Specifying Windows and Doors Using Performance Standards
This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services may be addressed at the conclusion of this presentation.
This presentation is protected by U.S. and International copyright laws. Reproduction, distribution, display and use of the presentation without written permission of the speaker is prohibited.

© American Architectural Manufacturers Association 2011
Specifying Windows and Doors Using Performance Standards

This course is designed to improve your understanding of:

- The evolution of window and door standards and code references
- How to use the standard to specify product type, performance level and key performance attributes
- Special requirements for different window and door types
- The short form specification and how to use it
The focus of this program is the AAMA/WDMA/CSA 101/I.S. 2/A440 – 08 standard, commonly known as NAFS-08.

Previous versions are still in use including AAMA/NWWDA 101/I.S.2-97, AAMA/WDMA 101/I.S. 2/NAFS-02 and AAMA/WDMA/CSA 101/I.S.2/A440-05. Check your local building codes to determine which version of the standard is in effect in that jurisdiction since some performance requirements differ from one version of the standard to another.

Skylights are also covered in NAFS-08 as they were in the 2005 and 2002 versions, but this course focuses mainly on windows and doors.
Getting to NAFS-08

1947
The first Guide Specification for Aluminum Windows was released.

1950
Performance levels for different applications were first defined.

1962
AAMA 302 aluminum window standard was released.

1985
AAMA “101” standard for aluminum windows and doors was released.

1988
AAMA “101” standard for aluminum windows and doors is updated from 1985 document and released.

1986
AAMA “101” standard for vinyl windows and doors was released.

The North American Fenestration Standard - AAMA/WDMA/CSA 101/I.S.2/A440-08 - and its predecessors have all been milestones in a decades-long effort to provide a level playing field for objectively evaluating the performance characteristics and quality attributes of fenestration products regardless of their framing material.
AAMA and the National Wood Window and Door Association (NWWDA) began work in 1994 to consolidate what were then the two major U.S. standards for windows and doors – AAMA 101-93 for aluminum and vinyl and NWWDA I.S.2-93 for wood. In 1997, this effort resulted in the publication of a new national standard, designated as AAMA/NWWDA 101/I.S.2-97 – the first to encompass all framing materials.
The 2002 standard added more performance requirements and more material options – such as fiberglass – and for the first time included unit skylights. In 2005, AAMA/WDMA/CSA 101/I.S.2/A440-05 was issued, fully consolidating U.S. and Canadian standards and adding four more operator types, eight additional materials and requirements for side-hinged doors.
Key Features of AAMA/WDMA/CSA 101/I.S. 2/A440–08

All four performance standards have similar key features that make them landmarks for the fenestration industry and practical tools for architects and specifiers.

1. Performance Based

That means that rather than attempting to prescribe detailed physical attributes such as frame thickness, completely fabricated products are rated according to how well they perform under prescribed conditions.
Key Features of AAMA/WDMA/CSA 101/I.S. 2/A440–08

1. Performance Based

2. Material Neutral

Because they are performance-based, these standards are also material-neutral. Performance rating automatically takes into account the strengths and weaknesses of all materials.
Key Features of AAMA/WDMA/CSA 101/I.S. 2/A440–08

1. Performance Based
2. Material Neutral
3. Referenced by IBC and IRC

The 2006 edition of these codes references the NAFS-05 standard, while the 2009 edition references the NAFS-08 standard.

All four standards (1997, 2002, 2005 and 2008) may serve as the basis for third-party certification, although earlier versions will eventually be phased out.
Key Features of AAMA/WDMA/CSA 101/I.S. 2/A440–08

1. Performance Based
2. Material Neutral
3. Referenced by IBC and IRC
4. Multinational in Scope

Finally, both NAFS-05 and NAFS-08 standards represent a harmonization of United States and Canadian window and door standards, which simplifies cross-border certification and specification.

