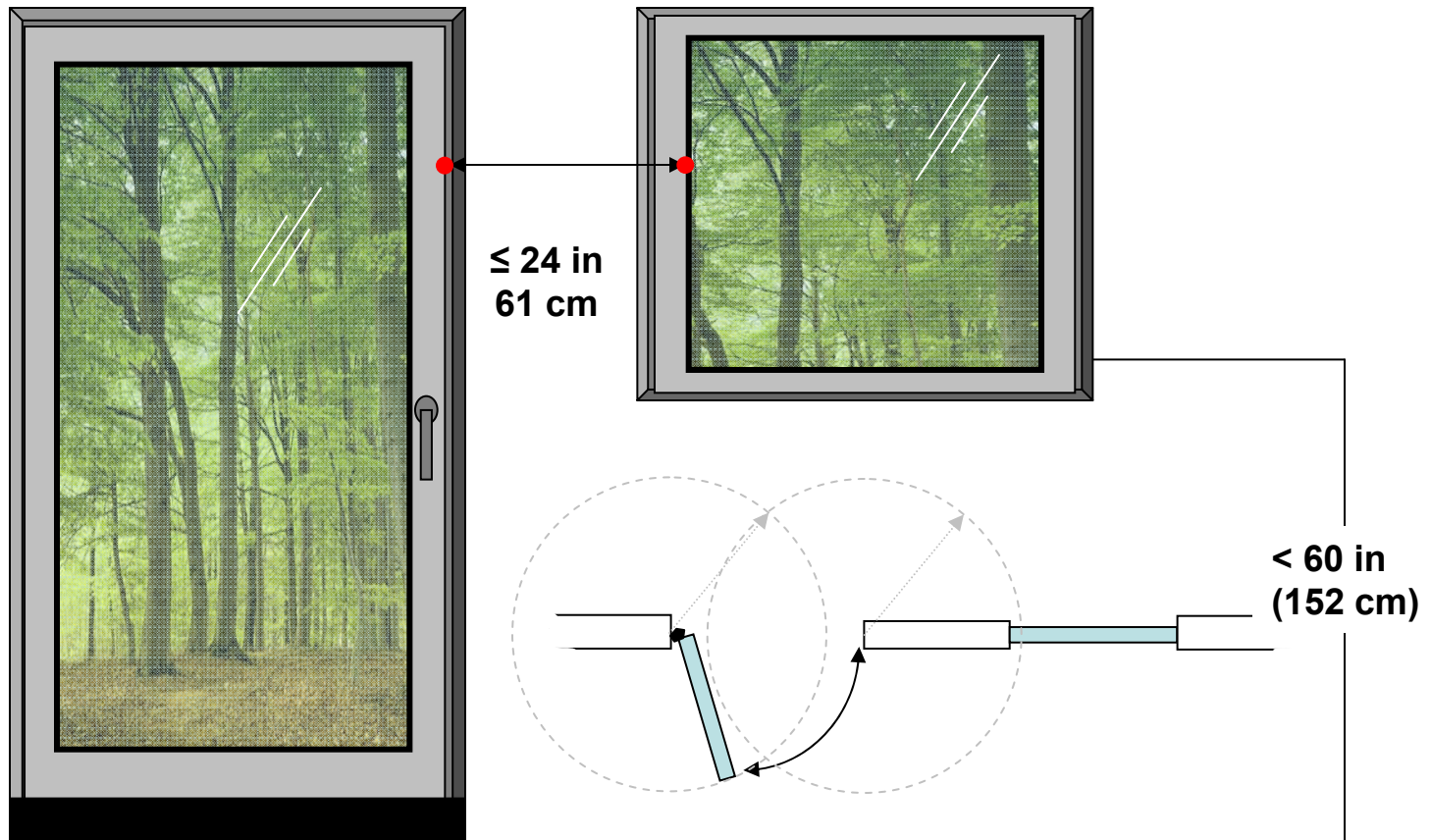


Legend

Safety

Non-Safety

Panel Adjacent to a Door

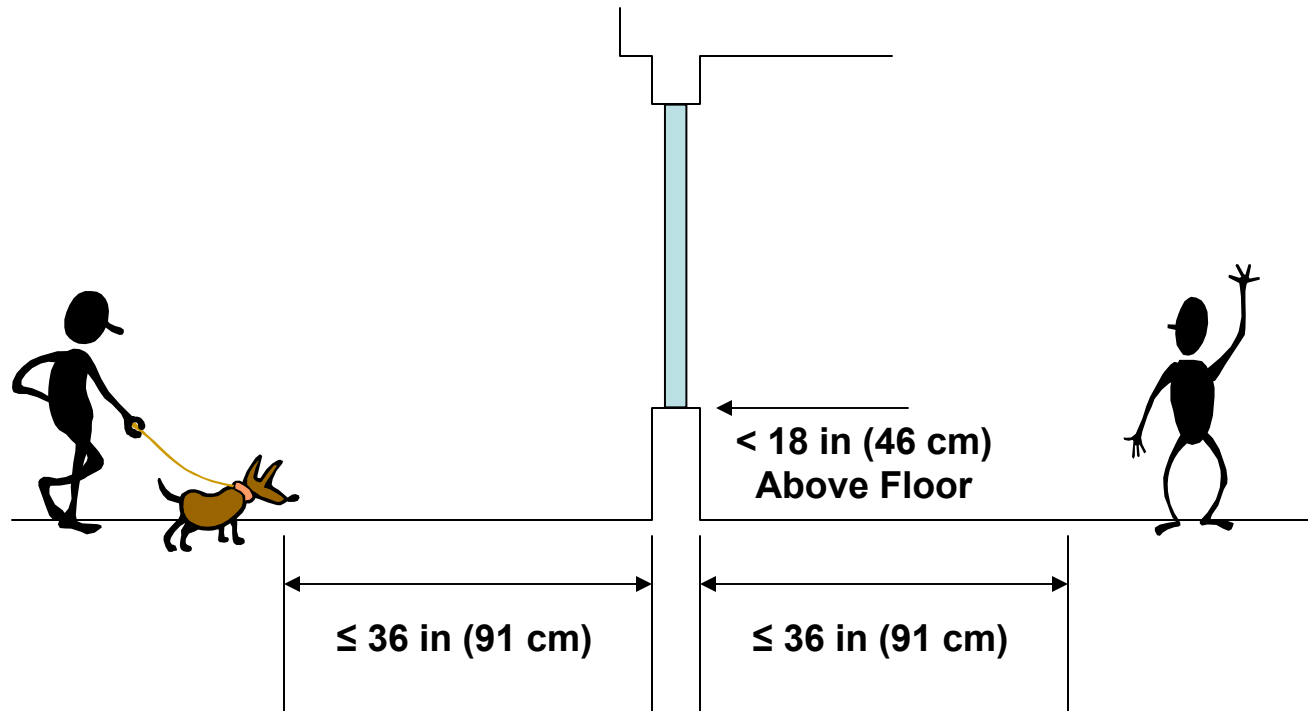


Legend

Safety

Non-Safety

Walking Surface Adjacent



Glazing in Guards and Railings

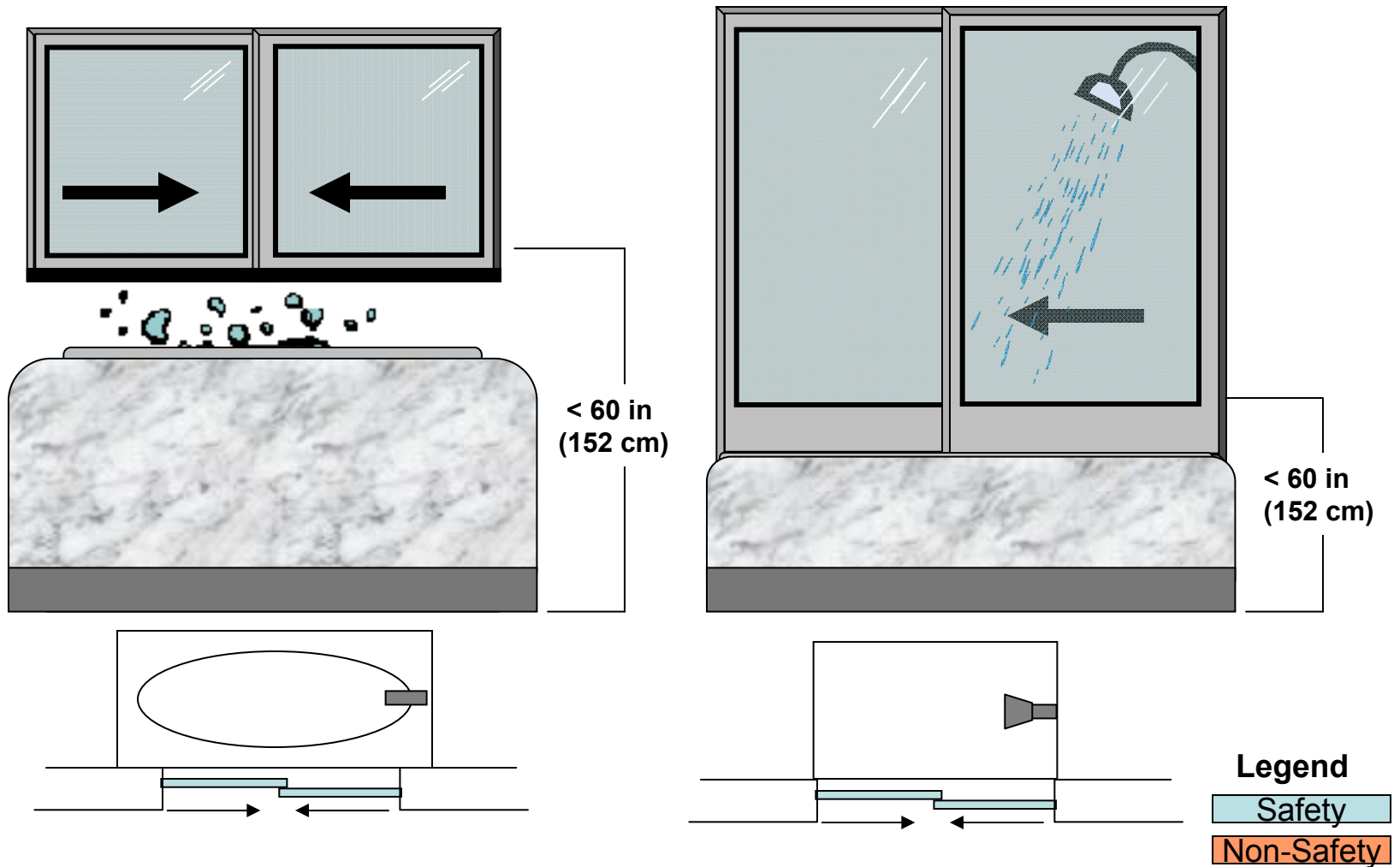


Legend

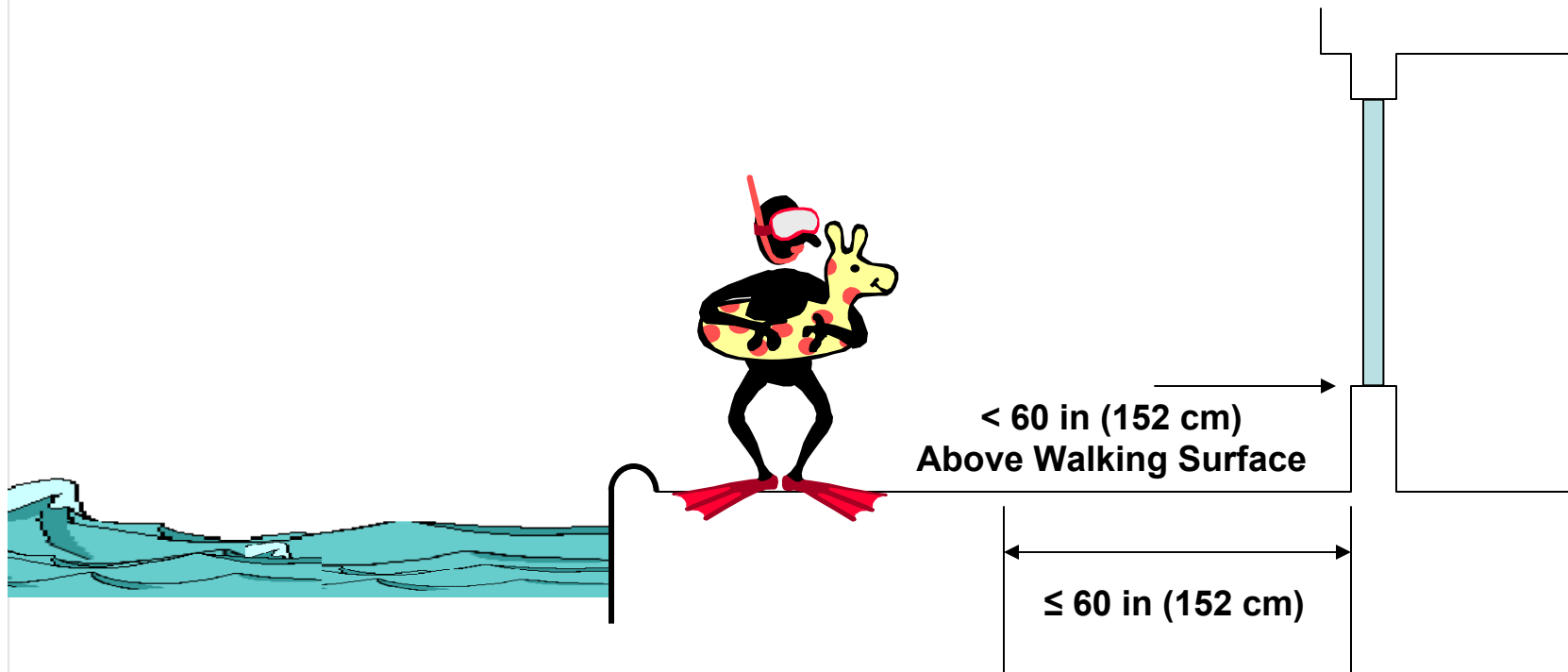
Safety

Non-Safety

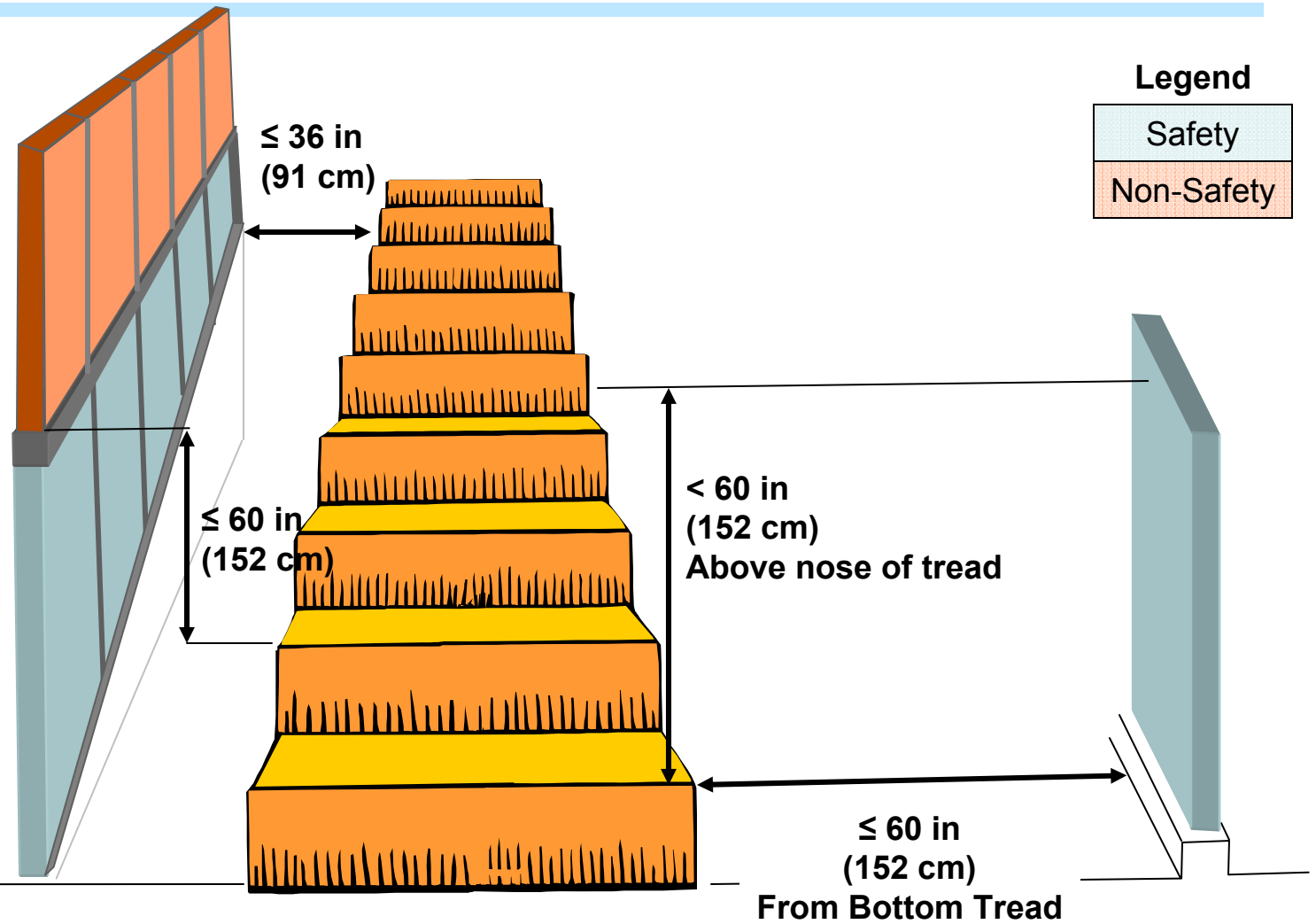
Bathtubs, Showers etc...



