Window Systems

June 2020

Historically a window's function has been primarily to allow light and air into the home. However, due to current code requirements for wind design and energy conservation, a window in a building in Florida has a rather complicated job. It must allow the sun's light to pass through, but also minimize the sun's heat. It must keep cool conditioned air inside, but not allow condensation to form on the interior surface of the glass. It must not allow hot, humid outside air to leak into the home in summer, nor allow warm inside air to leak out of the house in winter. It must resist high wind pressures due to hurricane winds and resist water intrusion due to wind-driven rain. Additionally, in some areas it must be able to resist or be protected from impact due to flying debris. The Florida Building Code (FBC) requires windows to be impact-resistant or protected from impact if located within one mile of the coast where the design wind speed is 130 mph or greater and anywhere the design wind speed is 140 mph and greater. (Of course, even if your home is not located in this area, protecting windows from flying debris in a hurricane is a good idea.)

Clearly, a window is a complex system that must comply with stringent energy efficiency requirements and wind and water intrusion requirements. In addition to glazing (glass), the system also includes the frame, sash, flashing and any operable elements as well. The primary focus of this fact sheet is windows. However, many of the requirements discussed also apply to glass doors.

DESIGN WIND PRESSURE RATING

One of the more fundamental performance characteristics a window must met is its design wind pressure (DP) rating. The DP rating for a window corresponds to the required design wind pressure the product is required to meet as specified by the code. The required design wind pressure is based on several factors: the design wind speed for the site, the surrounding terrain (Exposure Category), the height of the building, the size of the window, and the location of the window on the building. The required design wind pressure can be calculated using ASCE 7-16 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* which is referenced in the FBC for determining all design wind loads. However, the Florida Building Code, Residential (FBCR) contains a simplified approach that is relatively easy to use. Table R301.2(2) in the FBCR tabulates design wind pressures for a typical single-family home: mean roof height of 30 feet and located in Exposure Category B (urban, suburban, forested terrain). The design pressures specified in the table are based on the required design wind speed, location on the building (Zone 5 is located near the building corners, and Zone 4 applies to areas not located near building corners. See the FBCR for zone dimensions), and size of the window (effective wind area). A positive (+) and negative (-) design pressure is specified for each zone. If the building mean roof height is other than 30 feet or if the Exposure Category is other than B, a separate table provides a single multiplier to adjust the design wind pressures. An example and excerpt of these tables is shown below.

BASF Wind Loads – Impacts from ASCE 7-16 Fact Sheet

The BASF Wind Loads – Impacts from ASCE 7-16 Fact Sheet provides an overview of the significant changes to wind loads in ASCE 7-16 and the 7th Edition (2020) FBC. The BASF Wind Loads – Impacts from ASCE 7-16Fact Sheet can be downloaded at www.floridabuilding.org.

Example:

Assume a building is located where the design wind speed is 150 mph, has a mean roof height of 20 feet, and is located within 100 feet of the coast. What is the required design wind pressure for a window with an effective wind area of 10 square feet and located near the corner of the building (Zone 5)?

From Table R301.2(2), the required design wind pressure for Exposure Category B and mean roof height of 30 feet is +24.3 and -32.5 pounds per square foot (psf).

Excerpt of Table R301.2(2) in the 7th Edition (2020) FBCR

	Zone	Effective Wind Area (ft^2)	Ultimate Design Wind Speed, V_{ult} (mph)			
			150		160	
			Pos	Neg	Pos	Neg
Walls	4	10	24.3	-26.3	27.6	-30.0
	4	20	23.2	-25.2	26.4	-28.7
	4	50	21.8	-23.8	24.8	-27.1
	4	100	20.6	-22.7	23.5	-25.8
	5	10	24.3	-32.5	27.6	-37.0
	5	20	23.2	-30.3	26.4	-34.5
	5	50	21.8	-27.5	24.8	-31.2
	5	100	20.6	-25.2	23.5	-28.7

Since the building is located close to the coast, the likely Exposure Category would be D. Therefore, the required design wind pressure can be adjusted using the appropriate multiplier in Table R301.2(3).

Excerpt of Table R301.2(3) in the 7th Edition (2020) FBCR

MEAN ROOF HEIGHT (ft)	EXPOSURE CATEGORY		
	B	C	D
15	0.82	1.21	1.47
20	0.89	1.29	1.55
25	0.94	1.35	1.61
30	1.00	1.40	1.66

Design wind pressure $= +24.3 \times 1.55 = +37.7$ psf

$= -32.5 \times 1.55 = -50.4$ psf

The DP rating of the window must equal or exceed +37.7 and -50.4 psf.