The course will note where it differs from the 1997, 2002 and 2005 standards.
Using NAFS-08 to select and specify a fenestration product is quite straightforward. As with any project, you must first determine three basic things:

1. What type of product?
2. What application or environment?
3. What performance level is required for the job site?
First, consider the type of window, door or unit skylight you want. This is also known as the operator type – as determined by the way in which it operates, such as double-hung, casement, awning and so forth.
Product Types

- There are 31 Product Types identified in NAFS-08 by a specific letter code. The document lists all of these product types and their identifying codes.
Next, after determining the product type, consider the kind of environment in which the product is to be installed. In the standard, a general guide is provided to help in determining which class is best suited for a particular application.
The performance class, indicated by a letter code, is a major change in the 2008 version compared to previous versions.

The five classes defined in all previous versions were:
1. **R**: typically for one- and two-family dwellings
2. **LC**: typically for low-rise multi-family, offices, professional buildings or motels
3. **C**: typically lighter industrial buildings, hotels and retail buildings
4. **HC**: typically for hospitals, schools, government and other mid-rise buildings
5. **AW**: typically for larger institutional, high-rise buildings or where demanding use of fenestration products is expected
Performance Class

In the 2008 version, the total number of classes has been reduced from five to four, due to removal of the C and HC performance classes and the addition of the new CW classification.

- The R, LC and AW classes are essentially unchanged.
- The new CW class is primarily for low and mid-rise buildings ranging from hospitality to retail to institutional use.

These designations specify increasingly stringent basic performance requirements to meet the demands of the increasingly robust product applications. Note that these designations are descriptive guidelines only and are not directly related to similar designations often found in building codes.
<table>
<thead>
<tr>
<th>Year</th>
<th>R</th>
<th>LC</th>
<th>C</th>
<th>HC</th>
<th>AW</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
But – beyond these subjective designations – how do you know what performance class is needed for a given job and what the specific performance requirements are?

Entry into each performance class is based on a minimum – or “gateway” – set of primary requirements, which is simply the design pressure or wind load in pounds per square foot, for which the products have been designed and successfully tested. A given design pressure, of course, corresponds to a wind velocity as the table on the next slide shows. The conversion of wind speed is taken from ASCE-7.

Please note that the wind velocities shown are per calculation - state and local code requirements may include safety factors. These figures should not be used to assess building code compliance. These numbers can also vary depending upon site specific conditions.

Those familiar with the 2005 standard will note that the gateway design pressure remains unchanged in the 2008 edition for R, LC and AW class products at 15, 25 and 40 psf, respectively.
## Performance Grade

<table>
<thead>
<tr>
<th>Product Performance Class</th>
<th>Minimum Performance Grade</th>
<th>Minimum Design Pressure (psf)</th>
<th>Wind Speed Equivalent (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows and Doors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>15</td>
<td>15.0</td>
<td>77</td>
</tr>
<tr>
<td>LC</td>
<td>25</td>
<td>25.0</td>
<td>99</td>
</tr>
<tr>
<td>CW</td>
<td>30</td>
<td>30.0</td>
<td>108</td>
</tr>
<tr>
<td>AW</td>
<td>40</td>
<td>40.0</td>
<td>125</td>
</tr>
</tbody>
</table>

**Note that Performance Grade is not equal to design pressure.** The term “Design Pressure” describes a product’s ability to withstand uniform loads caused by either wind or, in the case of skylights, snow. A product only achieves a “Performance Grade” rating if that product complies with all performance requirements of the 101/I.S.2/A440 standard. This means that not only does the product have to comply with the structural loading performance requirement, but it also must comply with other performance requirements, such as air infiltration resistance, water penetration resistance, ease of operation, resistance to forced entry and more.
Using these key elements of product type, performance class and performance grade, we are ready to construct the performance rating, which you will use to specify a window or door for a specific application.

The rating consists of a four-part product designation, which has changed somewhat from the preceding editions of the standard:

The four parts include:

1. Performance class - here it is R, which we will address later.
2. Performance grade – that is, the minimum design pressure for the performance class. Here it is 15 for a 15 psf design pressure.
3. Maximum size tested - here it is 63 inches wide by 44 inches high.
4. Product operator type - in this example, it is “HS” for horizontal sliding window.
Product Designation System