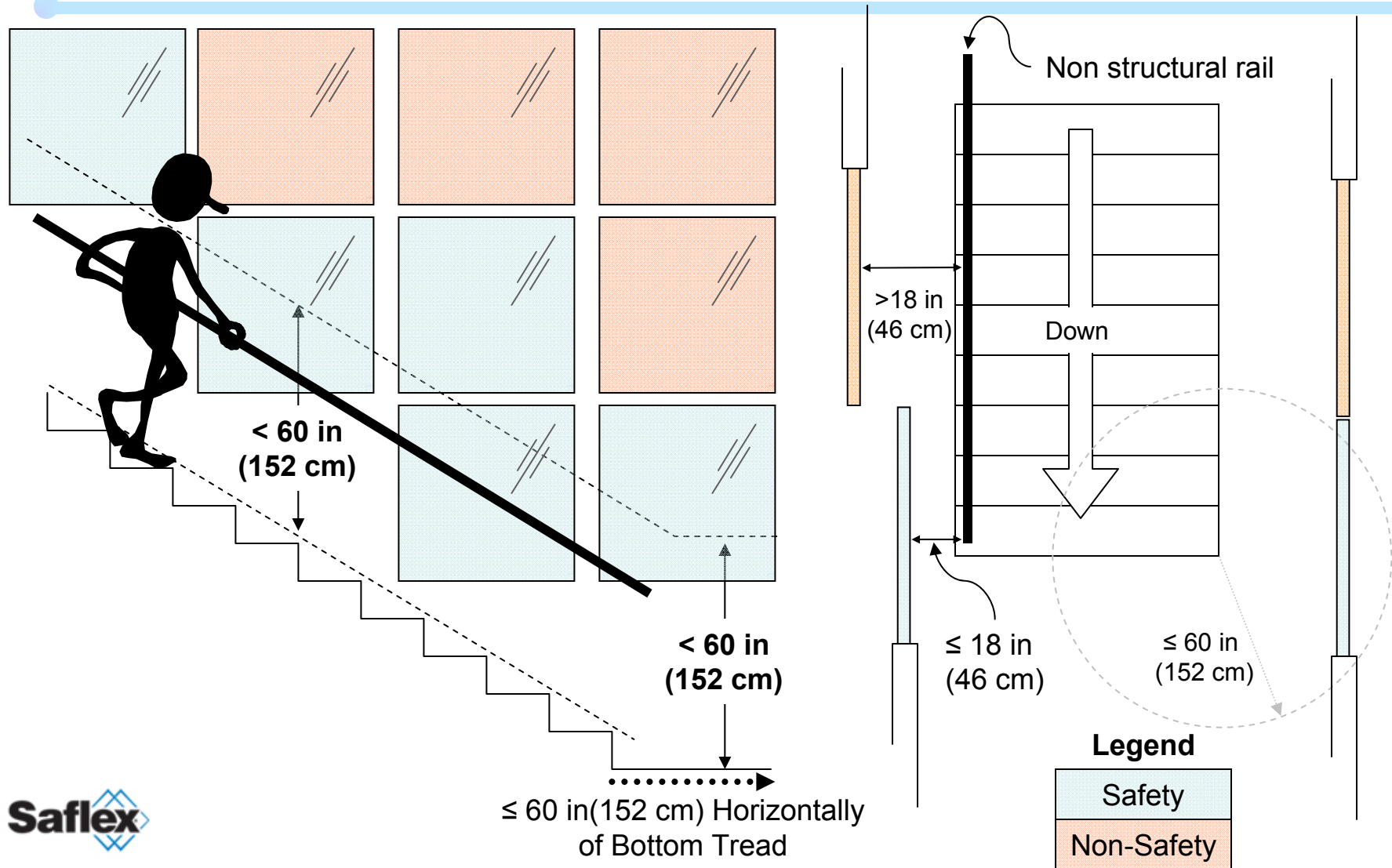
Glazing Near Pools, Tubs and Spas



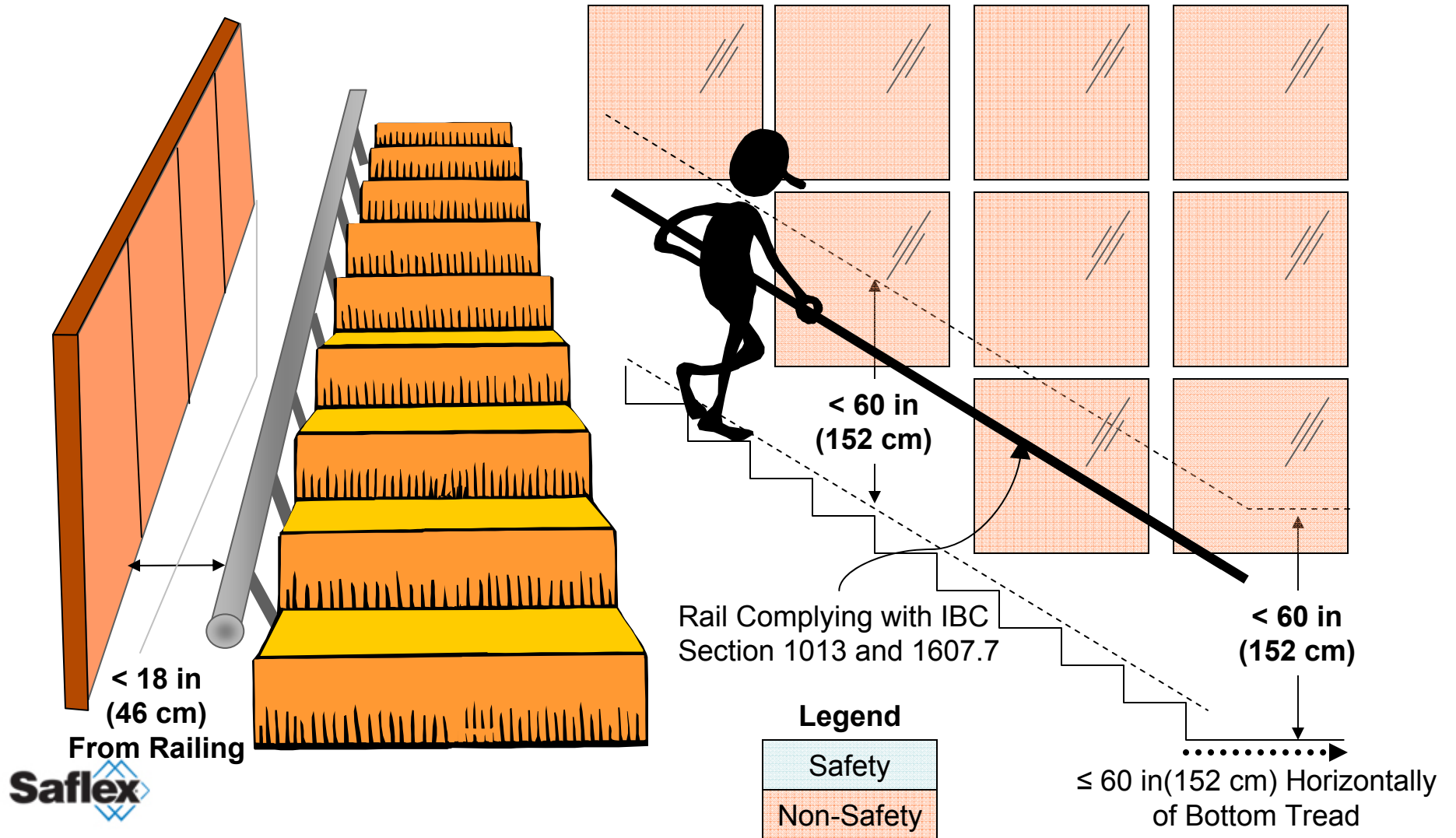
Glazing Adjacent to Stairways



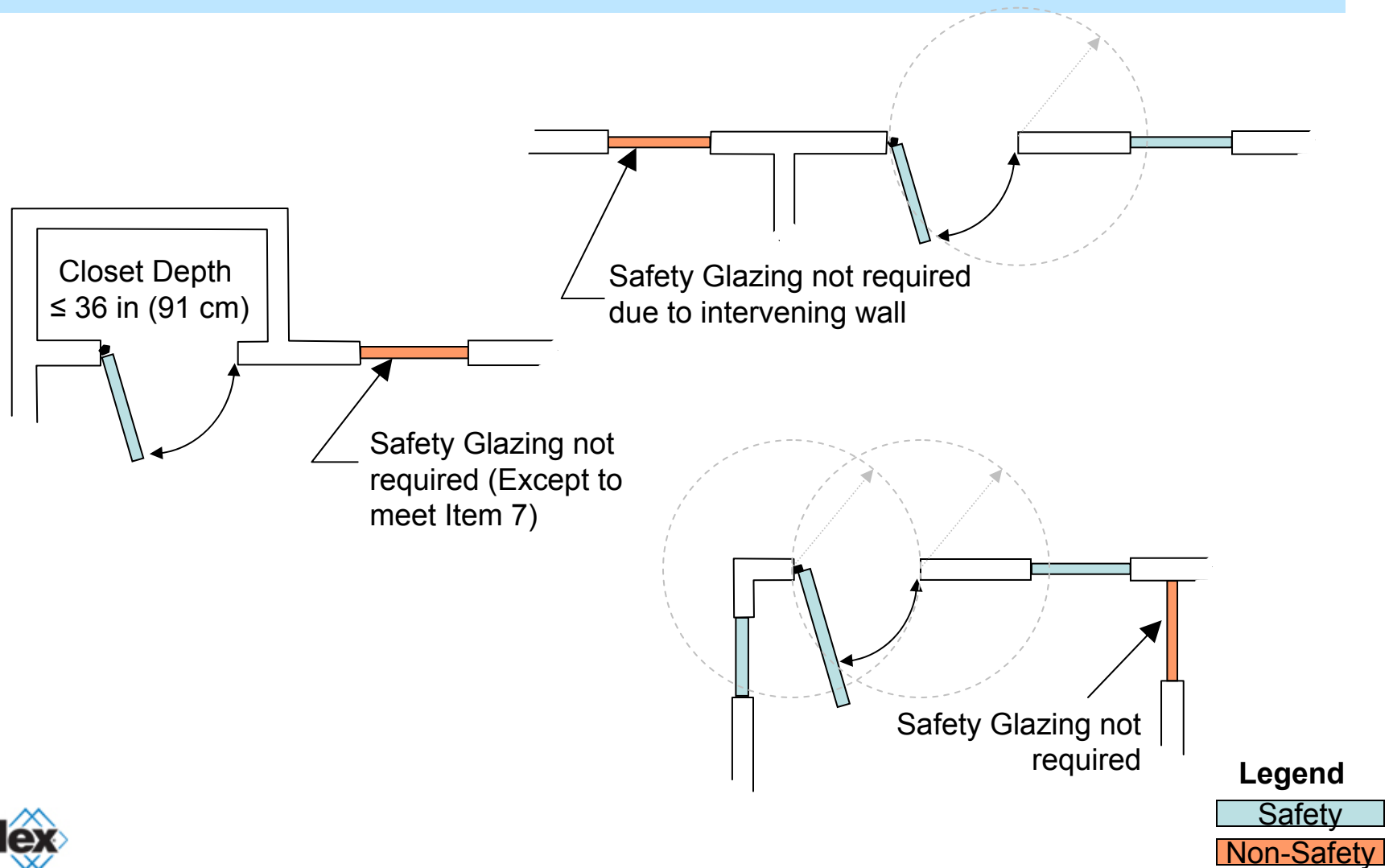
Stair Diagrams



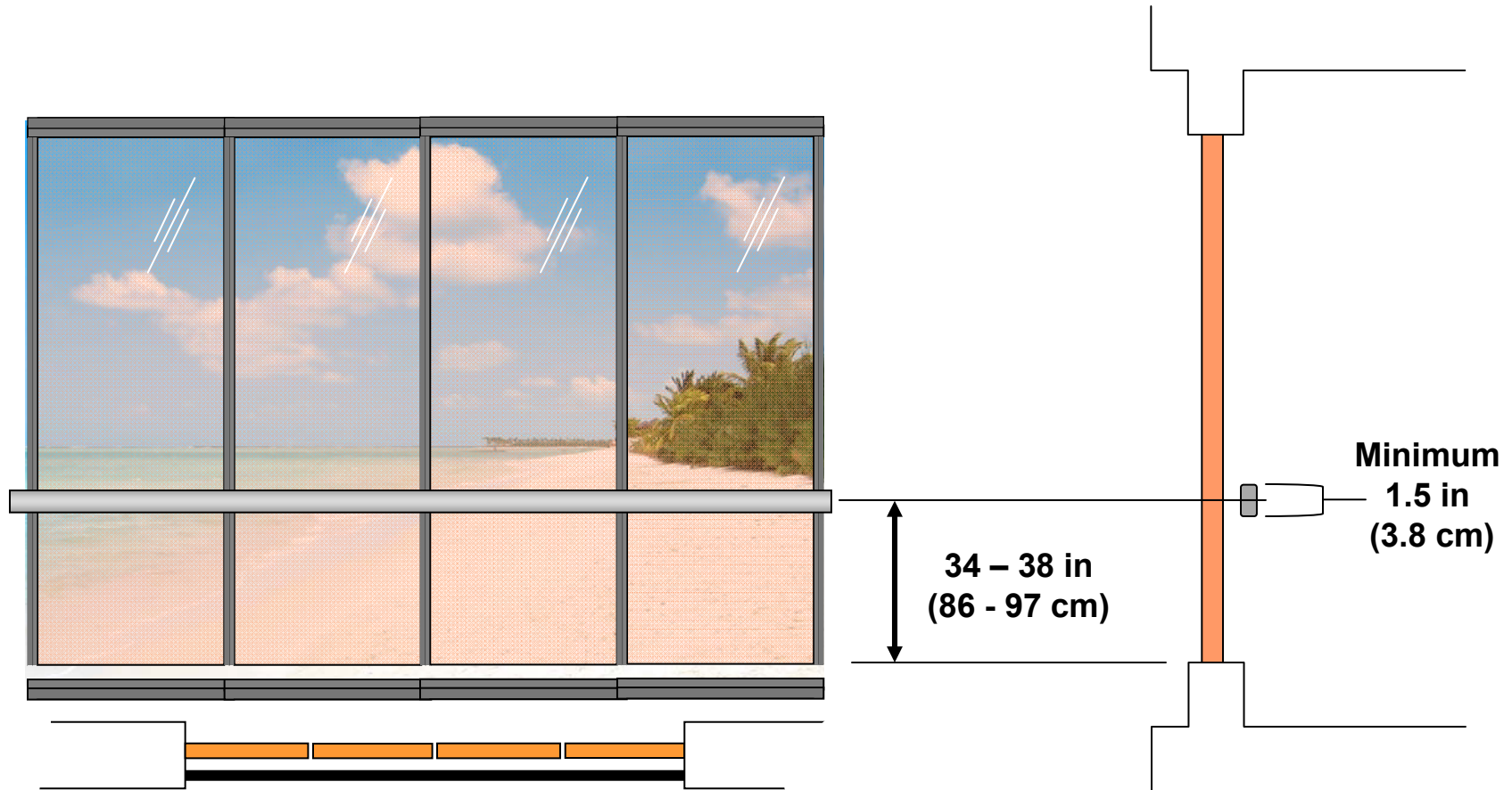
Stairways Exception & Diagram



Panel Adjacent to a Door Exceptions



Protective Bar Exception



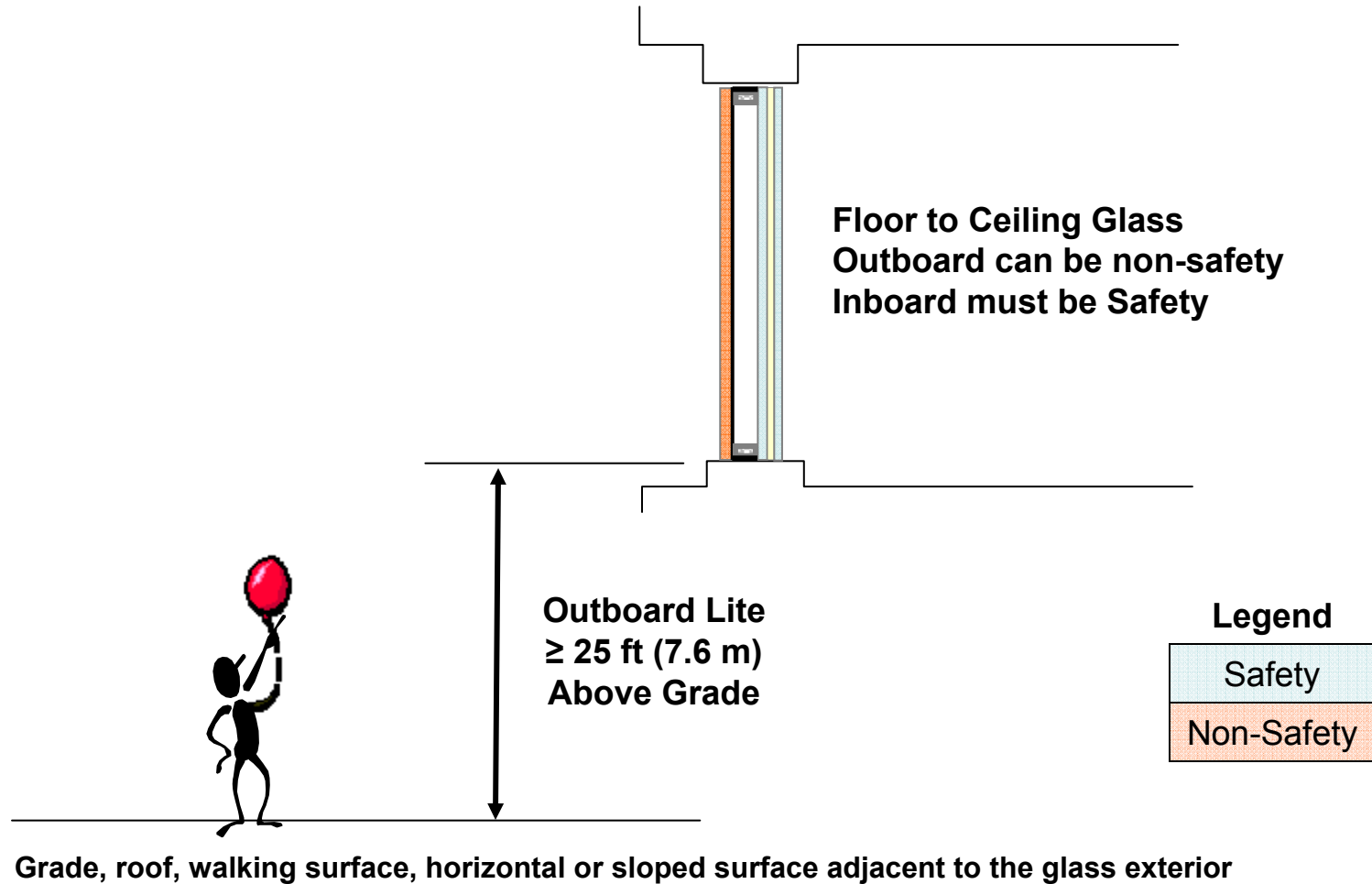
Bar capable of withstanding
Horizontal Load of 50 plf (730 N/m)
without contacting glass