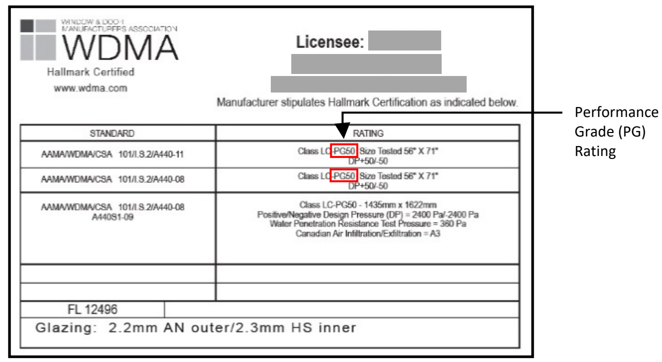
TESTING

The FBC prescribes performance and construction requirements for exterior windows and glass doors installed in wall systems. Testing by an approved testing laboratory is required, and approved labels must identify the manufacturer, performance characteristics and approved product certification agency, testing laboratory, evaluation entity or Miami-Dade notice of acceptance (NOA). Note that the requirements vary depending on your location within the state.

Design wind pressures and water infiltration

Testing requirements for windows are specified in several sections of the code. Section 1709 of the Florida Building Code, Building (FBCB) and Section R609 of the FBCR requires windows to be tested and labeled as conforming to AAMA/WDMA/CSA101/I.S.2/A440 or TAS 202 (the High-Velocity Hurricane Zones are required to comply with TAS 202). These tests address air infiltration, wind loads, and water infiltration. An example of a typical certification label is shown below which indicates several key performance characteristics.

Typical Label


WINDOW & DOOR MANUFACTURERS ASSOCIATION
WDMA
Hallmark Certified
www.wdma.com

Licensee:

Manufacturer stipulates Hallmark Certification as indicated below.

STANDARD	RATING
AAMA/WDMA/CSA 101/I.S.2/A440-11	Class LC-PG50 Size Tested 56" X 71" DP+50/-50
AAMA/WDMA/CSA 101/I.S.2/A440-08	Class LC-PG50 Size Tested 56" X 71" DP+50/-50
AAMA/WDMA/CSA 101/I.S.2/A440-08 A440S1-09	Class LC-PG50 - 1435mm x 1622mm Positive/Negative Design Pressure (DP) = 2400 Pa/-2400 Pa Water Penetration Resistance Test Pressure = 360 Pa Canadian Air Infiltration/Exfiltration = A3
FL 12496	

Glazing: 2.2mm AN outer/2.3mm HS inner

The DP rating indicated on the label must equal or exceed the required design wind pressure determined from the FBC or ASCE 7. The most important designation on the certification label regarding wind pressures and water infiltration is the Performance Grade (PG) Rating. The PG Rating correlates to the design pressure rating but is also directly correlated to water infiltration performance as well. For example, a window with PG Rating of 50 indicates that the product was tested for water infiltration at 15 or 20% (depending on the product class) of 50 psf. However, the DP rating does not necessarily correlate to the water infiltration test which is particularly important

FEMA Hurricane Michael in Florida Recovery Advisory 2

FEMA Hurricane Michael in Florida, Recovery Advisory 2 *Best Practices for Minimizing Wind and Water Infiltration Damage* provides guidance and recommendations for reducing wind and water infiltration damage to glazed openings and doors for new and existing residential buildings. (https://www.fema.gov/media-library/resources-documents/collections/24f)

in Florida due to wind-driven rain associated with hurricanes. Make sure windows have a PG rating that equals or exceeds the required design pressure rating. A Florida Product Approval number must also be on the label and a Miami-Dade NOA number in the High-Velocity Hurricane Zones (HVHZ). However, products certified with an NOA typically do not have a PG rating. The water infiltration resistance rating for these products is typically 15% of the positive design pressure.

Impact protection

While most people understand the importance of protecting windows and other glass during a hurricane, for some areas of the state, the FBC requires windows to be impact resistant or be protected with an impact-resistant covering such as a shutter. These areas are defined in the FBC as the Wind-borne Debris Region (WBDR). The WBDR applies to areas that are within a mile of the coastal mean high water line where the design wind speed is 130 mph and greater and areas where the design wind speed is 140 mph and greater. Figure R301.2(4) in the FBCR geographically depicts the WBDR for Risk Category II buildings and structures (See the BASF Wind Loads – Impacts from ASCE 7-16 Fact Sheet for additional discussion Risk Category classifications of buildings).