**PRODUCT KEY**

A = Performance Class: R
B = Performance Grade: Design Pressure = 15 psf
C = Maximum Size Tested: Width x Height (63x44)
D = Product Type: Horizontal Siding Window (HS)
This is how the designation appears on the AAMA Gold Certification Label. That last element of the product designation – maximum size tested, or “MST” (shown here in metric units followed by the IP equivalent) – is an important consideration that deserves some elaboration. First, let’s take a closer look at how the design wind load is used to specify the different performance levels.
Basic Performance Requirements

NAFS-08 and its predecessors define four mandatory basic performance requirements within each performance class for a completely fabricated product:

1. The minimum structural load that a product must withstand due to wind at the design pressure
2. The product’s resistance to water penetration due to wind-driven rain
3. The product’s ability to seal out air leaks that can decrease energy efficiency
4. The product’s security in terms of its ability to resist forced entry

The first two of these – arguably the most important for a product’s function as a structural element – are tied to the design pressure (or performance grade) for the building site.
The classic reference for determining design wind load is ASCE 7, “Minimum Design Loads for Buildings and Other Structures,” which includes this well-known map.

The map tells us the design wind speed – typically the maximum likely to be experienced – for the building’s location.

However, please keep in mind that local codes prevail and may cite other requirements or a specific edition of ASCE 7 (or may not cite ASCE at all). Always check your local codes.
ASCE Design Wind Load Map
Design Wind Load Table (psf)

Once the height of the building is known, the design pressure can be determined from a table within ASCE-7.

Excerpt from ASCE-7

<table>
<thead>
<tr>
<th>Mean Roof Height (ft.)</th>
<th>Positive Pressure Area 4</th>
<th>Positive Pressure Area 5</th>
<th>Negative Pressure Area 4</th>
<th>Negative Pressure Area 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BASIC WIND SPEED – 70 MPH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>16.6</td>
<td>-17.6</td>
<td>-22.6</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>18.0</td>
<td>-19.1</td>
<td>-24.6</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>19.2</td>
<td>-20.4</td>
<td>-26.2</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>20.3</td>
<td>-21.5</td>
<td>-27.7</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>21.9</td>
<td>-23.3</td>
<td>-29.9</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>23.4</td>
<td>-24.8</td>
<td>-31.9</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>24.6</td>
<td>-26.1</td>
<td>-33.6</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>25.7</td>
<td>-27.2</td>
<td>-35.0</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>26.7</td>
<td>-28.3</td>
<td>-36.4</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>27.7</td>
<td>-29.4</td>
<td>-37.8</td>
<td></td>
</tr>
</tbody>
</table>
Design Wind Load Table (psf)

Note that the table on the previous slide shows both positive and negative pressures. The former is the pressure the wind exerts against the building from the windward side, while the negative load is the negative pressure tending to pull the window out due to aerodynamic effects. This effect is greater near the building corners – area 5 in the table – than near the center of the wall – area 4 in the table. In general, the width of area 4 is considered to be 40% of the building height at the eaves. The width of area 5 is considered to be the smaller of 40% of the building's mean roof height or 10% of the building width.

The applicable design pressure is the largest absolute value of the positive and negative loads, rounded up to the nearest increment of 5 psf. Because negative pressure generally exceeds positive pressure, NAFS-08 permits products to have a secondary designator that shows the negative design pressure separately, in increments of 5 psf. Other factors that come into play when determining the load for a given building include such considerations as building use, category and site location (terrain).

The four variables used in establishing the wind load for components and cladding are 1) mean roof height, 2) basic wind speed, 3) importance factor and 4) exposure category.
Once determined, the design wind load directs the key performance considerations. First and foremost among these is structural loading.
NAFS-08 and its predecessors require that the window or door withstand a wind pressure test load, applied per ASTM E 330, of one and a half times the design pressure (in psf - not mph) for its class, which we just determined from the ASCE map and table. For example, the uniform load test pressure for a CW class window - whose minimum design pressure is 30 psf - would be 45 psf.
Minimum Performance Requirements Listed by Class

During all laboratory testing, the pressure effects of wind are simulated in the lab by applying a pressure differential across the face of the test specimen; blowers or compressors induce either a greater-than-atmospheric-pressure or less-than-atmospheric-pressure to either the interior or exterior face of the specimen.