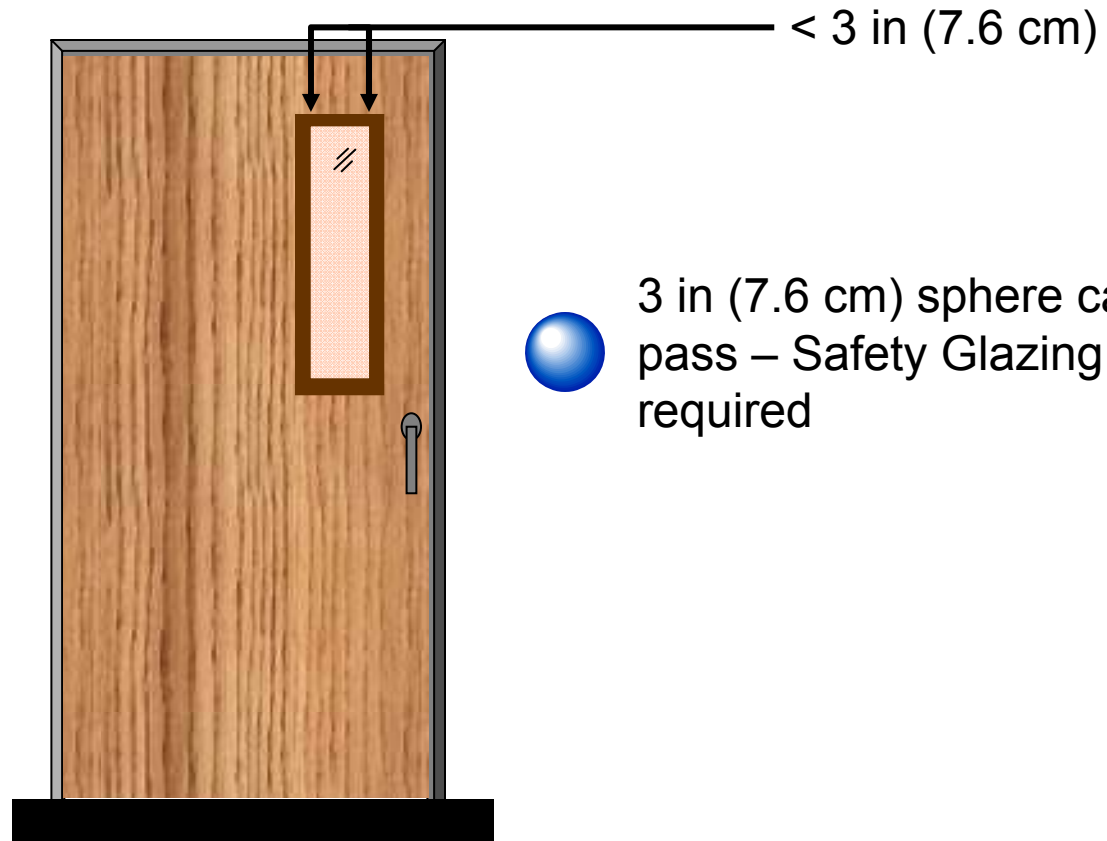
Legend

Safety
Non-Safety

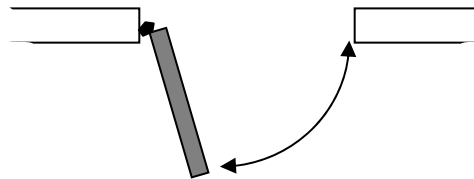
Outboard Lite of Insulating Glass Exception



Small Opening Exception



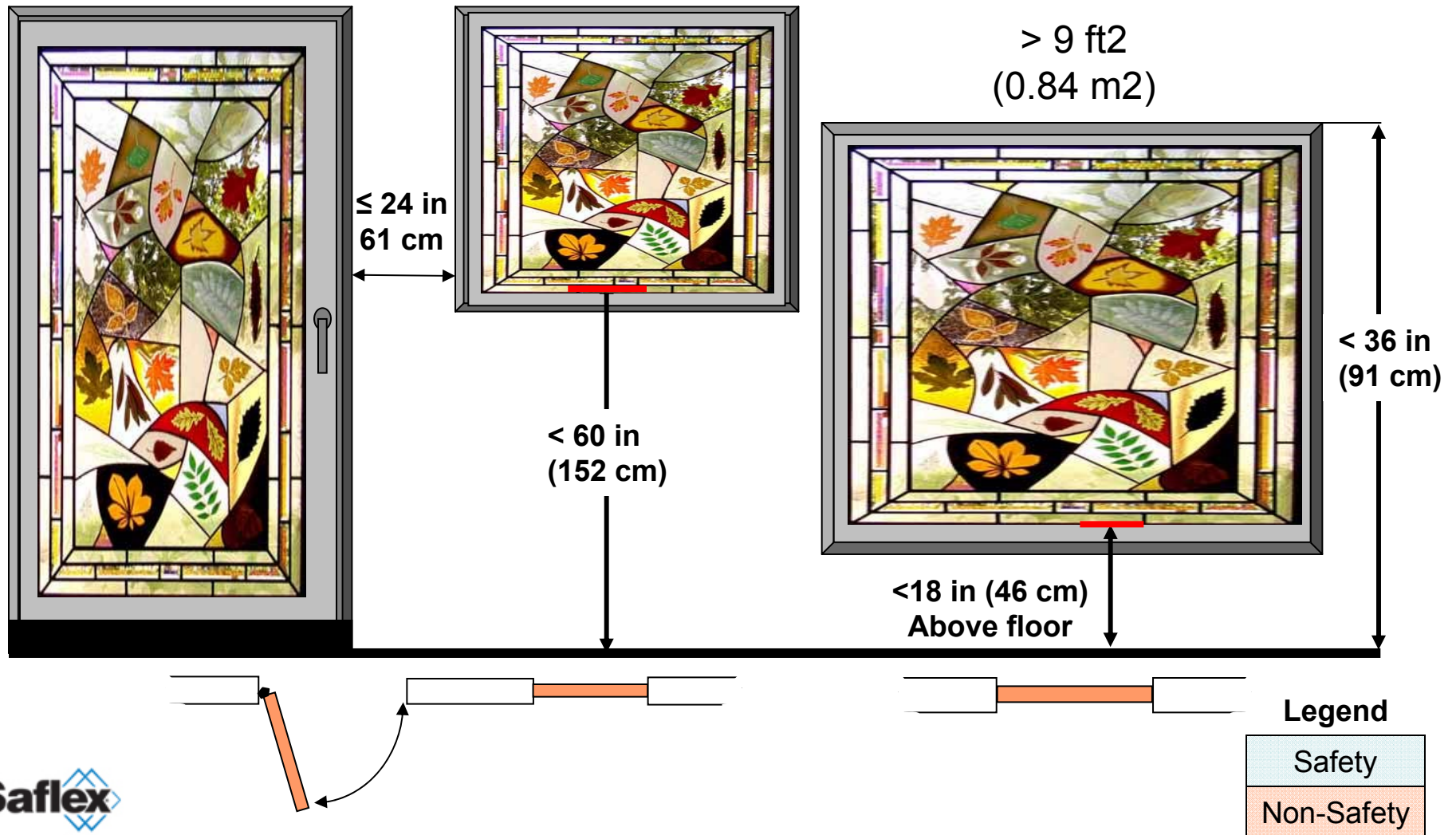
3 in (7.6 cm) sphere can not pass – Safety Glazing is not required



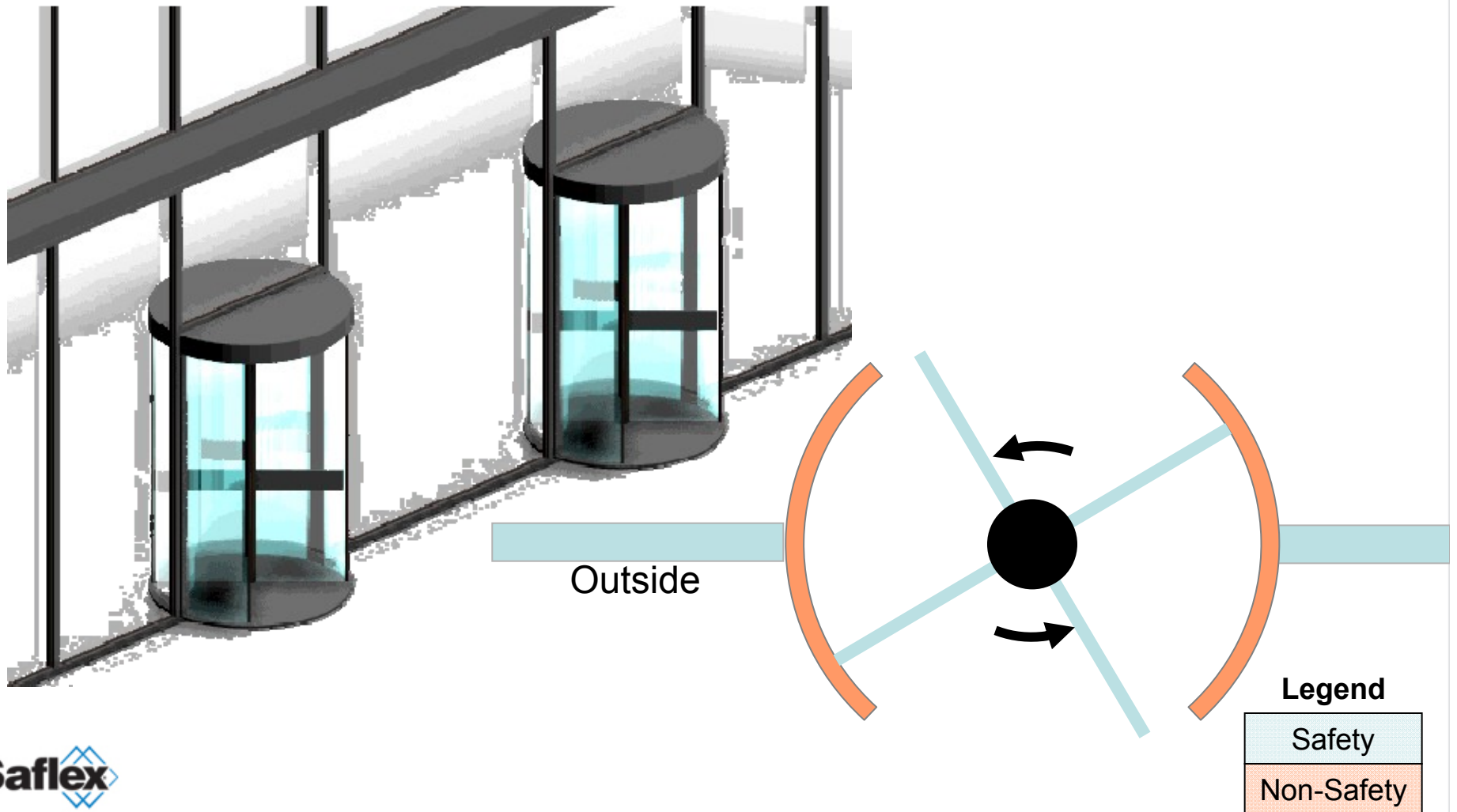
Legend

Safety
Non-Safety

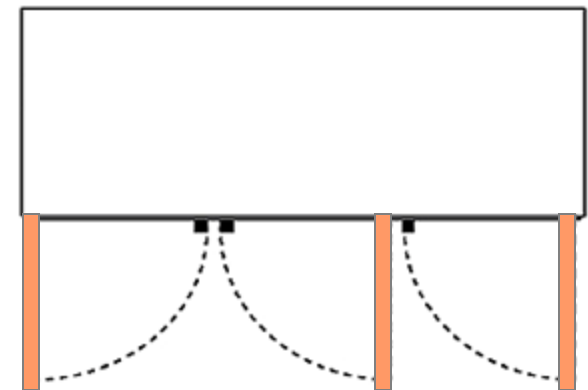
Decorative Glazing Exception



Revolving Door Exception



Commercial Refrigerated Cabinet Glazed Door Exception

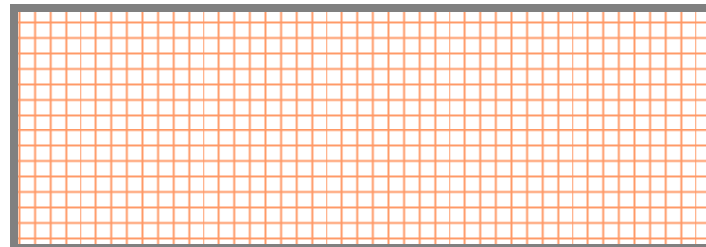


Legend

Safety

Non-Safety

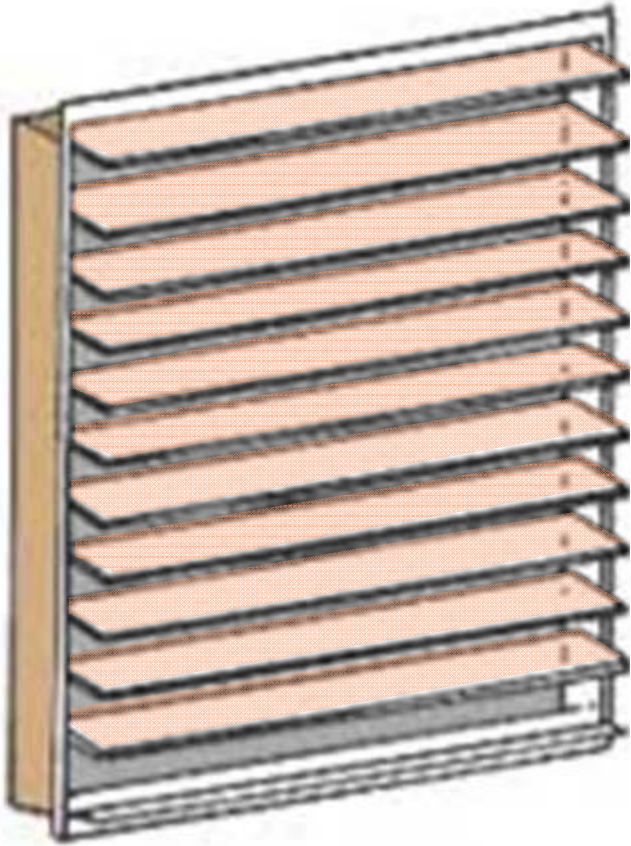
Glass Block



Legend

Safety
Non-Safety

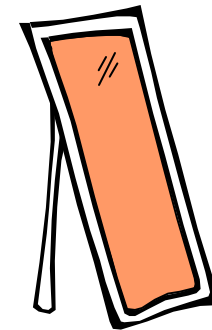
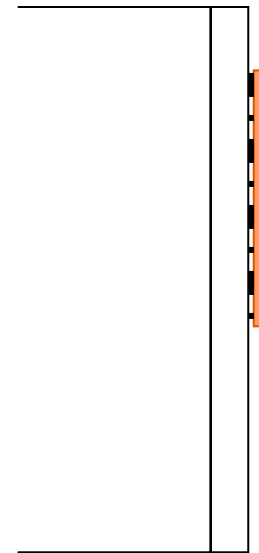
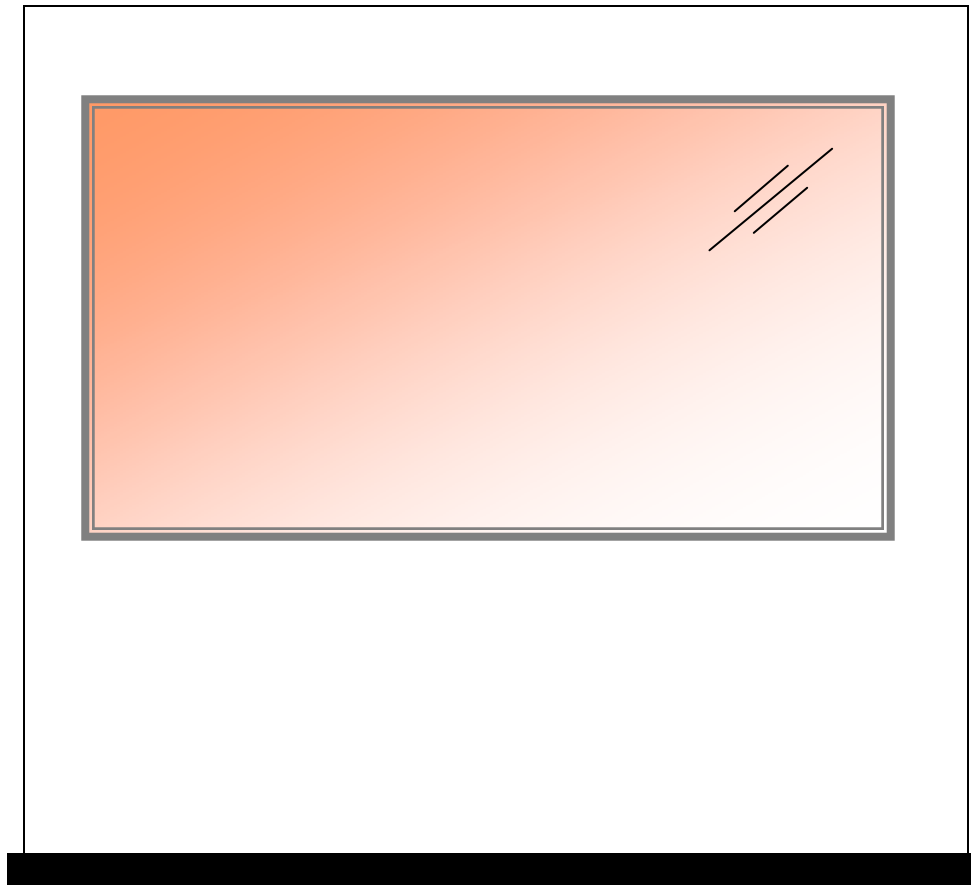
Louvered Windows & Jalousies Exception