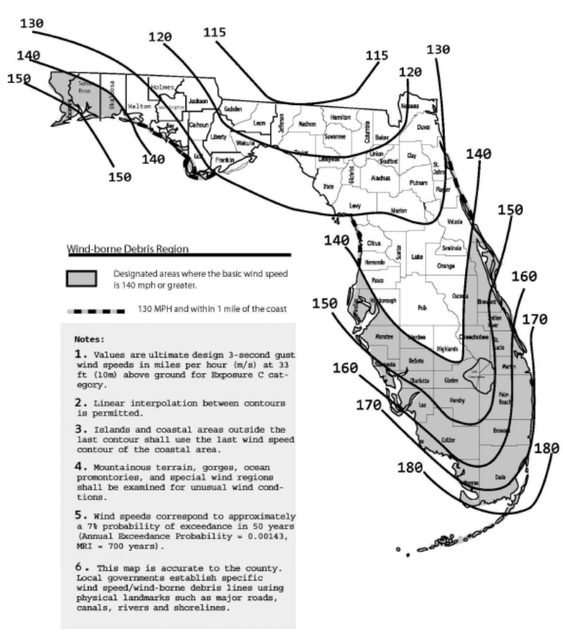


FIGURE R301.2(4)
ULTIMATE DESIGN WIND SPEEDS V_{ult}

Note: It is important to check with the local jurisdiction regarding the exact location of the WBDR. Many jurisdictions have local technical amendments to the FBC that specifically establish the location of wind speed lines. Additionally, the area within a mile of the mean high water line is not clearly defined. The local jurisdiction will be able to identify the WBDR in coastal areas where the design wind speed is 130 mph and greater.

In the WBDR, windows are required to be impact resistant or protected with an impact-resistant covering. Impact resistant coverings are often referred to as hurricane shutters. To qualify as impact resistant, products have to comply with ASTM E 1886 and ASTM E1996 or TAS 201, 202, and 203 (the HVHZ is required to comply with TAS 201, 202, and 203). Both sets of standards are similar with subtle differences that address large missile impact, small missile impacts, and a cyclic pressure test.

Impact-resistant glazing is available as laminated glass and is also considered a type of safety glazing. Laminated glass consists of two or more panes of clear glass bonded together with clear plastic-like film (usually polyvinyl butyral) sandwiched between the two panes. This inner “filling” typically ranging in thickness from .015 to .090 inches, is designed to hold the glass together upon impact. If cracked or broken, the glass fragments remain intact to the plastic interlayer thus preventing wind from entering the building and potentially causing major structural damage.

Note that the frames for laminated glass are generally heavier than for non-impact windows. While the laminate will prevent an opening in the glass, the frame must be strong enough to stay in the opening when impacted. When undergoing testing, the window is tested as a unit that includes the glass, frame, attachment hardware, and the installation method. Products designed to protect openings must be both tested and approved for wind load and wind-borne debris.

Product Approval

The Florida Product Approval System, established by Rule 61G20-3 of the Florida Administrative Code, applies to products that comprise the building envelope and the structural frame for compliance with the structural requirements in the code. The purpose of Florida Product Approval System is to ensure that safe products and technologies are used in building construction that meet the structural requirements in the FBC. Windows are specifically referenced in the rule as requiring product approval. A company may have its products approved for local or state use. Click on "Product Approval" at www.floridabuilding.org for more information.

INSTALLATION

The proper attachment/anchorage of the window to the structure and proper flashing are critical to the performance of the window. Each manufacturer specifies how its windows must be installed so that the window will perform as intended.

Installation and anchorage

The FBC has certain requirements for window installations but primarily refers to manufacturer's installation anchorage instructions. Minimum anchorage requirements for windows is addressed in Section 1710 of the FBCB and Section R609.7 of the FBCR.

Flashing

Proper flashing is critical to control water leakage around windows. The Fenestration Manufacturers Association (FMA) , the American Architectural Manufacturers Association (AAMA), and the Window and Door Manufacturers Association (WDMA) have collaborated to develop a series of flashing installation standards that are currently recognized in Section R703.4 of the FBCR. These standards include:

- FMA/AAMA 100 for windows with flanged mounting fins in wood frame walls.
- FMA/AAMA 200 for windows with frontal flanges (aluminum and vinyl) in surface barrier walls.
- FMA/WDMA 250 for windows without frontal flanges (wood) in surface barrier walls.
- FMA/AAMA/WDMA 300 for exterior doors with mounting fins in wood frame walls.
- FMA/AAMA/WDMA 400 for doors with mounting fins for surface barrier walls.

