saflex™ from Eastman

Beyond the storm

Saflex™ Storm PVB interlayers

EASTMAN

Winnie Palmer Hospital for Women & Babies | Orlando, Florida | Saflex™ Storm PVB interlayers

Since 1937, Saflex™ PVB has been the world's leading brand of protective interlayer used in laminated glass — extending the frontiers of performance glazing for architects and designers who demand the most reliable level of technical performance.

At its best when nature is at its worst

The severe and complex nature of hurricane winds creates special challenges for buildings — and for architects and designers who must address those challenges in hurricane-prone regions.

While no single product offers complete protection from hurricanes, cyclones and violent storms, laminated glass windows, doors and skylights made with Saflex™ Clear, Saflex™ HP or Saflex™ Storm PVB interlayers can be a critical first line of defense. In properly designed systems, laminated glass effectively withstands these natural forces to help maintain the critical exterior envelope. If broken by impact from wind-borne debris, the glass fragments bond firmly to the protective interlayer, continuing to safeguard building occupants and contents.

Hurricane performance

Protecting the building envelope

Under normal circumstances, buildings are designed to allow wind to flow over the structure. During a hurricane, a fully intact building envelope or "outer skin" allows wind to flow at, over and past the structure without damage. Preserving the building envelope, therefore, is among the most important steps to maintaining the integrity of the structure and ensuring nondestructive wind flow during hurricane-force winds.

During the sustained, high-speed winds of a hurricane, objects can be lifted and become airborne missiles or wind-borne debris. Large missiles, such as roof shingles and other construction materials, are common at heights up to 9 meters (30 feet) above grade; small missiles, such as roof gravel, are most prevalent at heights above 9 meters (30 feet).

When wind-borne debris breaks glass windows, skylights and doors, the building's protective exterior envelope is compromised, potentially allowing strong winds to rush into the structure. These trapped wind forces then exert tremendously increased pressure on the roof and outward pressure on exterior walls and can eventually cause total destruction.

Laminated glass with Saflex PVB interlayers in properly designed windows and doors can withstand the damaging impact of wind-borne debris. It can also remain in the opening during the remainder of the storm and may even function as a barrier after being broken, helping to preserve the integrity of the interior until repairs can be made.

Summary chart of Saffir-Simpson Hurricane Wind Scale

Category	Wind speed	Storm surge height	Damage
1	119–153 kph (74–95 mph)	1.2–1.5 m (4–5 ft)	Minimal — typically nonstructural elements
2	154–177 kph (96–110 mph)	1.8–2.4 m (6–8 ft)	Moderate — roofing materials, door and window damage; some trees toppled
3	178–208 kph (111–129 mph)	2.7–3.7 m (9–12 ft)	Extensive — structural damage to walled residences and utility buildings; minor amount of curtain wall failure
4	209–251 kph (130–156 mph)	3.9–5.5 m (13–18 ft)	Extreme — more extensive curtain wall failures; complete roof structure failures; extensive damage to doors and windows
5	> 252 kph (> 157 mph)	> 5.5 m (> 18 ft)	Catastrophic — complete roof and building failures; complete destruction of mobile homes; severe window and door damage; massive evacuation of residential areas within 5–10 miles of shoreline may be required

Codes and standards

Meeting building codes and standards

To meet hurricane building codes, commercial and residential window and door systems must meet vigorous impact tests, simulating wind-borne debris and subsequent winds. Test procedures call for the entire system to resist wind-borne debris impact followed by pressure cycling. To comply with the test requirements for an impact-resistant product, the systems may need to pass additional tests such as air and water infiltration, structural load and forced-entry resistance.

Properly designed window and door systems incorporating laminated glass made with Saflex Clear, Saflex HP or Saflex Storm PVB interlayers perform well during small and large missile impacts and cycling. When focusing on the use of laminated glass, it is critical to understand the importance of the overall system design, including:

- Glass size of the window or door opening
- Glazing installation within the frame
- Framing component design
- Thickness and composition of glazing materials

Saflex Clear, Saflex HP and Saflex Storm interlayers help properly designed laminated glass openings meet the tough testing requirements for hurricane resistance. Eastman's PVB interlayers are commonly found in windows, doors and skylights that meet the most stringent hurricane-resistant system requirements for performance and qualify for all state approval programs, including:

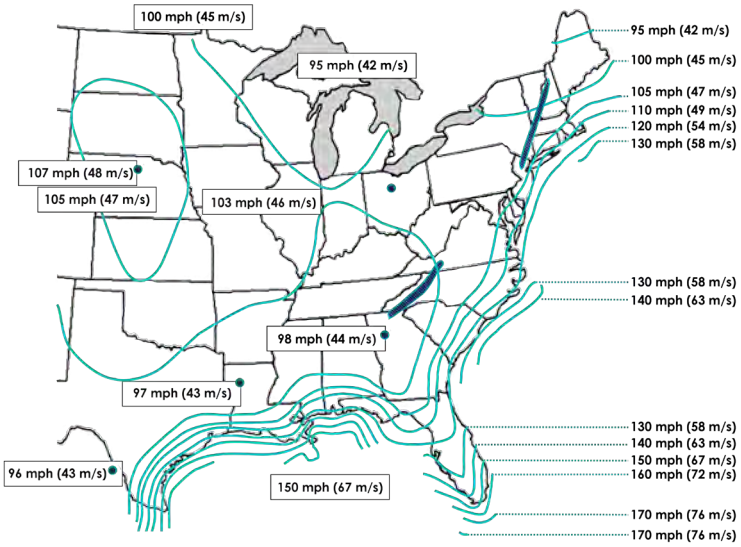
- Model building codes such as the International Building Code and International Residential Code (IBC and IRC)
- State product approval programs, including the Florida Building Code (FBC), which is part of the High-Velocity Hurricane Zone (HVHZ), and the Texas Department of Insurance (TDI)
- Relevant testing protocols and standards, including Dade County (Fla.) TAS 201 and 203, ASTM E1886, ASTM E1996, and forced-entry requirements such as ASTM F588 and ASTM F3561

Missile and wind zone chart for ASTM E1996

Missile level	Missile	Impact speed	Typical use
Level A	2-g steel ball	130 ft/sec (89 mph) 39.6 m/s (143 kph)	Above 9 m (30 ft) Wind zones 1 through 4 FBC and HVHZ area
Level B	2 lb lumber	50 ft/sec (34 mph) 15.2 m/s (54 kph)	Skylights ≤ 9 m (30 ft) Wind zone 2 (basic)
Level C	4.5 lb lumber	40 ft/sec (27 mph) 12.1 m/s (43 kph)	Less than 9 m (30 ft) Wind zones 1 and 2 (basic)
Level D	9 lb lumber	50 ft/sec (34 mph) 15.2 m/s (54 kph)	Less than 9 m (30 ft) Wind zones 3 and 4 (basic) Wind zones 1 and 2 (enhanced)
Level E	9 lb lumber	80 ft/sec (55 mph) 24.3 m/s (88 kph)	Less than 9 m (30 ft) Wind zones 3 and 4 (enhanced)

Where the standards are applied

The map is derived from the American Society of Civil Engineers (ASCE) 7-22 standard and indicates the wind speeds that tend to govern design pressures in the ASTM International (ASTM) impact standards. The ASTM test method has a corresponding specification, ASTM E1996, that indicates what missile size should be used depending on application and wind speed, location of impact, pass/fail criteria and substitution limitations. For example, below 30 feet from grade is typically the zone for impact by timber (large missile), whereas above 30 feet from grade is the zone for impact by 2-gram steel ball bearings (small missiles).



Basic wind speed example for category 1 buildings

Wind speed and missile summary

			Nonsloped fenestration				Sloped fenestration (skylights)	
			Enhanced facilities		Basic protection			
Wind zone	Wind speed[1]	Geographic boundaries	Missile ≤ 9 m (30 ft) from grade	Missile > 9 m (30 ft) from grade	Missile ≤ 9 m (30 ft) from grade	Missile > 9 m (30 ft) from grade	Missile ≤ 9 m (30 ft) from grade	Missile > 9 m (30 ft) from grade
1	130 mph (58 m/s) ≤ wind speed < 140 mph (63 m/s)	Includes Hawaii[2]	D	D	C	A	A	A
2	140 mph (63 m/s) ≤ wind speed < 150 mph (67 m/s)	≥ 1 mile (1.6 km) from the coastline	D	D	C	A	B	A
3	≥ 150 mph (67 m/s) wind speed or ≥ 140 mph (63 m/s) coastal windspeed	Within 1 mile (1.6 km) from the coastline	E	D	D	A	C	A
4[3]	> 170 mph (63 m/s)	High-velocity wind zone	—	—	D	A	—	A

[1] *Wind speed is either basic or ultimate, depending on the jurisdiction.*
[2] *Protection based on ASCE. Category II and above requires protected openings.*
[3] *Applicable to Chapter 16 Florida building code*

Saflex hurricane protection

Designing impact-resistant systems

It is critical for architects and designers to understand window system requirements to meet hurricane regulations — and laminated glass made with Saflex Clear, Saflex HP or Saflex Storm is the best place to begin.