Legend

Safety
Non-Safety

Continuous Backing Support Exception



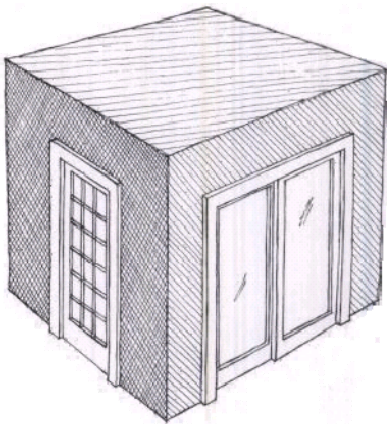
Legend

Safety

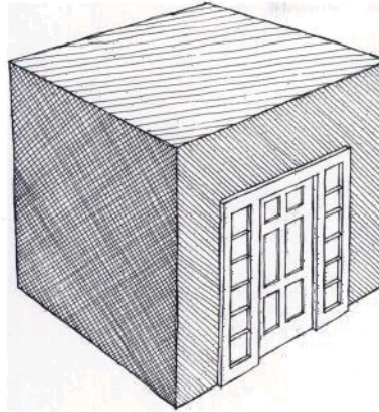
Non-Safety

Summary of Hazardous Locations

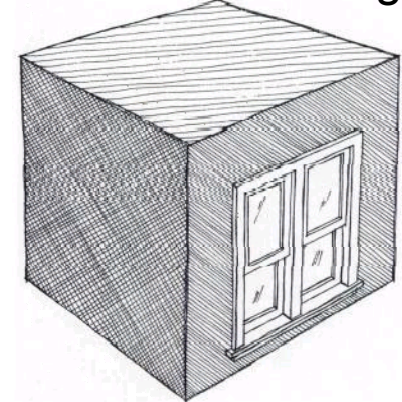
Doors



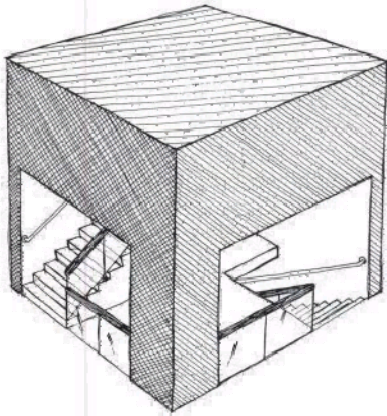
Adjacent Panels
to Doors



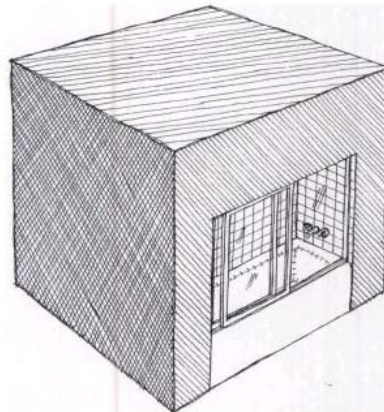
Windows
18" or below sill height



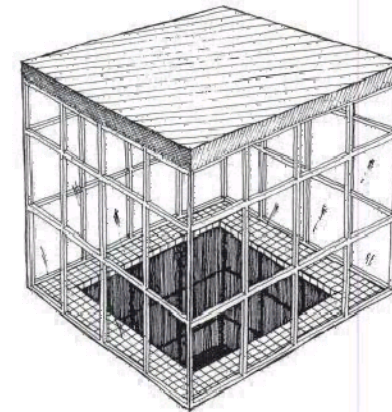
Guardrails



Tub and Shower
Enclosures



Swimming Pool
Enclosures



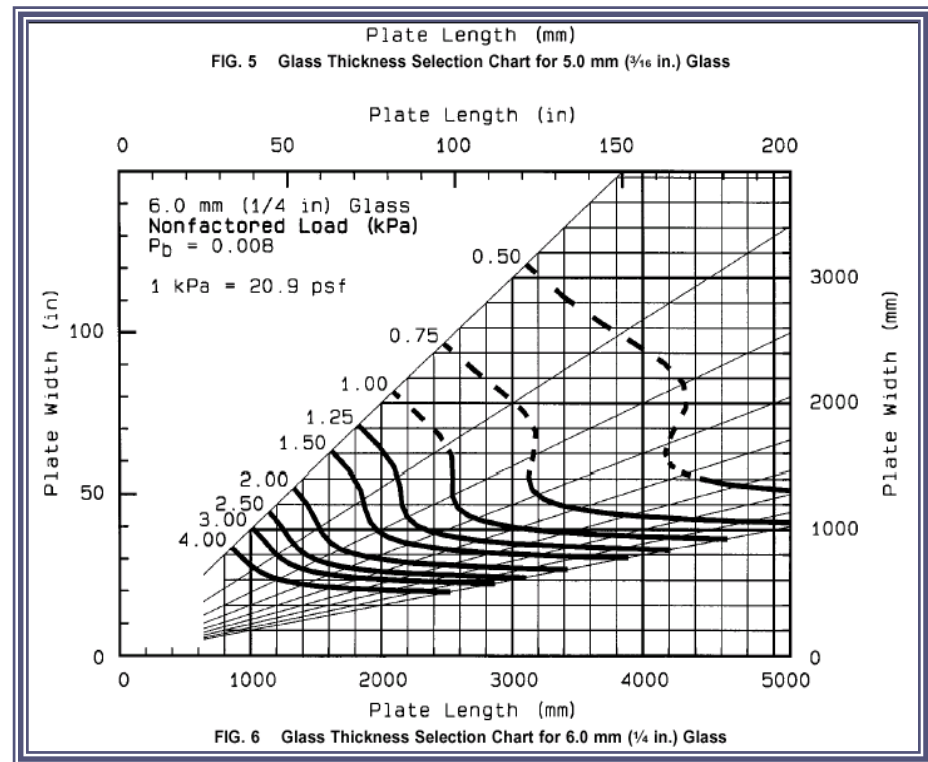


Code Mandated Applications

Safety Glazing

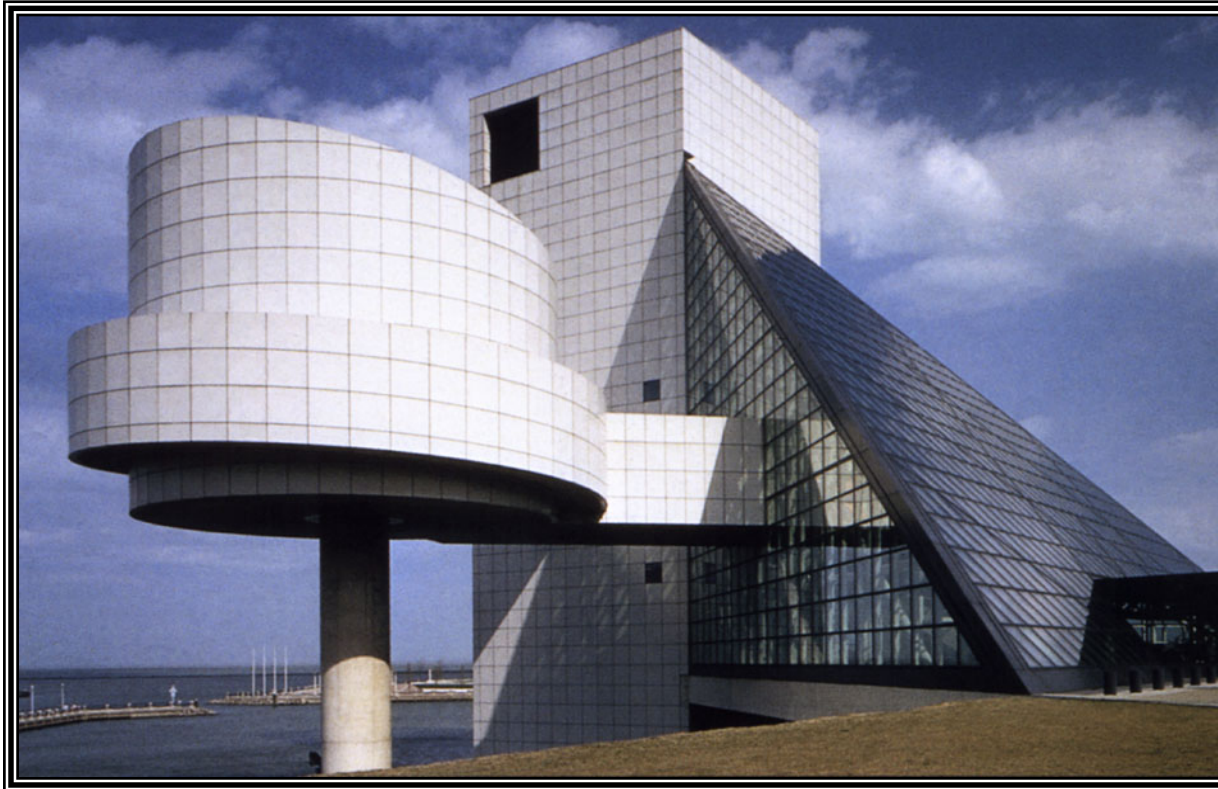
Structural

- Structural
 - Building Stability
 - Wind and Snow Loads
 - ASCE 7 Wind Speed
 - ASTM E 1300 Compliance
 - First Design Consideration



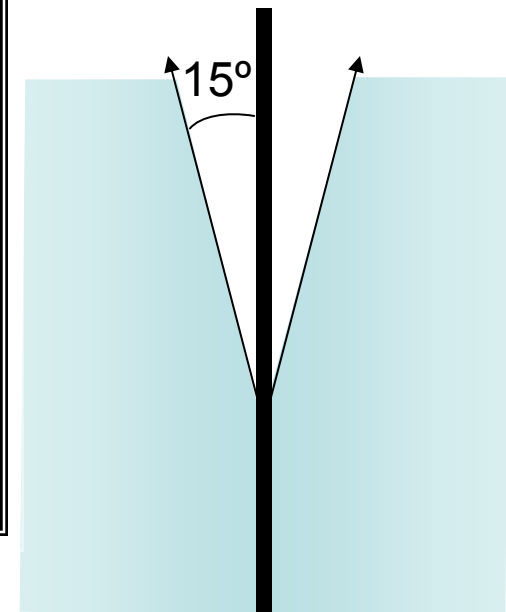
Sloped Glazing & Skylights

IBC 2405/IRC 308.6



Rock and Roll Hall of Fame and Museum
Architectural Firm: Pei Cobb Freed and Partners

Sloped Glazing:
Any glazing >15 degrees
from vertical



Applications

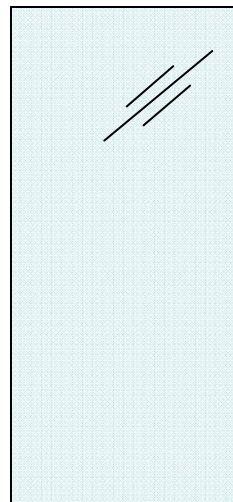


-
- Skylights
 - Unit skylights
 - Solariums
 - Sunrooms
 - Roofs
 - Slope walls

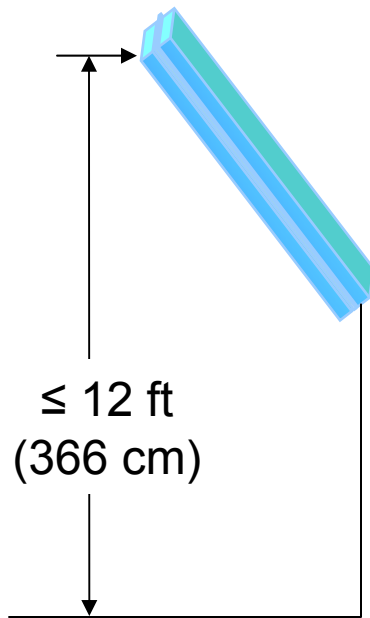
Allowable Glazing Materials

- Monolithic glazing systems
 - Laminated (0.030 in PVB – IBC)
 - Laminated (0.015 in PVB – IRC)
 - Wired glass
 - Heat Strengthened
 - Fully Tempered
 - Plastic materials (Section 2607; 2610)
 - Annealed Glass (IBC only)
 - Glass Block (IBC only - Section 2101.2.5)
- Multiple Layer systems
 - All Lites or layers made from above materials

Dimension & Height Requirements

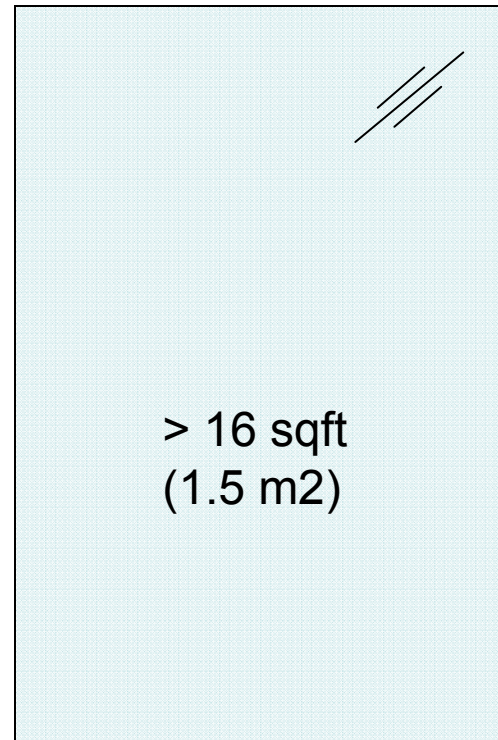


≤ 16 sqft
(1.5 m²)

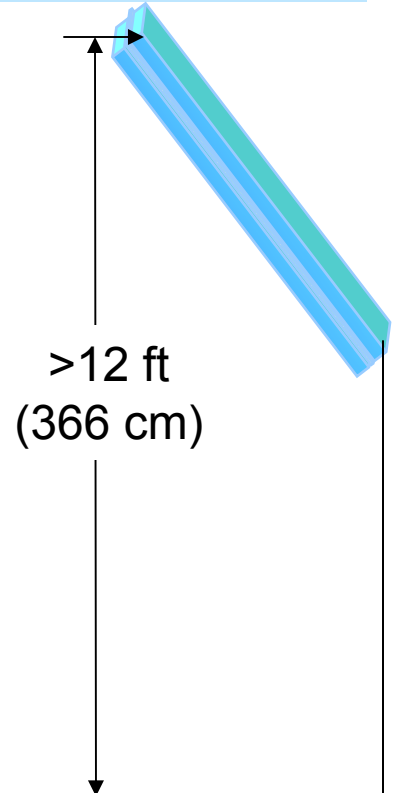


≤ 12 ft
(366 cm)

Laminated Glass
0.015 (0.38 mm) PVB
IRC R308.6.2 (1)



> 16 sqft
(1.5 m²)

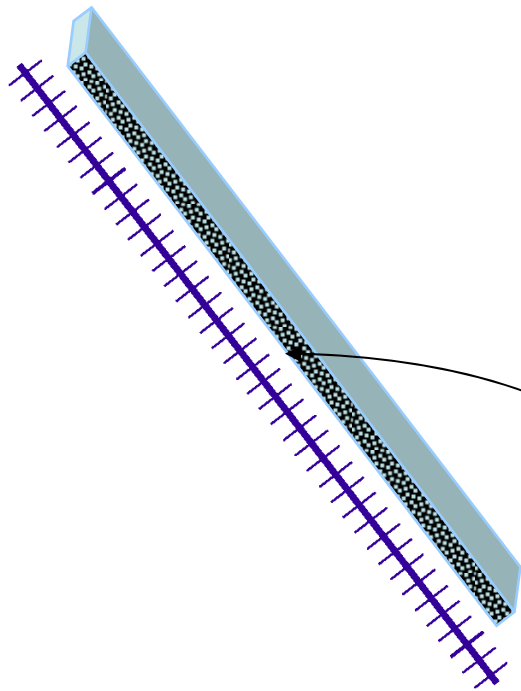


> 12 ft
(366 cm)

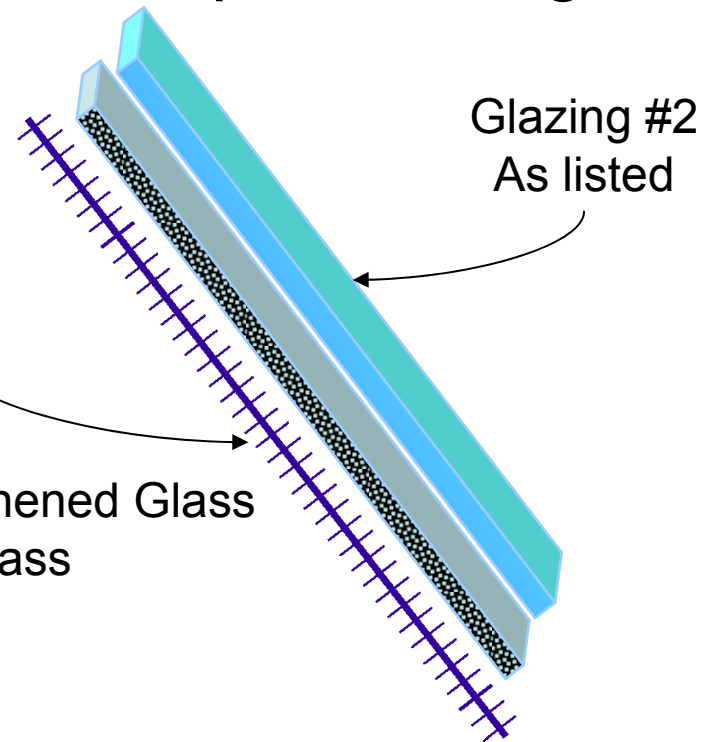
Laminated Glass
0.030 (0.76 mm) PVB
IRC R308.6.2 (1)