The code also permits flashing to be in accordance with the fenestration manufacturer's installation instructions, the flashing manufacturer's installation instructions, or in accordance with a flashing design developed by a registered design professional.

Detailed information about window and door flashing and sealing is also provided in the American Society for Testing and Materials (ASTM) standard ASTM E 2112 (*Standard Practice for Installation of Exterior Windows, Doors and Skylights*),.

TEMPERED GLASS WINDOWS

Tempered glass is considered safety glazing but alone is not considered impact resistant. Tempered glass is one type of heat-treated glass in which the glass is first heated, and then the surface is rapidly cooled. This treatment results in the center of the glass remaining relatively hot compared to the surface. As the center thickness cools, it compresses the surfaces and edges. When tempered glass does break, it fractures into small, relatively harmless fragments. This phenomenon, often referred to as "dicing," greatly reduces the likelihood of injury due to human impact.

The FBC specifies areas that are considered hazardous locations for glazing. In these hazardous locations, safety glazing such as tempered glass is required. Hazardous locations are those where the likelihood of human impact is high and include locations in or near door assemblies, near bathtubs, in railings, and glass adjacent to stairways. The specific hazardous locations are defined in Section 2406 of the FBCB and Section R308 of the FBCR.

REPLACEMENT WINDOWS

Due to improvements and advancements in window technology, window replacement is becoming an increasingly popular consideration for many homeowners and business owners. Many windows today are more energy efficient, require less maintenance, and have improved functionality compared to older windows. Replacing windows in Florida will require a permit as specified in Section 105 of the FBCB and depending on the situation, may trigger certain code requirements. In general, existing buildings, regardless of the year they were built, are permitted to continue to be legally occupied without change regardless of changes in a newly adopted building code. However, the replacement of windows, whether due to damage or other reasons, would be subject to the Florida Building Code, Existing Building (FBCEB). The FBCEB applies to the repair, alteration, change of occupancy, addition, and relocation of existing buildings.

Emergency escape and rescue openings

Emergency escape and rescue openings (EERO) are required in the FBCB for basements and sleeping rooms below the fourth story in Group R-2 occupancies and in the FBCR for basements, habitable attics, and sleeping rooms in R-3 occupancies. They are intended to provide an alternate way out or access for rescue in the event the primary means of egress is blocked in an emergency such as a fire condition. EEROs can be a door but are often a window. Considering their function, the code establishes minimum requirements for EEROs including minimum opening area, minimum net clear opening height and width, maximum sill height above the floor, and limits on operational constraints.

In accordance with Section 702.5 of the FBCEB, where windows are required to provide EEROs, replacement windows are required to comply with the minimum requirements in the FBCB or the FBCR for EERO's unless the replacement window complies with the following conditions:

- The replacement window is the manufacturer's largest standard size window that will fit within the existing frame or existing rough opening.
- The replacement window is not part of a change of occupancy

If a replacement window in existing building is required to be an EERO but meets the conditions above, the replacement window does not have to meet the requirements for EEROs in the current building code.

Impact protection and WBDR

Section 707.4 of the FBCEB requires replacement windows to comply with Chapter 16 of the FBCB. Accordingly, if an existing building is in area designated as a WBDR by the current code, replacement windows would have to be impact resistant or protected with an impact-resistant covering. However, an exception is provided for one- and two-family dwellings constructed under codes other than the FBC (for the HVHZ the exception applies to those constructed under codes prior to September 1, 1994). For such structures, the replacement windows installed within any 12-month period are not required to comply with the opening protection requirements provided the aggregate area of glazing in the replacement window does not exceed 25% of the aggregate are of glazed openings in the entire dwelling or dwelling unit. The replacement window would, however, be required to meet the minimum design wind pressure requirements.

For example, if a single family dwelling is located in a WBDR, and has 8 windows of equal size distributed around the building (assume no other glazed openings), only 2 windows could be replaced within any 12-month period to not trigger the opening protection requirements of Chapter 16 of the FBCB.

