

Hurricane Impact-Resistant Glass (Windborne Debris)

Introduction

The stringent code requirements of Florida and other coastal regions require that the building envelope be maintained during a hurricane. All elements of the building shell must resist the effects of windborne debris as well as sustained turbulent winds lasting several hours. Extensive research, following Hurricane Andrew in 1992, showed that breach of the envelope led to internal pressurization of the building. This effectively doubled the forces on major structural elements such as walls and roofs, leading to catastrophic failure.

The South Florida Building Code introduced hurricane-impact protection requirements in 1994. To meet these codes in South Florida, the glazing

must resist the penetration of either a large missile (a 9 LB wood 2" x 4" traveling at 50 feet per second/33mph) or small missiles (2 gram steel ball bearings traveling at 130 feet per second). These impacts are then followed by 9,000 inward and outward acting pressure cycles.

Other areas of the world are gradually introducing similar codes. The Texas Department of Insurance (TDI) has specified similar testing for property close to the Gulf Coast. The model code of SBCCI, which was used as the basis of the Florida Building Code that was made into law in 2002, includes windborne-debris protection requirements, as does the International Building Code.

Description

The latest national standard is the ASTM E1996 *Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors and Storm Shutters Impacted by Windborne Debris in Hurricanes*. It defines several other missiles applicable to different wind zones, building types and building heights, while incorporating the requirements of southern Florida. Tables 1 and 2 show the requirements of ASTM E1996, with the southern

Florida counties of Broward and Miami-Dade being in Wind Zone 4. Essential facilities are hospitals, evacuation centers and command and control positions, which are required during emergencies. All other building types come under the category of Basic Protection, apart from a few specifically excluded uninhabited buildings such as greenhouses.

Table 1: ASTM E1996 Wind Zones and Missile Types (See Missile Types in Table 2, page 33)

System Height		Enhanced Protection (Essential Facilities)		Basic Protection	
		≤ 30 FT	> 30 FT	≤ 30 FT	> 30 FT
Wind Zone 1	110 - 120 mph + Hawaii	D	D	C	A
Wind Zone 2	120 - 130 mph more than 1 mile from coast	D	D	C	A
Wind Zone 3	130 - 140 mph or 120 - 140 within 1 mile of coast	E	D	D	A
Wind Zone 4	> 140mph (South Florida)	E	D	D	A

For systems intended to be used 30 feet and higher from ground level, a small missile is used. Following either the small or large missile impact, the specimens are subjected to pressure cycling, as described in Table 3 on the following page.

Each cycle takes between one and three seconds, so the complete test can last up to 7-1/2 hours for each specimen. P_{pos} and P_{neg} are defined as the design pressures of the system being tested.

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Description (continued)

**Table 2: ASTM E1996--
Applicable Missiles**

Level	Missile	Speed (ft/s)	Comment
A	2 g \pm 5% steel ball	130	Small missile
B	2 LB \pm .25 LB 2 x 4 lumber	50	Some residential skylights
C	4.5 LB \pm .25 LB 2 x 4 lumber	40	Lower wind zones only
D	9 LB \pm .25 LB 2 x 4 lumber	50	Large missile
E	9 LB \pm .25 LB 2 x 4 lumber	80	Essential facilities only

Testing is carried out on the glazing system. Glass is therefore a component in this system, which includes aluminum, gaskets, sealants, weather-stripping, hardware and fasteners. Most codes require that three identical specimens be tested without penetration. All components used on the tested specimens must be carefully detailed on the test report so that exactly the same system is used in practice. Glass supplied by Oldcastle BuildingEnvelope™ has been successfully tested in many glazing systems for both residential and commercial applications.

All the products supplied by Oldcastle BuildingEnvelope™ for these

**Table 3: ASTM E1996--Cyclic Static
Air Pressure Loading**

Loading Sequence	Loading Direction	Air Pressure Cycles	Number of Cycles
1	Positive	0.2 to 0.5 P _{pos}	3,500
2	Positive	0.0 to 0.6 P _{pos}	300
3	Positive	0.5 to 0.8 P _{pos}	600
4	Positive	0.3 to 1.0 P _{pos}	100
5	Negative	0.3 to 1.0 P _{neg}	50
6	Negative	0.5 to 0.8 P _{neg}	1,050
7	Negative	0.0 to 0.6 P _{neg}	50
8	Negative	0.2 to 0.5 P _{neg}	3,350

types of applications have Component Product Approvals from Miami-Dade County. Full details are available on request. This component product approval must be specified on the System Product Approval, which is owned by the manufacturer of the glazing system. System Product Approval is now required in all of Florida.

Each of the test standards mentioned above has slight variations in such items as impact locations and pass/fail criteria. Careful examination of the standards is necessary to ensure that any testing is correctly performed.

Capabilities

Hurricane Impact-Resistant Glass Selection

Oldcastle BuildingEnvelope™ supplies all the main types of laminated glass used for hurricane-resistant applications. (See Table 4 on the following page.) Usually, the laminate is made up of two pieces of glass of the same thickness; however, the two pieces of glass may be annealed, heat-strengthened or tempered, depending on the system in which it was tested.