Screening Requirements

Monolithic Lites



Multiple Glazing



Screen

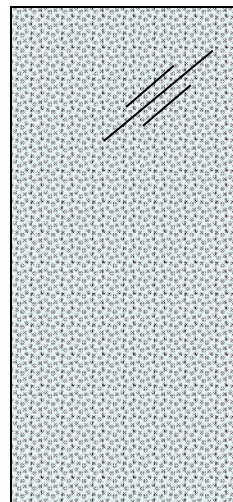
Glazing #2
As listed

Heat Strengthened Glass
Tempered Glass
Wired Glass

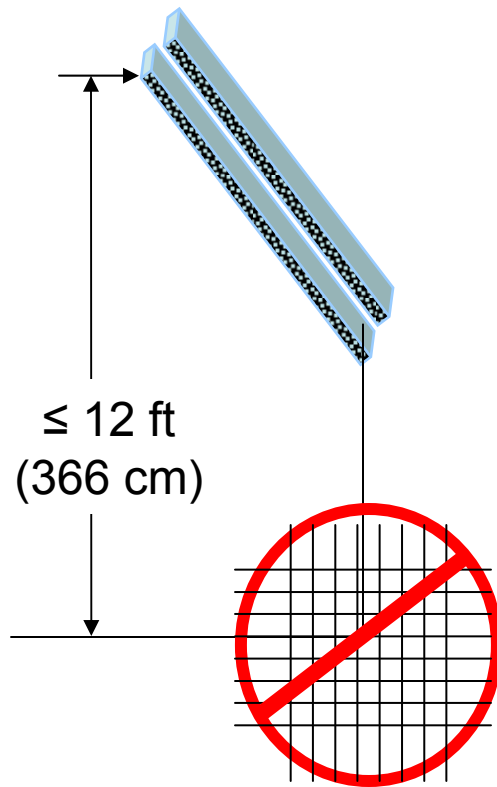
Screen Requirements

- Capable of supporting 2x the weight of the glazing
- Firmly fastened to framing members
- Mesh opening not greater than 1 in x 1 in (2.5 cm x 2.5 cm)
- Installed within 4 inches (10 cm) of the glazing (IBC only)
- Non combustible material (IBC only)
- Non Corrosive material (IBC only)

Screening Exceptions Individual Dwelling Units

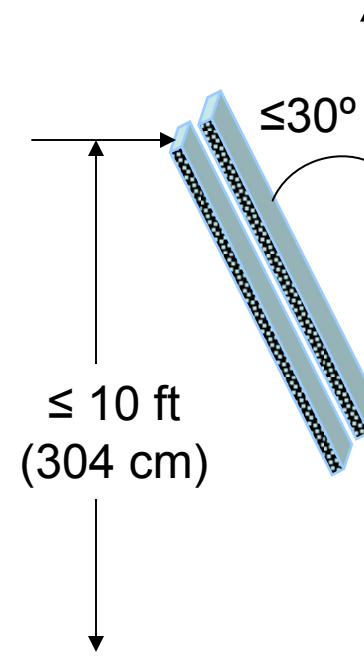
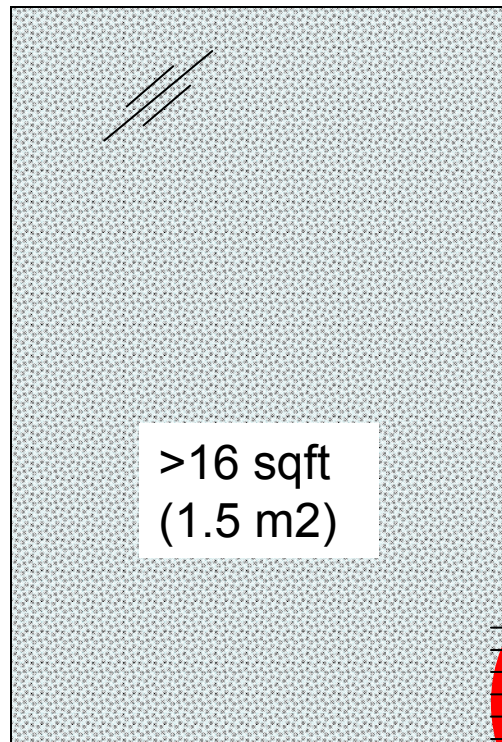


≤ 16 sqft
(1.5 m²)



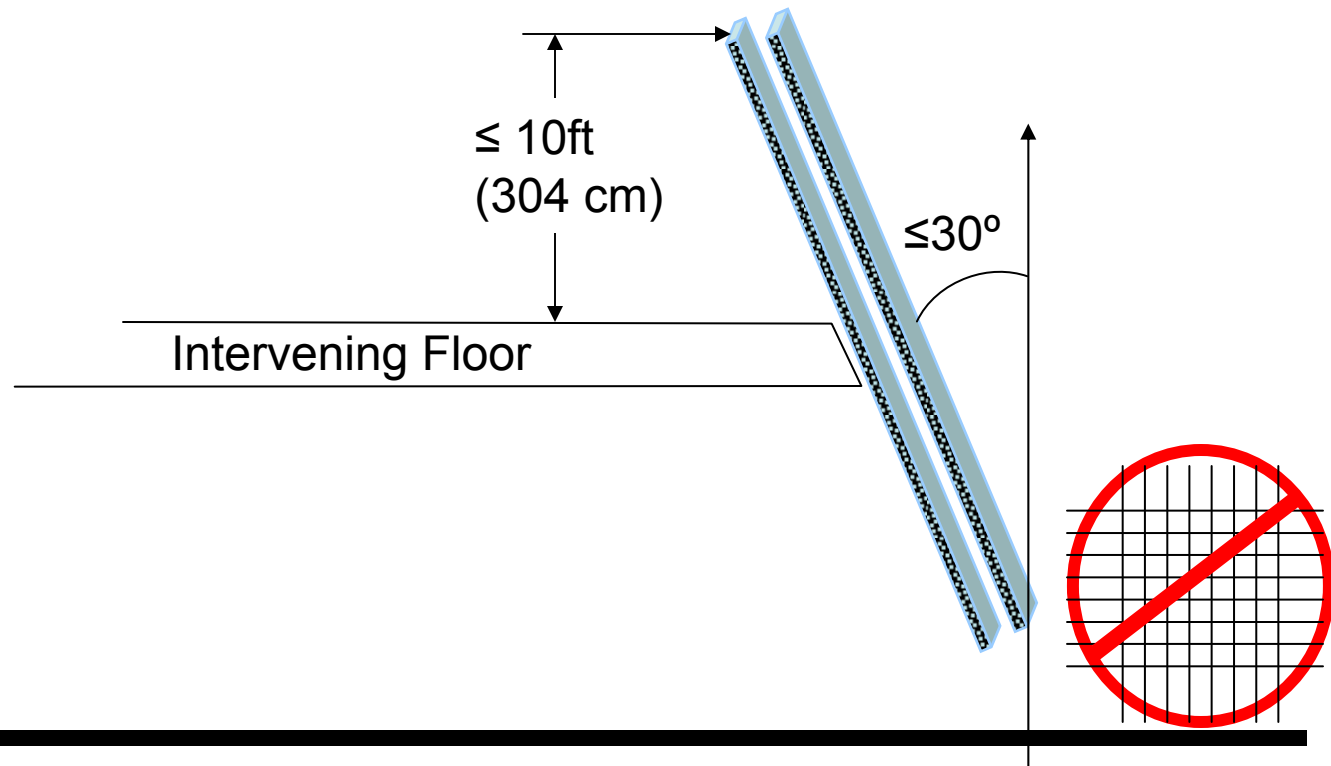
- Laminated glass with 0.015 in (0.38 mm) PVB
- Fully tempered Glass
- Single or Both Panes of IG
- $\leq 3/16$ in (5 mm)

Screening Exceptions Individual Dwelling Units



- Fully tempered Glass
- Single or Both Panes of IG
- $\le 3/16$ in (5 mm)

Screening Exceptions Intervening Floor

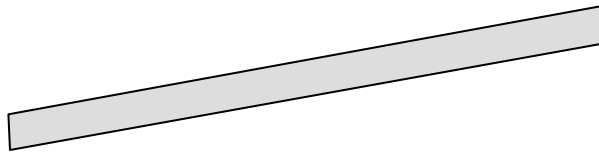


- Fully tempered Glass
- Single or Both Panes of IG

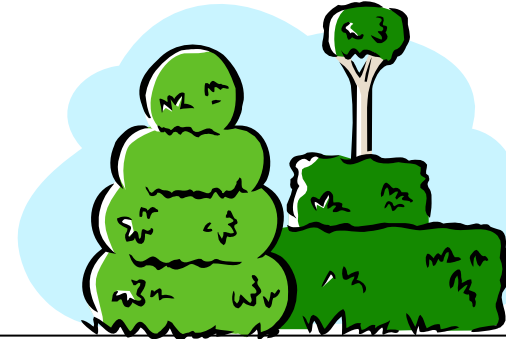
Protected or Prohibited

No Screen
Any Glazing Material

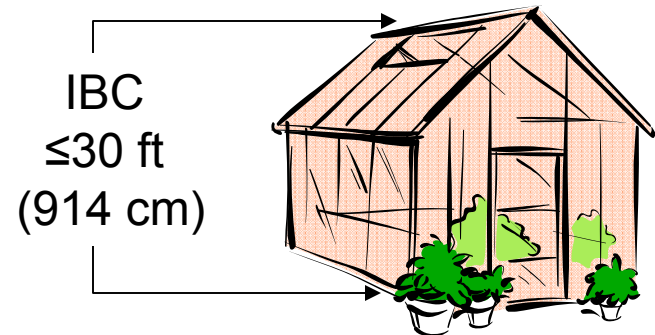
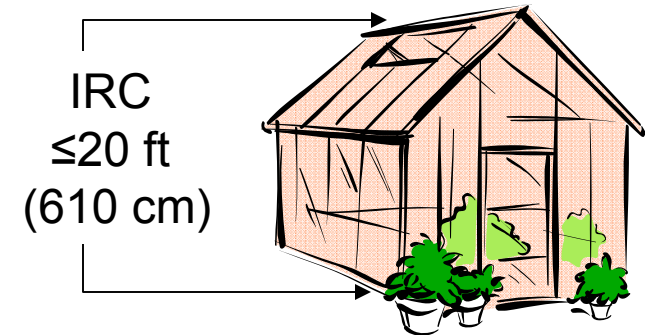
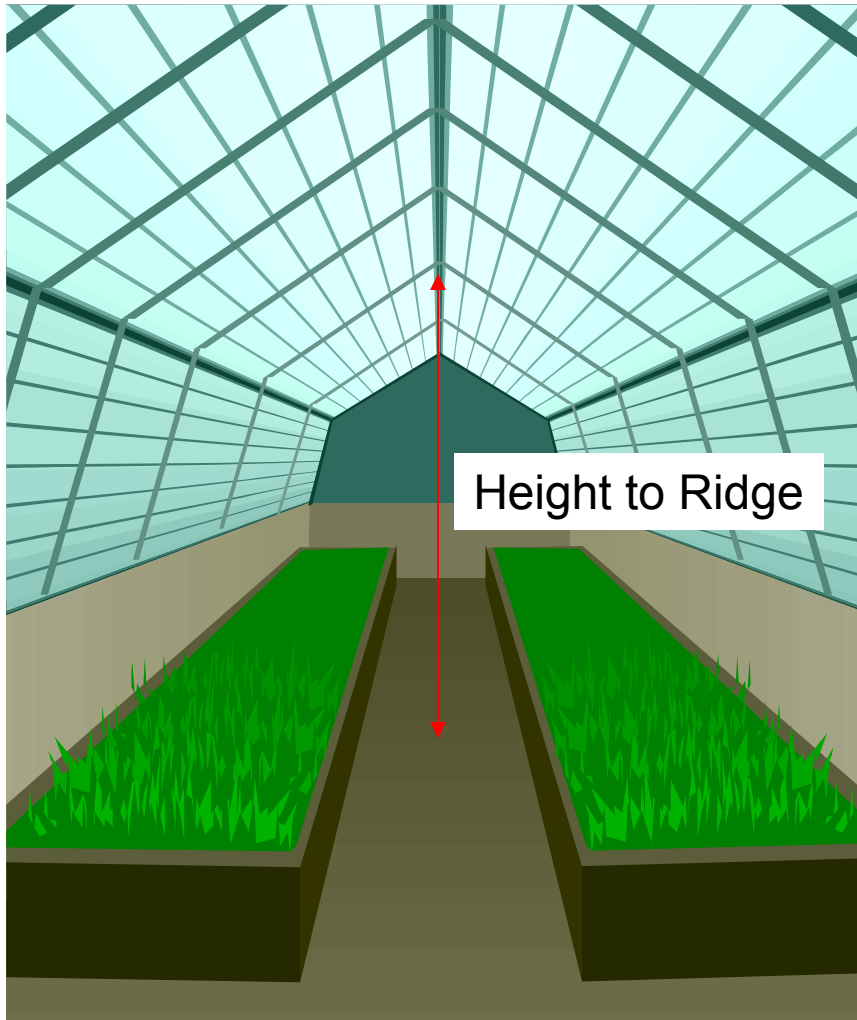
Protection from Falling Glass



No Screen
Any Glazing Material



Greenhouses



Exclusively for Growing Plants
Not Open to the Public

Glazing Subject to Impact Loads

- Racquetball and Squash Courts
- Gymnasium and Basketball Courts
- Glass in Elevator Enclosures

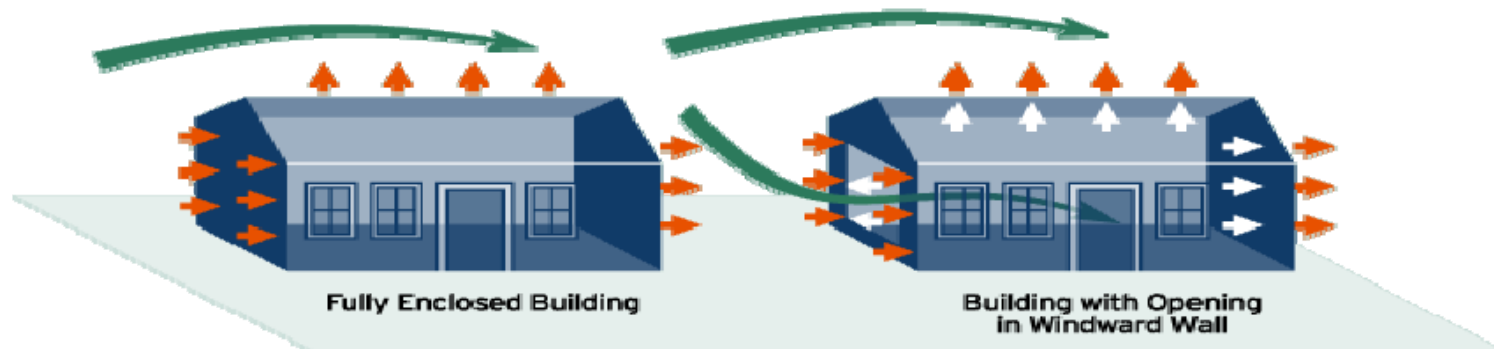
Hurricane



Objective Standards & Codes

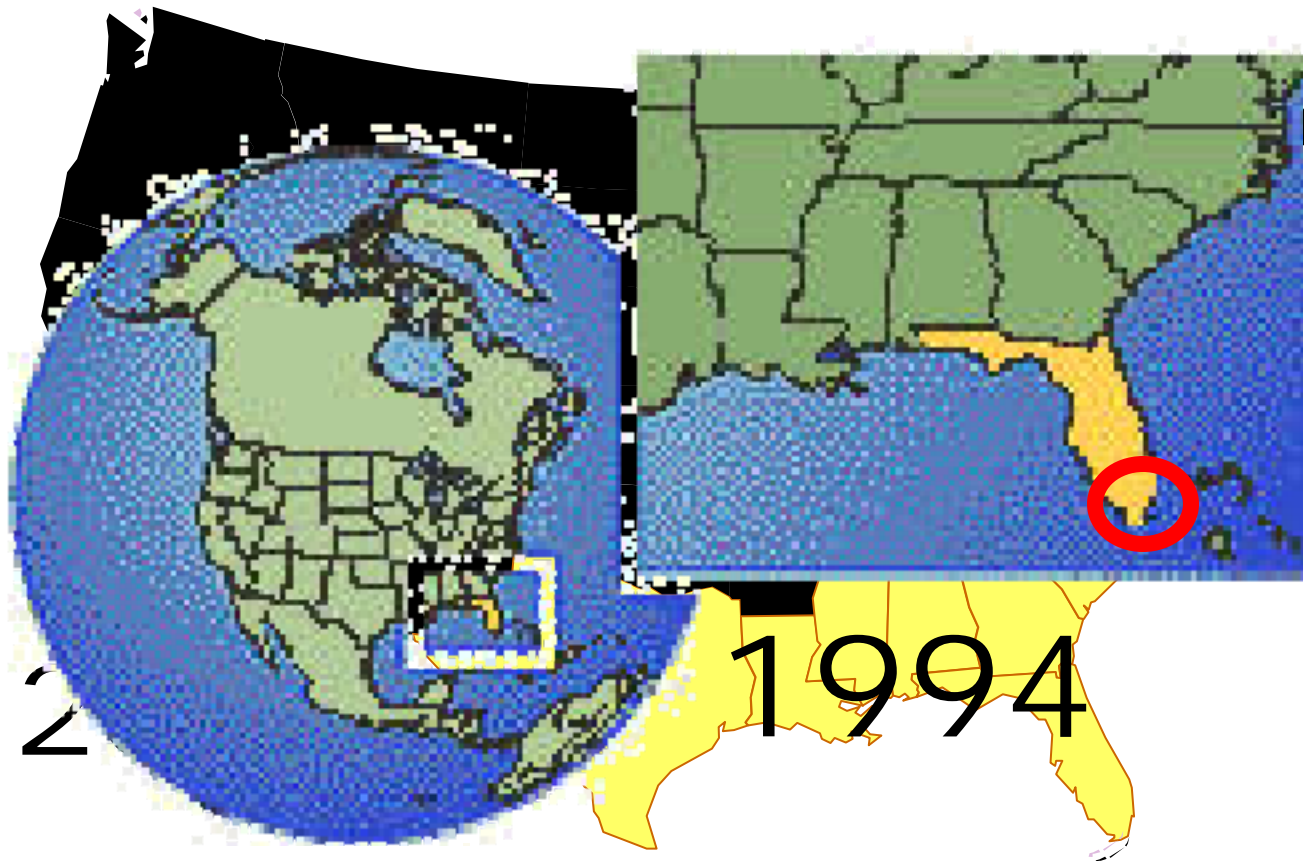
- Ensure elements of the building envelope remain Unbreached during storms (hurricanes) to protect lives and property