When designing hurricane-resistant window and door systems, key elements are the framing system, laminated glass, glass bite and glazing attachment or weatherproofing method. All must work together to withstand air and water infiltration, forced entry, structural, impact and cycling loads. Different interlayers and thicknesses have a direct effect on the performance during impact and cycling loads.

Some variants of performance are window type, glass size, geometry and pressure. As shown in the following chart, interlayers are recommended based on glass size and dimensions. For instance, a typical large missile system (or window system below 9 m or 30 ft) uses laminated glass with a PVB interlayer that is at least 2.29-mm (0.090-in.) thick. A thinner, specialty interlayer using composite technology, such as Saflex Storm (1.91-mm or 0.075in. thick), tends to allow larger glass sizes and achieve higher pressures. A typical small missile system (or window system above 30 ft) uses laminated glass with an interlayer that is typically 0.060 in. (1.52 mm) in thickness, or Saflex Secure, a PVB-based composite interlayer of 0.035 in. (0.81 mm) in thickness.

Designing for essential facilities: level E protection

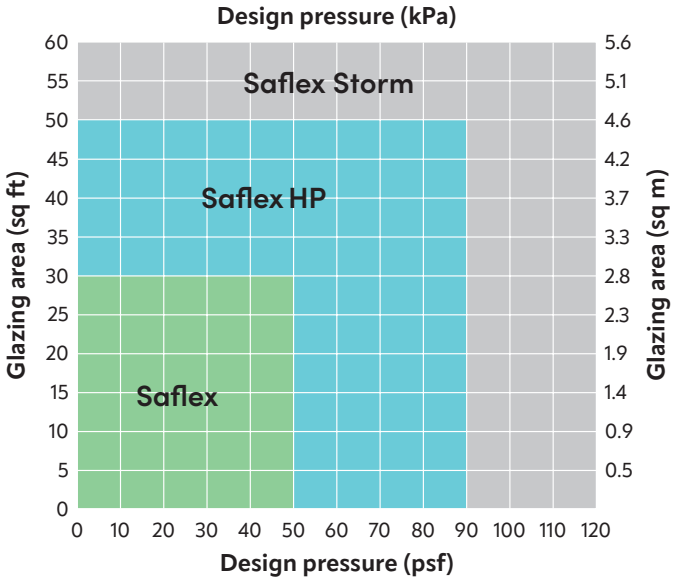
While most hurricane-related building codes are designed to protect homes and businesses during a hurricane, experts still advise people to follow all evacuation protocols. Some facilities are not able to evacuate during a storm. Building standard ASTM E1996 level E was designed to protect essential facilities like hospitals, emergency shelters and institutions, where the people inside usually don't have the option to evacuate.

In early 2008, Saflex introduced a hurricane interlayer system that could meet level E in a single piece of laminated glazing. Saflex level E hurricane solution uses a combination of Saflex's most powerful interlayers laminated between two pieces of glass under heat and pressure. The resulting piece of glass looks and functions like a single piece of ordinary glass but is stronger and tougher than that needed for typical large-missile protection. It's a convenient and cost-effective solution for architects and building owners who demand the highest level of protection.

There are three common ways to achieve level E performance:

- Saflex HP (DM) at 5.08 mm (0.200 in.)
- Saflex HP (DM) with Saflex Storm (VS) at 4.45 mm (0.175 in.)
- Saflex Storm (VS) at 3.81 mm (0.150 in.)