For small missile performance, glass with an 0.060" PVB interlayer is normally adequate. For

best performance, the outer lite of glass should be tempered and the inner lite heat-strengthened.

For large missile performance up to about 25 SQ FT and 65 PSF design pressure, laminated glass with an 0.090" PVB interlayer is usually used. This is combined with various glass configurations, depending on the opening size, design pressure and window or glazing system design.

For the higher-level performance that is required for curtain wall, storefront and large residential

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Capabilities (continued)

applications, it is often necessary to use StormGlass™, a unique, high-performance interlayer by Oldcastle BuildingEnvelope™. Alternatively laminated glass containing a Saflex® HP interlayer by Solutia, or SentryGlas™ Plus ionomer by DuPont can be used. These products contain interlayers that are much stiffer than regular PVB, and that can sustain much greater design pressures during the pressure cycling phase of the test. In addition, they can be used in very large sizes, even exceeding 50 SQ FT in some cases. These types of products are usually laminated between two lites of 3/16" or 1/4" heat-strengthened glass.

For the ultimate performance, it is necessary to use a glass-clad polycarbonate construction. The core of this 5-layer laminate is a thin polycarbonate sheet that is the strongest clear plastic available today. It is virtually unbreakable and therefore can resist the greatest forces.

Often, a window or glazing system will only have been tested with a small selection of the products detailed below, so it is essential to check with the system manufacturer in order to specify the correct one. None of the building codes permit the substitution of one product for another, without testing.

Table 4: Oldcastle BuildingEnvelope™ Hurricane Impact-Resistant Products

Product #	Description	Test	2 x 1/8" glass		2 x 3/16" glass		2 x 1/4" glass	
			Thickness inches	Weight LBS/FT²	Thickness inches	Weight LBS/FT²	Thickness inches	Weight LBS/FT²
411000	Laminated glass with .060 PVB	Small Missile	0.31	3.58	0.44	5.21	0.56	6.53
412000	Laminated glass with .090 PVB	Large Missile	0.34	3.75	0.47	5.38	0.59	7.00
452000	Laminated glass with .100 HP PVB	Large Missile	0.35	3.77	0.48	5.40	0.60	7.02
462000	Laminated glass with .090 SGP	Large Missile	0.34	3.75	0.47	5.38	0.59	7.00
462500	Laminated glass with .100 SGP	Large Missile	0.35	3.77	0.48	5.40	0.60	7.02
472000	StormGlass™ by Oldcastle BuildingEnvelope™	Large Missile	0.33	3.67	0.46	5.30	0.56	6.76
422000	Glass-clad polycarbonate	Large Missile	0.43	4.29	0.55	5.88	0.68	7.50

Additional Important Information

All the laminates detailed in the table above can be supplied with tinted, reflective or Low-E glass to allow the designer and the engineer to control solar heat gain and glare in the building. As the impact codes are adopted by other municipalities outside Florida, more hurricane impact-resistant glass will be supplied as insulating glass units. In this case, the laminated glass lite is usually the inboard lite of the insulating glass unit. For detailed

recommendations and glass selection, it is necessary to carefully examine all the requirements of the glazing system and the desired design pressure rating. Oldcastle BuildingEnvelope™ has extensive experience with the testing of hurricane impact-resistant systems and welcomes the opportunity to discuss the selection of a suitable laminated glass for your application.

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Additional Important Information (continued)

Tornadoes

The speeds of windborne debris and the peak wind pressures in tornadoes can be, in many cases, much higher than those specified in ASTM E1996.

The Federal Emergency Management Agency (FEMA) has produced a document titled *Design and Construction Guidance for Community Shelters*. This document presents test methods and construction guidance, and specifies a 15 LB. wood 2x4 fired at 100 mph. This has approximately 14 times the energy of the large missile used in wind zone 4 of ASTM E1996.

Oldcastle BuildingEnvelope™ can manufacture glass to meet these requirements; however, FEMA states in section 6.5, Windows: "Testing indicates that glass windows in any configuration are undesirable for use in tornado shelters. The thickness and weight of glass systems required to resist penetration and control glass spall, coupled with the associated expense of these systems, make them impractical for inclusion in shelter designs".

Glass and glazing that are designed and tested to resist hurricane impact and cyclic pressure loads can, however, give considerable resistance and protection against lower categories of tornadoes.

Specifications

A sample Section 08 81 00 Specification for North America can be found in Section 11M of this binder titled: Sample Architectural Glass Specifications.

For specifications on other laminated glass make-ups, call 1-866-OLDCASTLE (653-2278) or log on to www.oldcastlebe.com and click on "Project Assistance" and enter your request.

Contact Us

For any additional information, including details, technical data, specifications, technical assistance and samples, call 1-866-OLDCASTLE (653-2278).

Visit Us on the Web

Log on to www.oldcastlebe.com for project photos, product colors, general inquiries and project assistance.

To view performance data on a wide range of glass make-ups, or to build your own product specification, log on to www.oldcastlebe.com and choose GlasSelect®.