Unprotected Structure



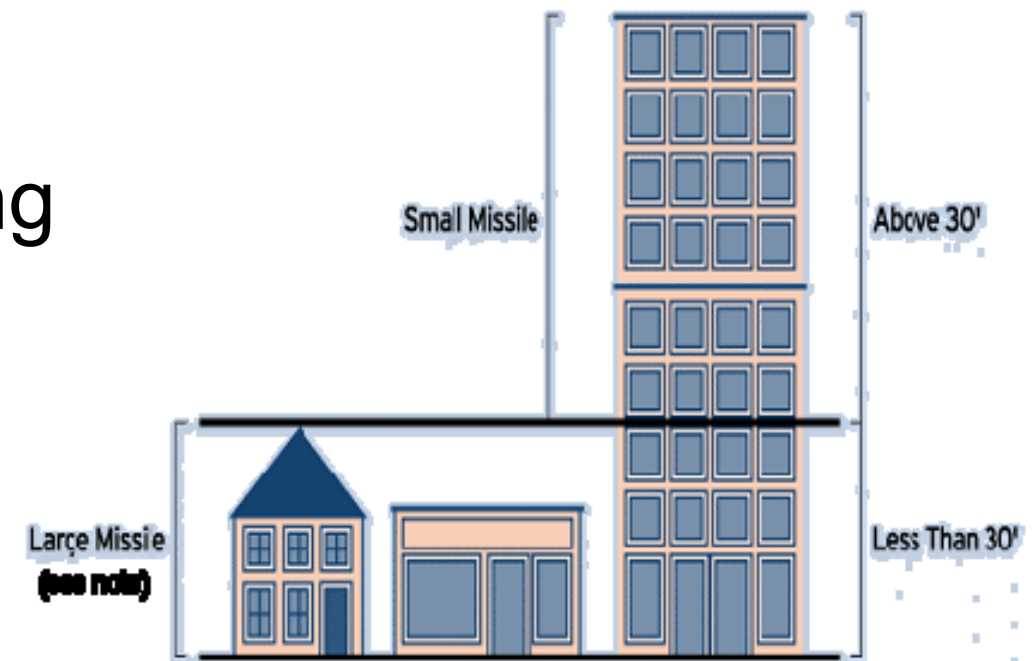
- Flying debris breaks glass
- Wind and rain enters a building through breached openings
- 1% opening on windward wall
 - 200% increase in pressure on underside of roof
 - 50% increase in pressure on exterior walls

Hurricane Requirements



Hurricane Test Segments






- Large missile
- Small missile
- Cyclical Loading



Note: Missile size based on Protection classification and wind zone

Windborne Debris Requirements

- Missile sizes

Missile Level	Missile	Impact Speed feet/sec (mph)	Typical Use
A	2 gram steel ball 	130 (89)	Above 30 ft
B	2 lb. Lumber 	50 (34)	Skylights \leq 30 ft. Wind Zone 2
C	4.5 lb. Lumber 	40 (27)	Less than 30 ft. Wind Zone 1 & 2
D	9 lb. Lumber 	50 (34)	Less than 30 ft. Basic Protection
E	9 lb. Lumber 	80 (55)	Less than 30 ft. Enhanced Protection

Hurricane Regulations

- Mandated by code
- Method in a standard
 - Dade County, FL
 - ICC (IRC, IBC)
 - NFPA 5000
 - ASTM E1886 & E1996



Large Missile Impact



Laminated Glass Construction

Glass Configuration Criteria & Recommendations

Glass Designed to meet ASCE-7 & ASTM E 1300

Glass Constructions:

<u>Missile</u>	<u>Code</u>	<u>Glass Configuration</u>
Large	PA(TAS) 201/3 Dade	Glass / .090" Saflex*; .100" Saflex HP; or .075" Saflex VSO2 / Glass
Large	SSTD-12	Glass / .090" Saflex*; .100" Saflex HP; or .075" Saflex VSO2 / Glass
Large	ASTM E 1886/1996	Glass/ .090" Saflex*; .100" Saflex HP; or .075" Saflex VSO2 / Glass
Small	SSTD-12	Glass / minimum .060" Saflex / Glass
Small	ASTM E 1886/1996	Glass/ minimum .060" Saflex* / Glass

* Thinner gauge has been demonstrated to intermittently pass the large missile impact test.





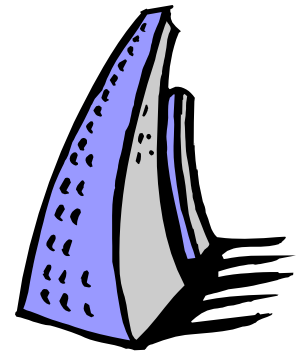
Laminated Glass for Seismic Applications

Seismic Background

- 500,000 “events” detectable each year
- 100,000 are felt by humans
- 100 cause damage
- Southern California has 10,000 Seismic events yearly
- Alaska is most prone to seismic events

Architectural Glass and Earthquakes

- Building vibrates with low intensity quakes
- Inter-story drift may occur
- Building Sways
- Glazing system “racks” with movement
 - Glass contact frames
 - Glass cracks
 - Monolithic glass fall-out
 - Building breach
 - lacerations
 - Engineered glass may crack, but typically is retained
- Glass First Crack ~ 3” of movement
- Delta Fall Out – NRG ~3 in movement



Seismic Summary

- Seismic Requirements in IBC
- AAMA 501.4 and 501.6
- FEMA Studies
- NEHRP Provisions
- NIBS BSSC
- Retention Specifications
- Laminated Glass as design choice
- Anchored Filmed Glass (Retrofit)



Design Considerations and Other Benefits

Safety Glazing

Other Safety Glazing Applications

- Golf Course Homes
 - Golf ball impact
 - Fear of Shards
- Bird Impact
- Potential Fall-Out/Fall-Through Areas



Laminated Glass Benefits

Beyond Safety...

Sound Control



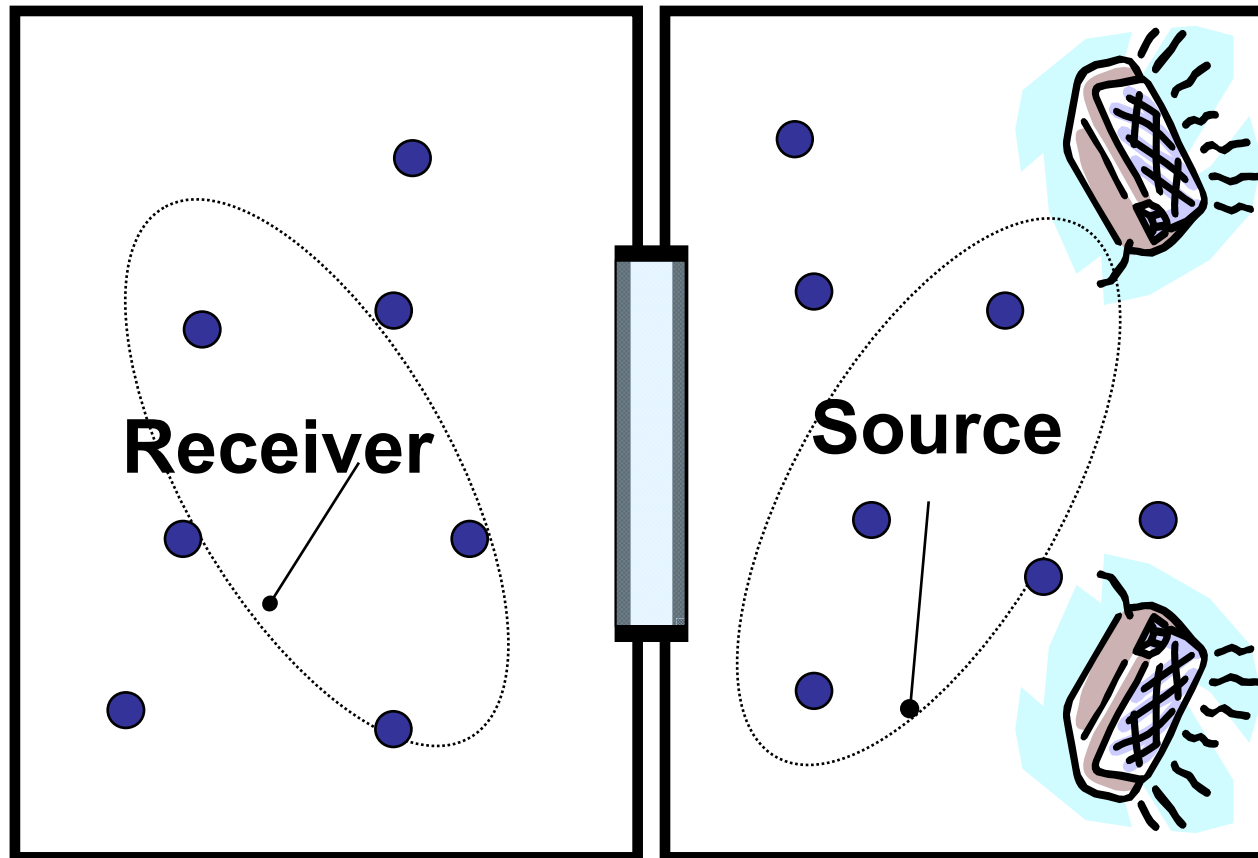
Acoustic Glazing

- Noise is an overwhelming problem
- Population Density increasing
- Landscape of Built environment changing
- Sources and pressures are increasing and varied
 - Trains, Planes, Automobiles...
 - Building is Stationary
- Human need for quiet
- Windows can be a weak link for Noise Infiltration

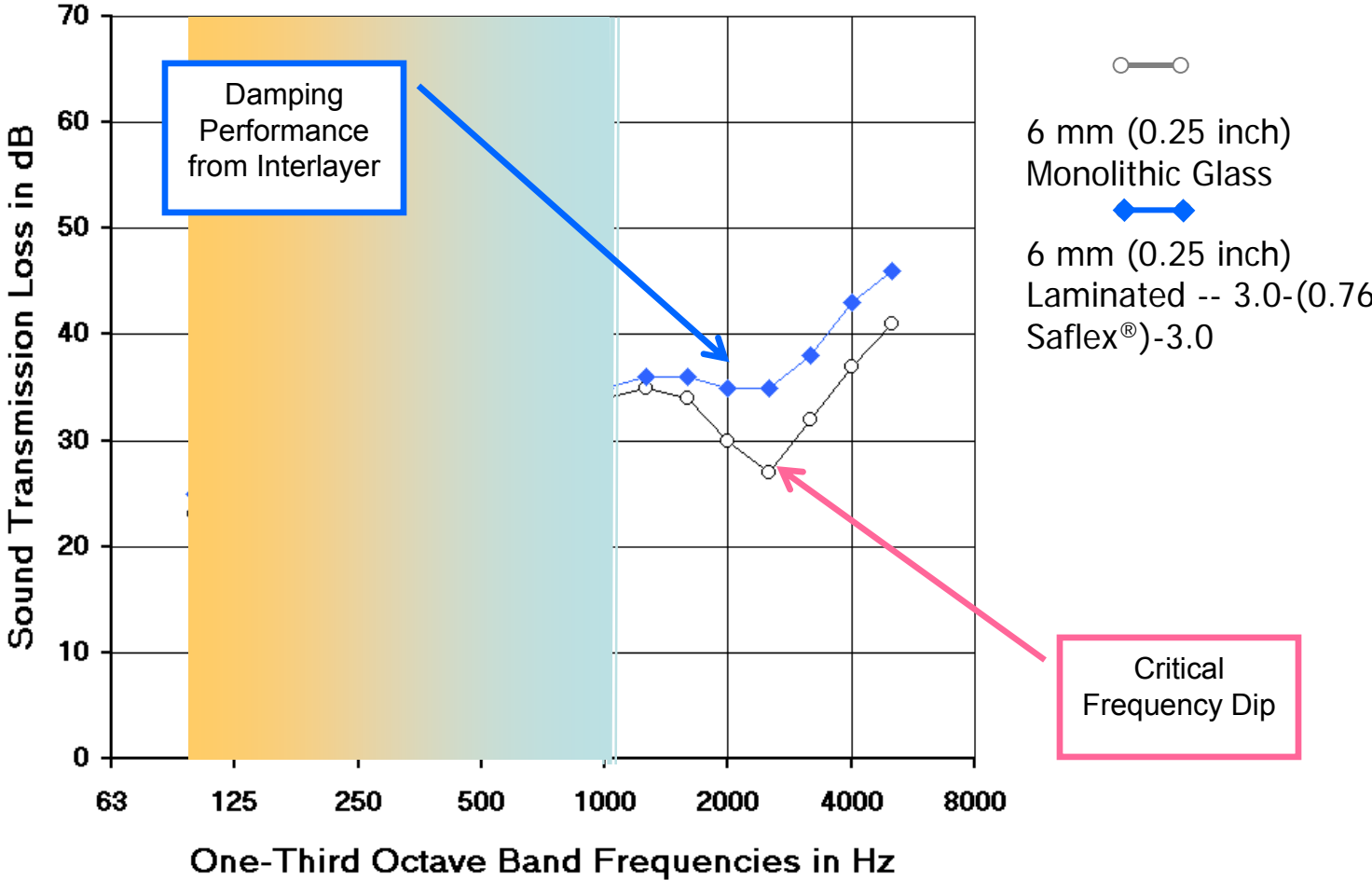
Noise disrupts activities

- Disturbs peace and quiet
- Impedes Communication
- Disrupts Comfort
- Detrimental to Safety
- Decreases Job performance
- Adverse Effects
 - Physically
 - Psychologically

Sound Transmission Loss Measurement



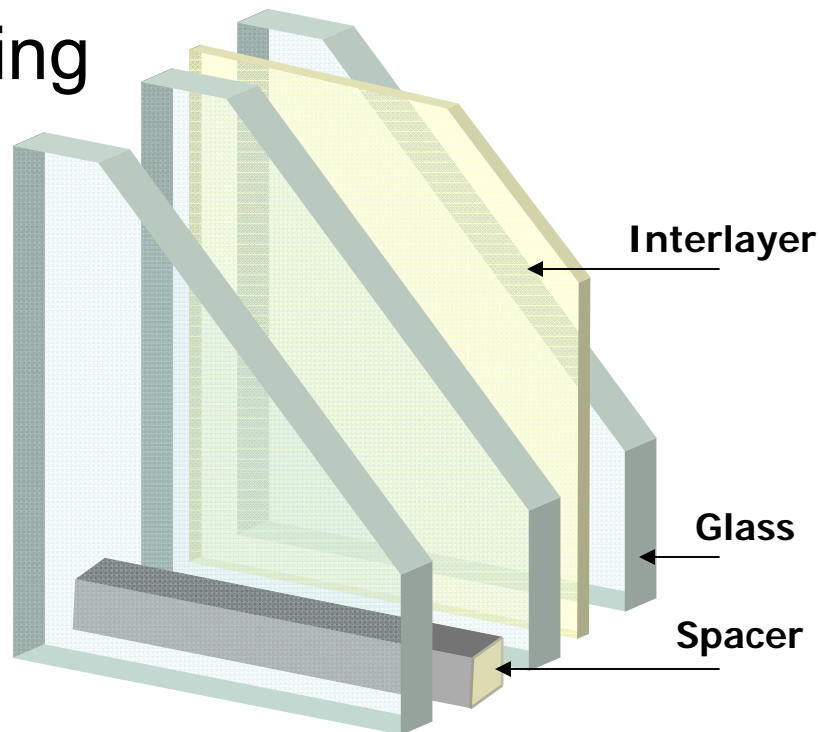
Sound Transmission Loss Equivalent Mass Units