If the pressure is greater on the exterior face than the interior face, a "positive pressure" is being applied, which simulates a "positive wind load" or wind blowing against the exterior face of the unit. If the pressure on the exterior is less than the pressure on the interior face, a 'negative pressure' is being applied, and this simulates "negative wind load," which is encountered on the leeward sides of buildings and roof areas.

Note that the relationship between static pressure differential and wind load is not linear; therefore, twice the static load does not correspond to twice the simulated wind speed.
Uniform Load Deflection Test at the Design Pressure

A minimum uniform design pressure load is applied to the test specimen, first to the exterior surface (positive) and then to the interior surface (negative).

Deflection at design pressure is reported for all products. For HC and AW products, the deflection must not exceed L/175.

For all performance classes, normal operation after the application of the deflecting force is required. Note that we are talking about temporary deflection here, not permanent deformation. While deflection is measured and recorded for all product classes, the AW and CW performance classes require a maximum deflection of 1/175th of the unit’s span.
2008 Version
Uniform Load Structural Test

There should be no permanent deformation of any mainframe, sash, sash member, leaf or threshold/sill in excess of 0.4% of its span for R and LC class products, 0.3% of its span for CW class products or 0.2% of its span for AW class products.”
The language on the previous slide comes from the section of NAFS-08 pertaining to the uniform load structural test at 150% of design pressure. The document states that “in the test a minimum uniform load structural test pressure will be applied, and the test specimen should be evaluated for permanent damage after each load. There should be no permanent deformation of any mainframe, sash, sash member, leaf, or threshold/sill in excess of 0.4% of its span for R and LC class products, 0.3% of its span for CW class products or 0.2% of its span for AW class products.”

In NAFS-08, the 0.3% limit was assigned to the new CW class.

Many of these increased requirements are derived from AAMA GS-001, “Voluntary Guide Specifications for Aluminum Architectural Windows” – a document widely used by architects prior to its inclusion into ANSI/AAMA 101-93 and subsequent versions.
The second major performance consideration is water penetration resistance.
In order to simulate wind-driven rain, testing for water leakage is conducted at a pressure equal to 15% of the design pressure, subject to a minimum of 2.90 psf and a recommended maximum of 12 psf (15 psf in Canada). The exception is the AW class, which is tested for water penetration at a pressure of 20% of design pressure, but is also capped at 12 psf.

Each performance class thus has a progressively higher minimum test pressure. When the performance grade is increased, the product must be tested for water resistance at a correspondingly higher pressure.

Notice that the test methods for water resistance are dependent upon performance class. R, LC and CW products are tested to ASTM E 547, while AW products are tested to both ASTM E 547 (cyclic static pressure) and ASTM E 331 (uniform static pressure).

Minimum water test pressure is further explained through the chart on the next slide.
Minimum Water Test Pressure

- 20% of Design Pressure
- 15% of Design Pressure (or 2.9 minimum as shown)

<table>
<thead>
<tr>
<th>Pressure in psf</th>
<th>R 15</th>
<th>LC 25</th>
<th>CW 30</th>
<th>AW 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Water Test Pressure</td>
<td>2.9</td>
<td>3.8</td>
<td>4.5</td>
<td>8.0</td>
</tr>
</tbody>
</table>
## Minimum Performance Requirements Listed by Class

<table>
<thead>
<tr>
<th>Window/Door Classes</th>
<th>Design Pressure (psf)</th>
<th>Structural Test Pressure (psf)</th>
<th>Water Resistance Test Pressure (psf)</th>
<th>Required Percentage For Water Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>15</td>
<td>22.5</td>
<td>2.9</td>
<td>*</td>
</tr>
<tr>
<td>LC</td>
<td>25</td>
<td>37.5</td>
<td>3.8</td>
<td>15%</td>
</tr>
<tr>
<td>CW</td>
<td>30</td>
<td>45.0</td>
<td>4.5</td>
<td>15%</td>
</tr>
<tr>
<td>AW</td>
<td>40</td>
<td>60.0</td>
<td>8.0</td>
<td>20%</td>
</tr>
</tbody>
</table>

R-class products with a performance grade of 15 are tested at 2.9 psf, which is higher than the 15% of design pressure, as required for other higher ratings within the R class.