Window fall protection

Window opening control devices (WOCD's) or window fall prevention devices are required on windows where there is a significant risk of small children falling out a window and being injured due to the height above finished grade. While there are several conditions that trigger these requirements, in general they apply where the sill height is less than 24 inches above the finished floor, and where the vertical distance from the top of the sill to finished grade or surface below is more than 72 inches. In section 702.4 of the FBCEB window opening control devices complying with ASTM F2090 are required on replacement windows where all the following conditions apply:

- The window is operable.
- Includes replacement of the sash and frame
- Sill height less than 36 inches above the floor for R-2 and R-3 buildings regulated by the FBCB; 24 inches for R-3 regulated by the FBCR
- The replacement window opening will allow the passage of a 4-inch dimeter sphere
- The vertical distance from the top of the sill to finished grade or surface below is more than 72 inches

ENERGY PERFORMANCE OF WINDOWS

The Florida Building Code, Energy Conservation (FBCEC) provides specific building envelope requirements for both commercial and residential buildings. There are several paths available for demonstrating compliance and for windows, doors and skylights, the easiest method is with a NFRC Certification label or certificate. The National Fenestration Rating Council (NFRC) is a voluntary testing and certification program for thermal performance for windows, doors, and skylight. The NFRC does not address structural characteristics, such as impact-resistance, but rather provides a standard method for rating the thermal performance of the whole window, door, or skylight (including the frame) for the following characteristics: U-Factor, Solar Heat Gain Coefficient (SHGC), Visible Transmittance, Air Leakage, and Condensation Resistance.

An NFRC certification label is not an indicator that a window, door, or skylight is energy efficient. Rather, it provides information about energy performance that users can then use to determine if the product is efficient for the region or situation. The label contains other information as well, including company name, framing material, product type, etc., so similar products can be compared. In Florida, the SHGC rating is the most important because the primary goal from an energy standpoint is block the most heat from coming in while admitting the most visible light. The lower the SHGC rating, the less heat enters through the window or door. The Florida Building Code-Energy Conservation contain U-factor and SHGC requirements for both residential and non-residential and in order to verify compliance, a window or door must have an NFRC label affixed to it or the products U-factor and SHGC are taken from a default table

NFRC label

U-Factor
U-factor measures the amount of heat that escapes through the product. The lower the rating, the better the window is at preventing heat loss (as imagined, this is more of a concern in northern climates). NFRC certified products require U-factor ratings. In Florida, select windows with a U-factor at least as low as 0.65.

Condensation Resistance* (CR)
CR measures the ability of a product to resist the formation of condensation on the interior surface of that product. While this rating cannot predict condensation, it can provide a credible method of comparing the potential of various products for condensation formation. CR is expressed as a number between 0 and 100. The higher the CR rating, the better that product is at resisting condensation formation.

Solar Heat Gain Coefficient (SHGC)
SHGC measures how well a product blocks heat caused by sunlight. The SHGC is the fraction of incident solar radiation admitted through a window, both directly transmitted, and absorbed and subsequently released inward. SHGC is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat it transmits. In Florida, select windows with a SHGC of 0.40 or less.

Air Leakage* (AL)
AL is indicated by an air leakage rating, expressed as the equivalent cubic feet of air passing through a square foot of window area (cfm/sq ft). Heat loss and gain occur by infiltration through cracks in the window assembly. The lower the AL, the less air will pass through cracks in the window assembly.

Visible Transmittance (VT)
VT measures how much light comes through a product. The visible transmittance is an optical property that indicates the amount of visible light transmitted. VT is expressed as a number between 0 and 1. The higher the VT, the more light is transmitted.

RESOURCES

Florida Building Code, www.floridabuilding.org

International Code Council, www.iccsafe.org

Insurance Institute for Business and Home Safety, www.ibhs.org

FEMA Hurricane Michael in Florida Recovery Advisory 2, *Best Practices for Minimizing Wind and Water Infiltration Damage*, https://www.fema.gov/media-library-data/1560174739479-8856110e0c3fa30e750370dc5129348a/MichaelRA2_060719_508_FNALforposting.pdf

Fenestration & Glazing Industry Alliance www.fgiaonline.org

Window and Door Manufacturers Association, www.wdma.com

Fenestration Manufacturers Association

American Society of Civil Engineers, www.asce.org

National Fenestration Rating Council www.nfrc.org

ASTM E1886 and ASTM E1996, www.astm.org

TAS 201, TAS 202, TAS 203, www.floridabuilding.org

Don't know where to go for an answer to a specific question?

Contact: Florida Building Commission 850-487-1824 www.floridabuilding.org

Contact: Building A Safer Florida, Inc. 850-222-2772 www.buildingasaferflorida.org