Typical glass performance for standard four-side glazing using recommended conditions



Note: *Experienced product performance. Based on panels glazed with structural silicone, minimum 12-mm (½-in.) glass bite; standard test temperatures 15°–35°C (59°–95°F). Not guaranteed for all samples.*

Typical standards for wind-borne debris impact tests				
Large missile impact test (for windows, doors, skylights, glazing and shutters between grade and 9 m [30 ft] above grade)	**Three identical test specimens** • Missile is 5 x 10 cm timber weighing 4 kg (2 x 4 in. timber weighing 9 lb). • Two impact points at 15 m/sec (50 ft/sec): at center and within 15.2 cm (6 in.) of a corner • All three specimens must survive impacts without penetration before proceeding to cyclic pressure loading.			
Small missile impact test (for windows, doors, skylights, glazing and shutters between grade and 9 m [30 ft] above grade)	**Three identical test specimens** • Missile is steel sphere weighing 2 g (0.07 oz). • 30 small missile impacts at 40 m/sec (130 ft/sec): 10 at center, 10 near long edge, 10 near corner • All three specimens must survive impacts without penetration before proceeding to cyclic pressure loading.			
Followed by cyclic pressure (applied to all three specimens following large or small impact tests; duration of each cycle is 1–3 seconds; all inward-acting pressure cycles are applied first, followed by outward-acting cycles.)	**Inward acting pressure**		**Outward acting pressure**	
	Range	**Cycles**	**Range**	**Cycles**
	0.2 P_{max}–0.5 P_{pos}	3500	0.3 P_{max}–1.0 P_{neg}	50
	0.0 P_{max}–0.6 P_{pos}	300	0.5 P_{max}–0.8 P_{neg}	1050
	0.5 P_{max}–0.8 P_{pos}	600	0.0 P_{max}–0.6 P_{neg}	50
	0.3 P_{max}–1.0 P_{pos}	100	0.2 P_{max}–0.5 P_{neg}	3350

P_{pos} and P_{neg} is the maximum inward (positive) and maximum outward (negative) air pressure differential for which qualification is sought.

All three specimens must survive the missile impacts as outlined for a specific standard. If no tear or crack longer than 12.7 cm (5 in.) or no opening through which a 7.6-cm (3-in.) sphere can pass has formed in any of the three specimens after completion of the pressure cycles, they are deemed to have passed the test. See specific test method, code protocol or specification for individual pass/fail criteria.

Additional benefits of laminated glass

In addition to proven hurricane-protection capabilities, Saflex Clear, Saflex HP and Saflex Storm interlayers deliver all the other benefits inherent in laminated glass:

- **Safety** — Protecting building occupants and pedestrians from cutting and piercing injuries due to accidental glass impact, breakage or fallout
- **Security** — Providing burglary and forced-entry resistance, ballistic (bullet) protection and bomb blast resistance
- **Acoustic** — Reducing the transmission of unwanted sound into a building's environment
- **Solar** — Filtering more than 99% of UV rays, controlling visible light radiation and reducing heat buildup
- **Animal safety** — Providing bird- and turtle-friendly capability coupled with hurricane resistance using embedded visual markers or uniformly colored interlayers

Additionally, Saflex PVB interlayers for hurricane protection can be combined with Vanceva™ color PVB interlayers, enabling architects to specify laminated glass to create a broad array of aesthetic designs that are hurricane-code compliant.

Extreme wind and impact — glass constructions

Missile	Code/standard	Glass configuration
Large	FBC TAS 201/3 Dade (HVHZ)	Glass | 2.29-mm (0.090-in.) Saflex | glass Glass | 2.54-mm (0.100-in.) Saflex HP | glass Glass | 1.91-mm (0.075-in.) Saflex Storm | glass
Large	ASTM E1996 (HVHZ)	Glass | 2.29-mm (0.090-in.) Saflex | glass Glass | 2.54-mm (0.100-in.) Saflex HP | glass Glass | 1.91-mm (0.075-in.) Saflex Storm[1] | glass
Small	FBC TAS 201/3 Dade (HVHZ)	Glass | 1.52-mm (0.060-in.) Saflex[2] | glass
Small	ASTM E1996 (HVHZ)	Glass | 1.52-mm (0.060-in.) Saflex[2] | glass

[1]Saflex Storm is also known as Saflex VSON [2]Typical minimum-gauge interlayer for indicated performance. Large missile automatically qualifies for small-missile applications. Glass thickness and type determined by use of ASTM E1300.

The architectural industry trusts Saflex and Vanceva color PVB interlayers.

Since 1937, glass fabricators have counted on Saflex for high-quality products, reliable service and expert advice to help deliver world-class technology for laminated glass. Eastman architectural glazing products include Saflex PVB interlayers for laminated glass as well as Vanceva color PVB interlayers. Architects and engineers are taking advantage of our products, which offer structural performance, over 69,000 colors, acoustic sound reduction and solar UV protection that provide safety, security and weight reduction inherent to the PVB when laminated between two pieces of glass.

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