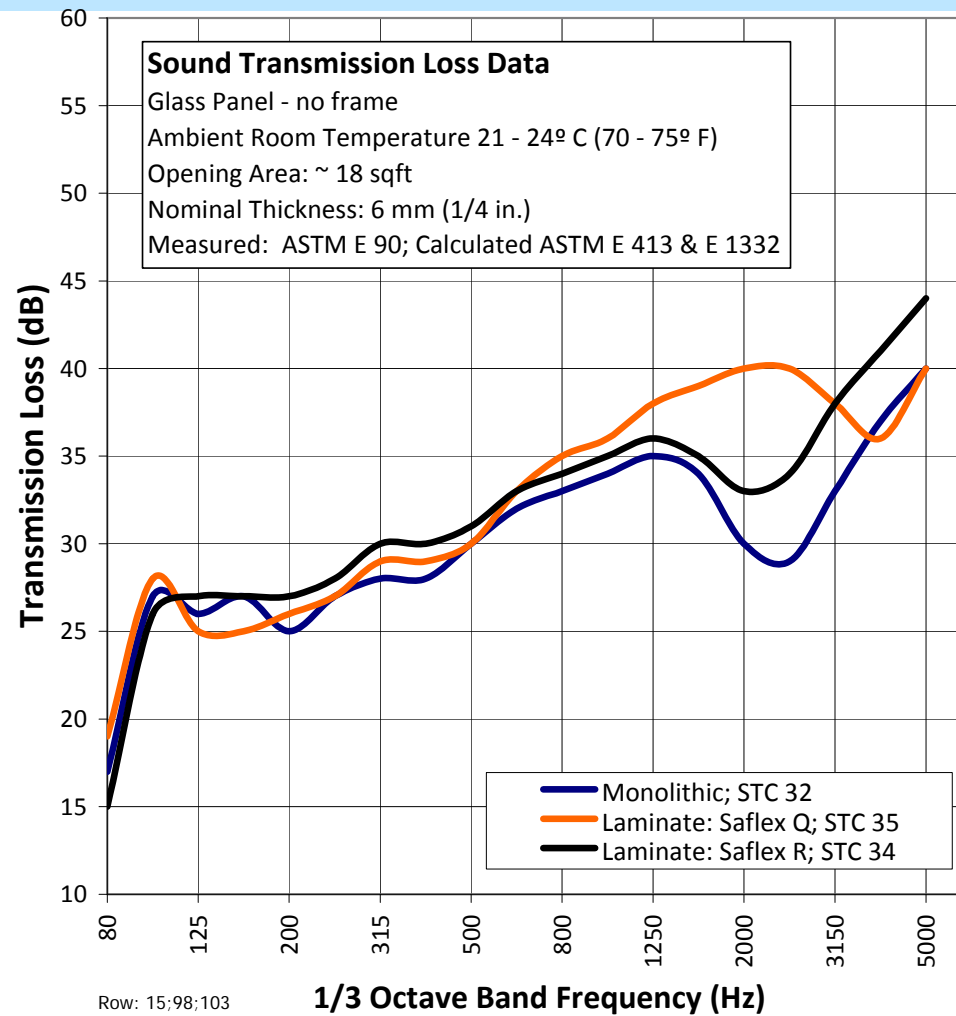
Glazing Design

Sound Transmission Loss

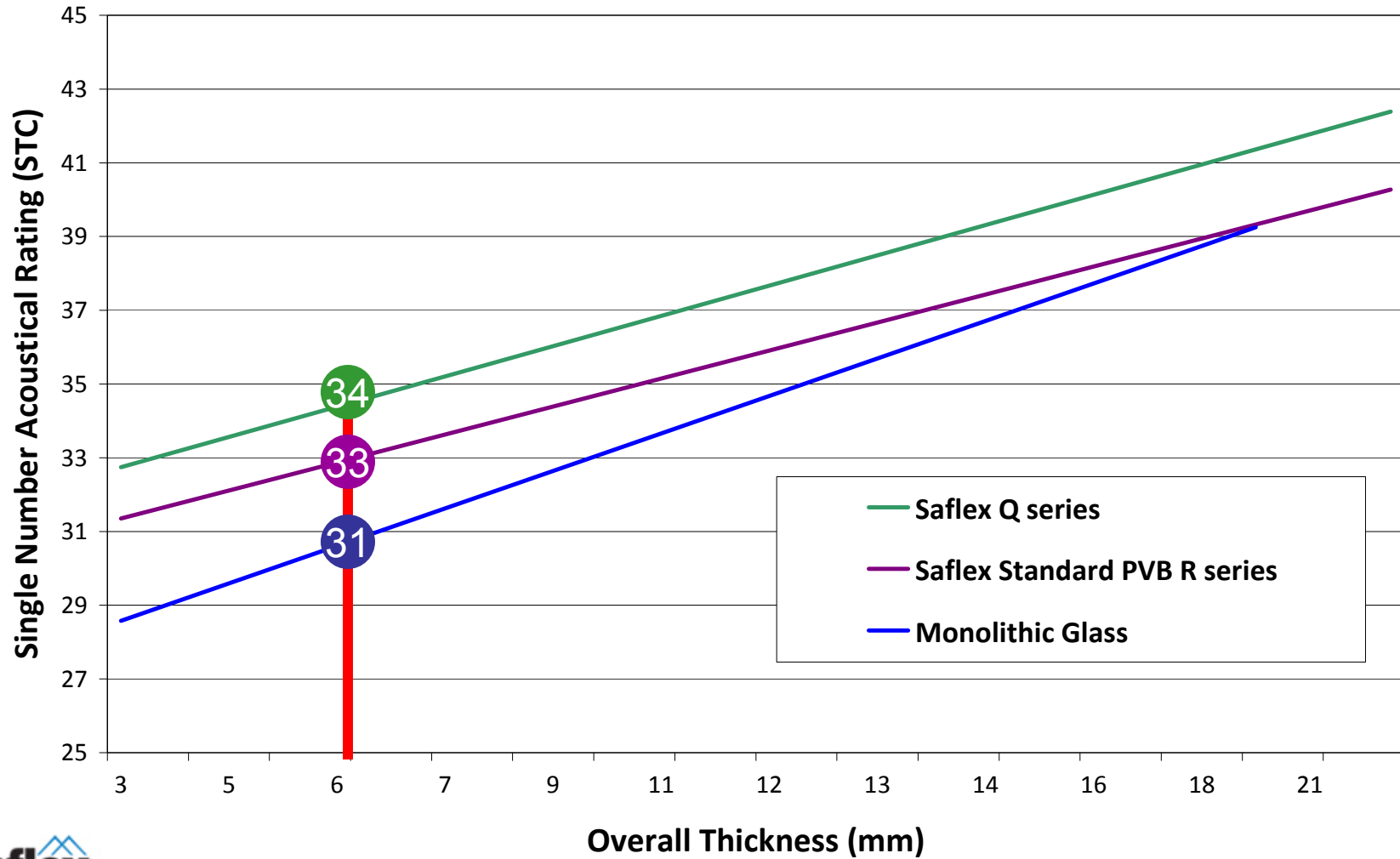
- The three basic features
 - Glass thickness (stiffness)
 - Insulating glass air space thickness
 - Interlayer damping



STL by Type



Glass Thickness and Interlayer Type



Saflex SilentGlass Technology™



Conclusions

- Acoustical interlayer delivers high performance damping with lower weight configurations
- Typical STC ranges from 30 - 50
- Laminates offer flexibility in design variables
- Up to 10 db noise reduction can be achieved in the critical frequency range
- Laminated glazings can be used to create acoustically comfortable architectural settings

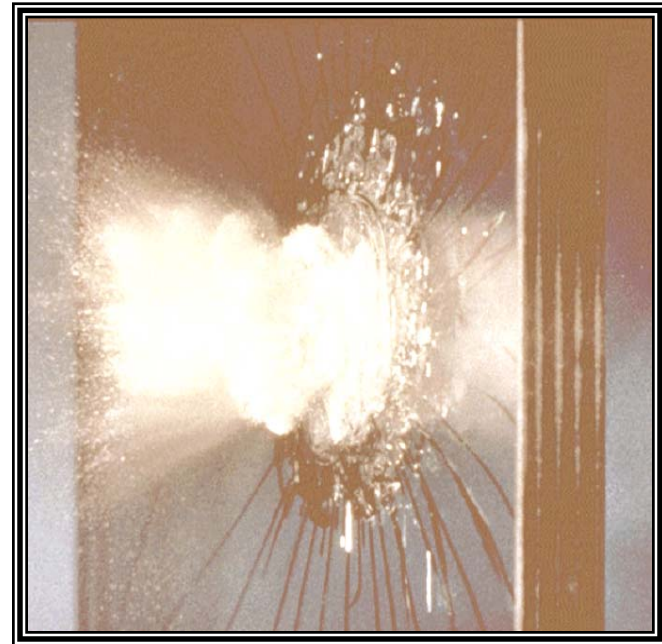
Security



Security

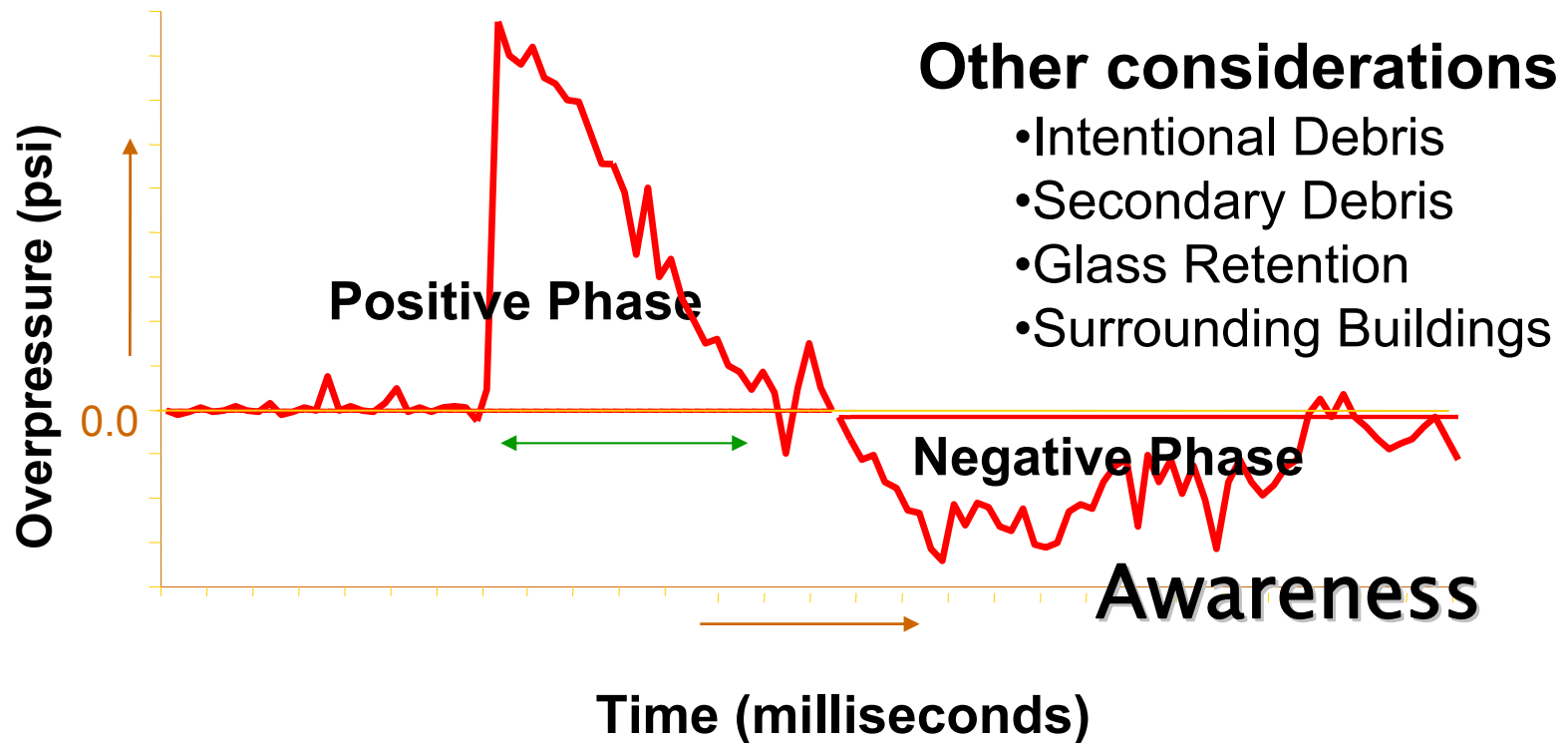
- Penetration resistant glazing that deters falling and flying glass generated from the intentional attack
 - Forced Entry
 - Forced Exit
 - Ballistic
 - Bomb Blast

Voluntary Requirements



Security: Blast

Chronology of a blast event



Large Shock Tube



Photo Courtesy of Baker Risk – San Antonio, Tx

Explosive in tube



Specimen Chambers



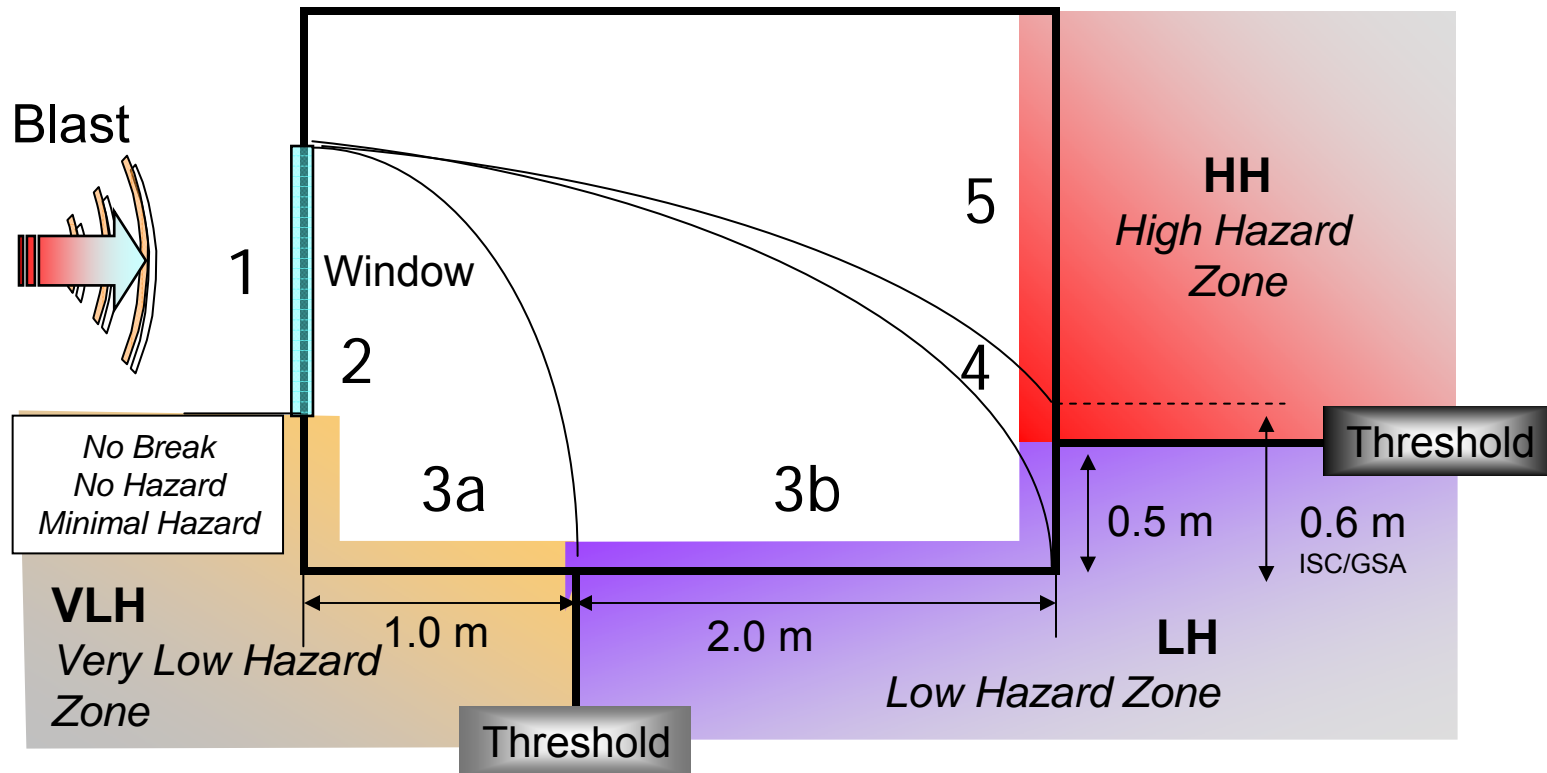
Blast Detonation



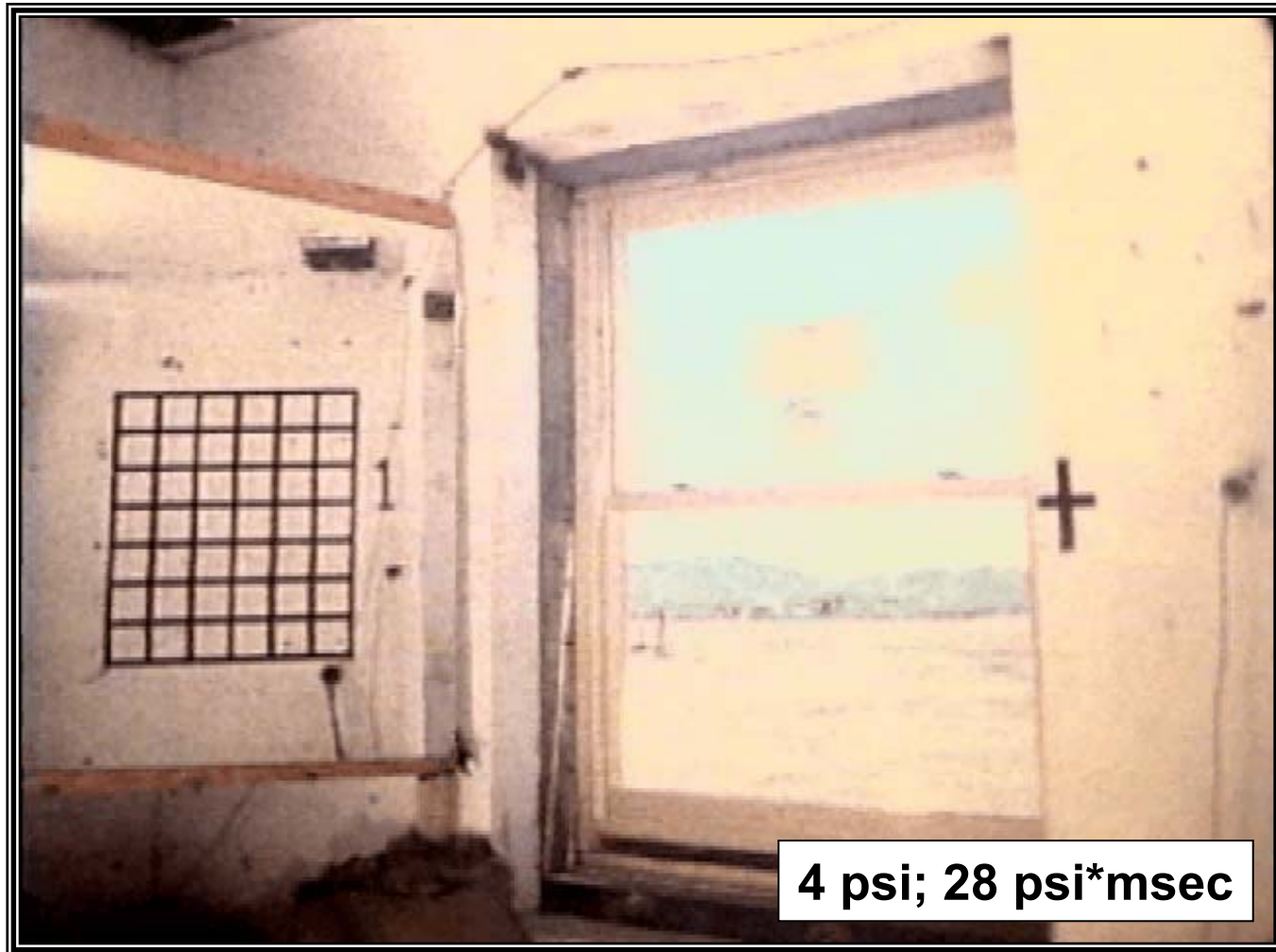
Post Blast Analysis

- Blast Information
- Glass Crack / Shatter
- Glass Retention/Opening
- Location of Shards
- Damage to Witness Panel

Blast Protection/Hazard Rating

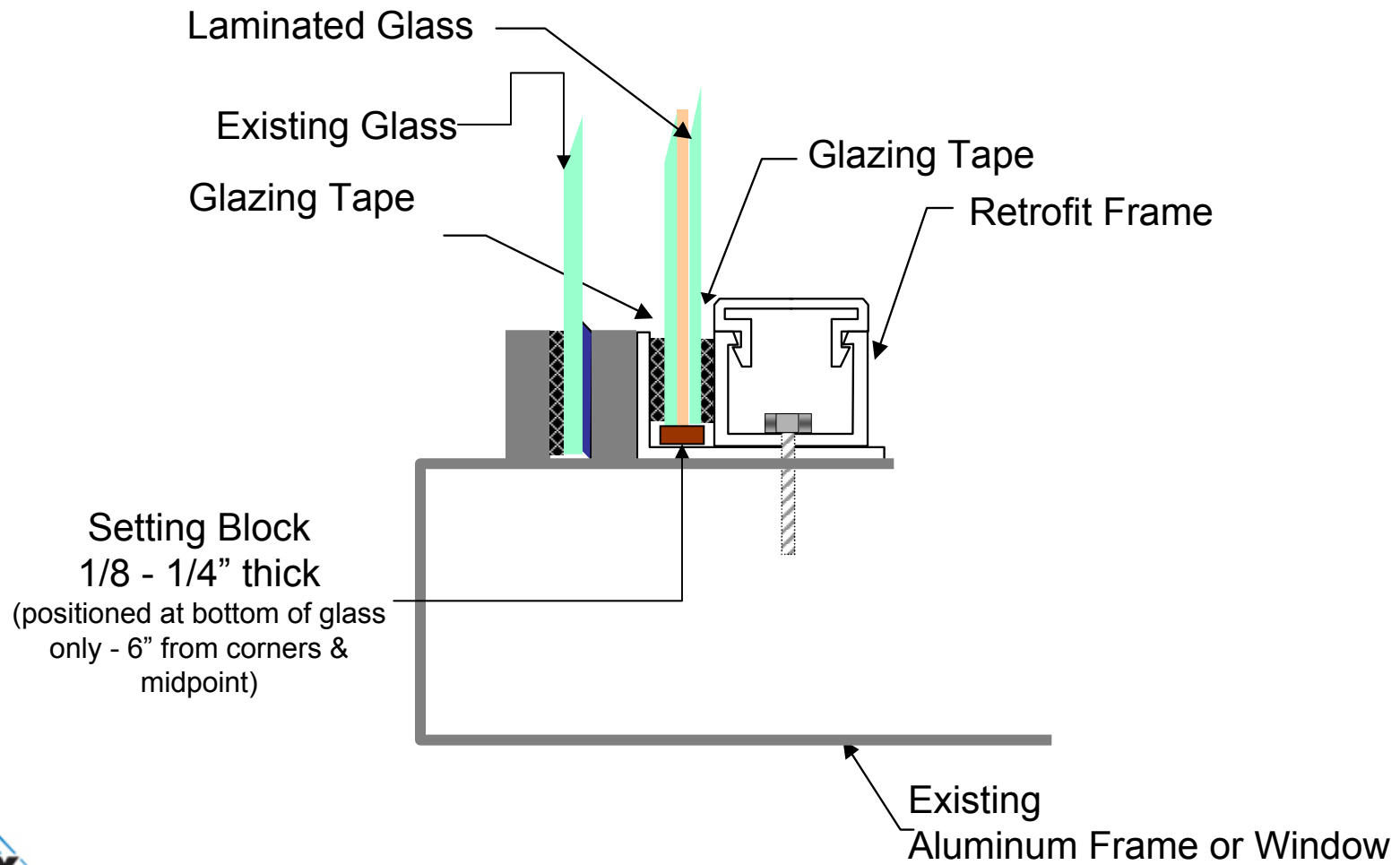


High Grade Wood Window - AN Glass



Blast Resistant Glazing

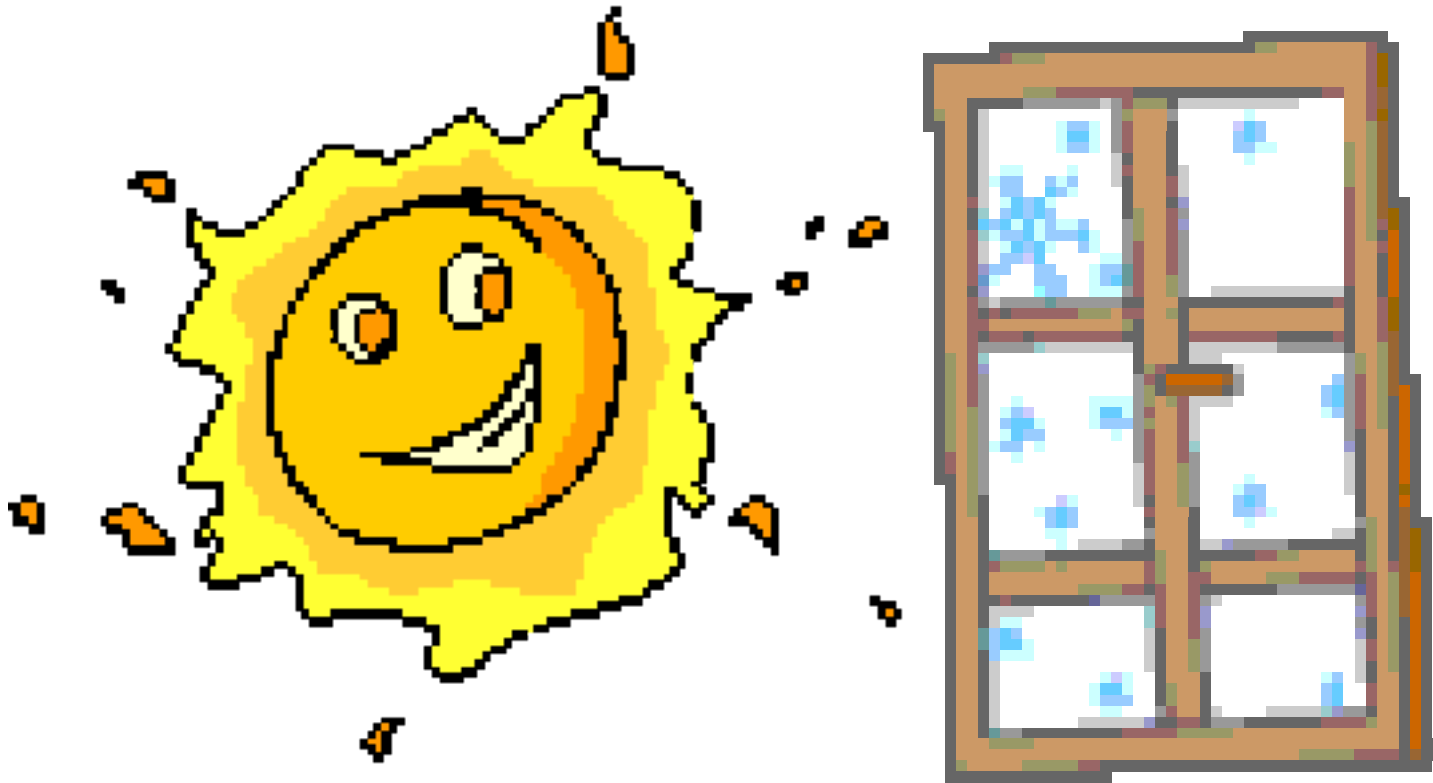
Retrofit Installations



High Grade Wood Window LAG Retrofit



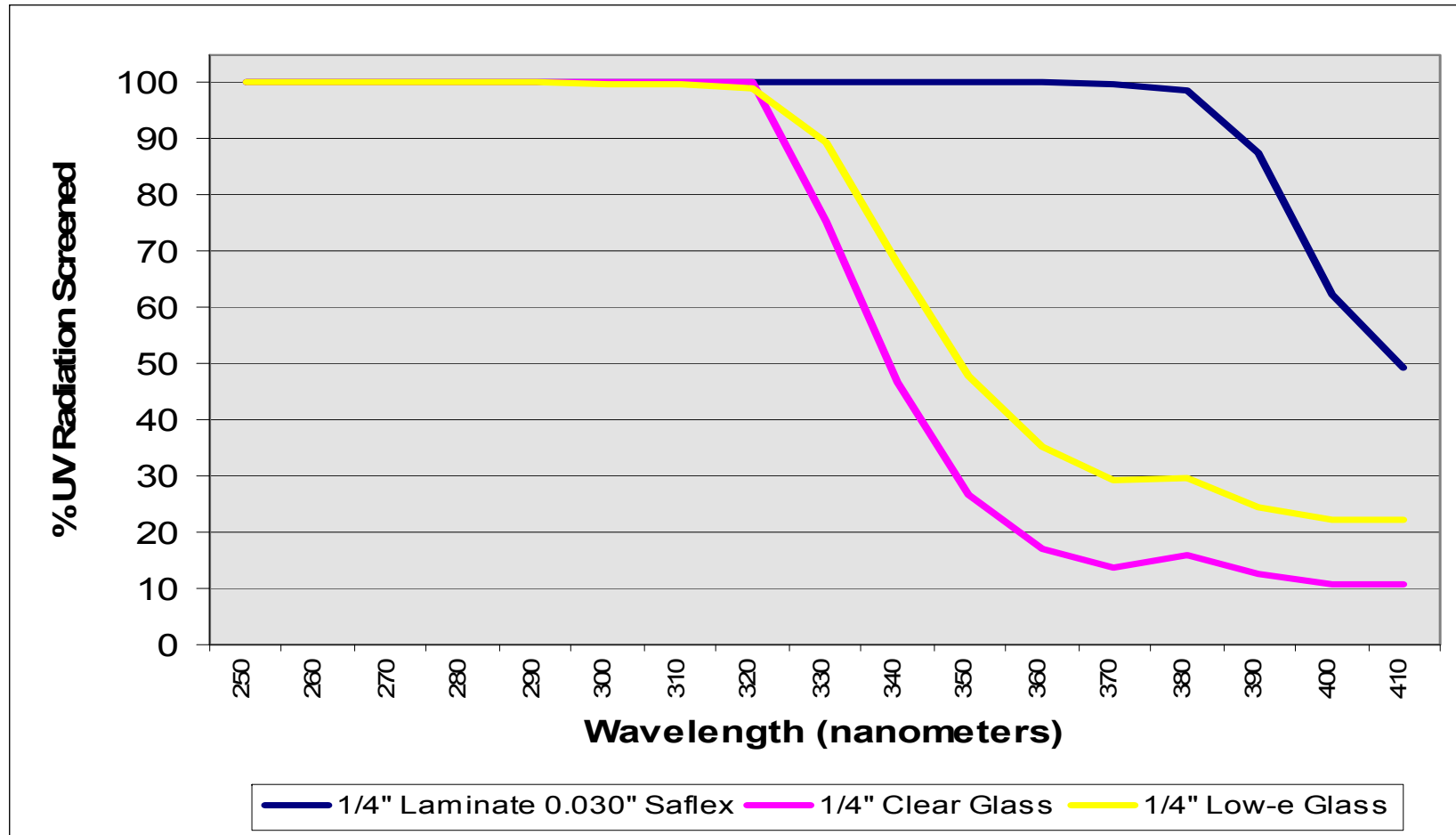
Solar/Energy



Fade Resistance

- Reduces fading of fabrics, carpets, furniture
- No adverse affects on plant life
- Blocks out approximately 99% UV rays (up to 380 nanometers)
- Untreated glass blocks out less than 15% of UV rays

Comparative UV Screening Performance



Regulatory Trends



-
- Energy Codes
 - Windborne Debris Protection
 - Acoustics
 - Seismic
 - Bomb Blast Protection (overall security)
 - Certifications

Growing Applications

- + Energy Efficient Building Demand
- + Windborne Debris Protection
- + Fall out prevention
- + Acoustic damping
- + Interior Glass Use Increase
- + Customization of Space
- + Multi-functional glazing
- + Laminated Heat Strengthened
- + Laminated Insulating Units
- + Availability of Products Increase
- Amount of Glass use in Buildings Could Decrease
 - Lack of Performance Understanding
 - Perceived Threat
 - Energy Requirements



Industry Trends

- Consolidation
- Vertical Integration
 - Independent Lamination
 - Glazing Contractors Developing Proprietary Systems
- Demand for Glass Retention
- Four Sided Structural Applications
- In House Assembly/Unitized Construction
- Green Buildings
 - Energy Performance
 - Sustainability
 - Double Wall Construction
 - RFID
 - Deconstruction Requirements

U.S. MARKET DRIVERS

- Building Codes
- Government Regulation/Mandates
- Government Mitigation Programs
- Insurance Industry
 - Lobbying efforts
 - Premiums
 - Availability of Insurance
- Architects, Specifiers and Glazing Contractors
- Standard Development
- Consolidation
- Need for Differentiation
- Need for “Security and Comfort”
- Social Responsibility
- Ease of acquisition and use

Laminated Glass Protection

Summary

Application	Requirement		Basic Configuration	
Structural		Glass	Saflex 0.030 in (0.76 mm)	Glass
Safety Glazing	CPSC 16 CFR 1201 Cat I	Glass	Saflex 0.015 in (0.38 mm)	Glass
	CPSC 16 CFR 1201 Cat II	Glass	Saflex 0.030 in (0.76 mm)	Glass
	ANSI Z97.1 Class A	Glass	Saflex 0.015 in (0.38 mm)	Glass
	ANSI Z97.1 Class B	Glass	Saflex 0.030 in (0.76 mm)	Glass
Overhead & Sloped	IRC & IBC < 16 sqft	Glass	Saflex 0.015 in (0.38 mm)	Glass
	IRC & IBC >16 sqft	Glass	Saflex 0.030 in (0.76 mm)	Glass
Hurricane	Small Missile	Glass	Saflex 0.060 in (1.52 mm)	Glass
	Large Missile	Glass	Saflex 0.090 in (2.29 mm)	Glass
	Large Missile	Glass	Saflex HP 0.100 (2.54 mm)	Glass
	Large Missile	Glass	Saflex Storm 0.075 in (1.91 mm)	Glass
Seismic	IBC	Glass	Saflex 0.030 in (0.76 mm)	Glass
Forced Entry/Exit	UL 972; ASTM F 1233	Glass	Saflex 0.060 in (1.52 mm)	Glass
Ballistic	UL 752; ASTM F 1233	Glass	Saflex 0.015 in (0.38 mm)	Glass
Blast	ASTM F 1642; GSA	Glass	Saflex 0.030 in (0.76 mm)	Glass
UV Screening	NFRC	Glass	Saflex 0.015 in (0.38 mm)	Glass
Sound	ASTM E90, 413, 1332	Glass	Saflex 0.030 in (0.76 mm)	Glass



Contact Information

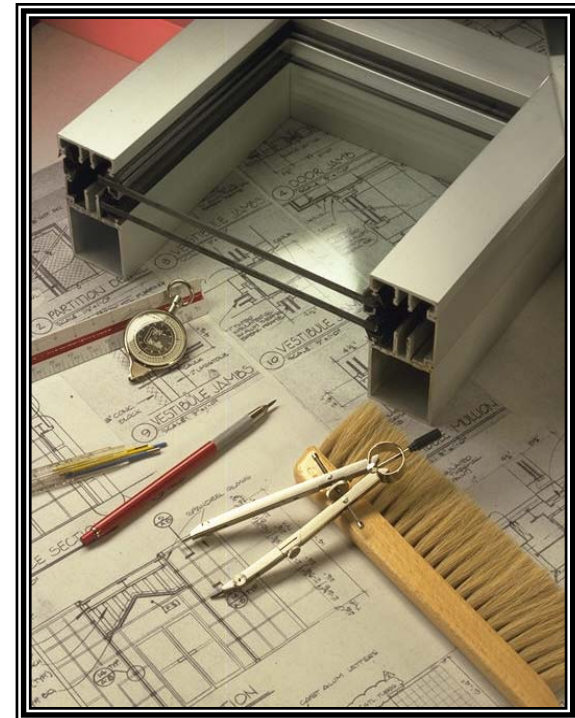
For further information
visit our website at:

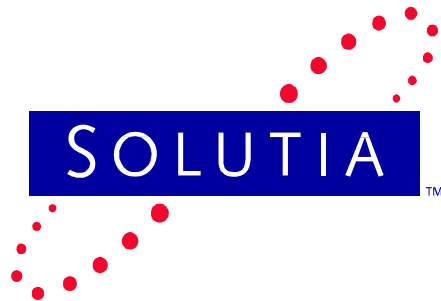
www.Saflex.com

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