Also, notice that the water resistance test pressure is higher for AW class products, set at 20% of the design pressure.
Performance Considerations Related to Design Pressure

Performance Grade = Design Pressure

Structural Test Pressure = 1.5 Design Pressure

Water Resistance Test Pressure = 0.15 Design Pressure for R, LC, CW
0.20 Design Pressure for AW

This, then, is the key to understanding product performance requirements and testing – that the major structurally-related aspects are all related directly to the design pressure.
But there are other important performance considerations – air infiltration for example – a major aspect of energy efficiency and user comfort.
Air Infiltration Test Pressure

FOR VARIOUS PERFORMANCE CLASSES

Here we see how air infiltration test pressures are assigned. They are not keyed to the design pressure, but vary by performance class and operator type.
In reference to the chart on the previous slide, all operator types in the R, LC and CW classes are tested at 1.6 psf. This is the approximate pressure generated by a 25 mph wind.

All AW class windows are tested for air infiltration at 6.2 psf, the approximate pressure generated by a 50 mph wind.

All air infiltration tests are per ASTM E 283.

There are two parameters for air infiltration testing:
1) Test pressure
2) Maximum allowed air leakage
Maximum Air Infiltration
FOR VARIOUS PERFORMANCE CLASSES AND GRADES

0.05
0.1
0.15
0.2
0.25
0.3

cfm/sq. ft.

0.1 cfm/sq. ft. for all compression seal products
In reference to the chart on the previous slide, the maximum air infiltration that is allowed varies by window operator type and performance class. For all except the AW class, the allowable infiltration rate is 0.3 cubic feet per minute per square foot of frame area.

All AW compression and fixed products are further reduced to 0.1 cubic feet per minute per square foot.

Two exceptions:
- Jalousie windows, whose design demands an allowable rate of 1.2 cubic feet per minute per square foot of frame area
- AW class products with sliding seals, which have an allowable rate of 0.3 cubic feet per minute per square foot of frame area
The fourth of the major performance considerations is forced entry resistance, defined as the product’s ability to restrain, delay or frustrate a break-in.

NAFS-08 and its predecessors reference ASTM F 588 or ASTM F 842 for forced entry resistance requirements. The former provides test methods for various operator types, while the latter covers sliding glass doors. Both address prying the window or door open or manipulating the locks or latches, and exclude entry by means of breaking the glass.

AAMA 1304 is to be used for hinged doors requirements.
That covers the four basic performance requirements addressed by NAFS-08, but what about that last item in the product designation system – maximum size tested?
Window Testing

This is important because the size of the unit submitted for testing is a critical factor in determining whether or not a product complies with the standard and what sizes are covered by certification.

To understand "maximum size tested," we must first have a look at the minimum test size.
To provide a uniform basis for comparing the performance of products of the same type and grade, product specimens must be tested at the same minimum or larger test size specified by the standard. This is because the smaller the test sample, the smaller the area exposed to loading and the shorter the frame span between corners, making it easier for the specimen to pass the test.

Minimum test size is thus an important equalizer when evaluating and comparing various products.
## Minimum Test Size Requirements

### Test Sample Requirements
*(Example: Casement Windows)*

<table>
<thead>
<tr>
<th>Window Designation</th>
<th>2008 Minimum Frame Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-PG15-C</td>
<td>24&quot; (600 mm) x 60&quot; (1500 mm)</td>
</tr>
<tr>
<td>LC-PG25-C</td>
<td>32&quot; (800 mm) x 60&quot; (1500 mm)</td>
</tr>
<tr>
<td>CW-PG30-C</td>
<td>32&quot; (800 mm) x 60&quot; (1500 mm)</td>
</tr>
<tr>
<td>AW-PG40-C</td>
<td>36&quot; (900 mm) x 60&quot; (1500 mm)</td>
</tr>
</tbody>
</table>

Minimum size requirements, always expressed as width by height, are dependent on the window or door operator type and the performance class.

For example, this chart shows that the minimum frame size to be tested varies by class for casement windows. Note that while the test specimen size for some classes is the same, the design load and therefore the structural test pressure increases as you progress upward through the classes.
Minimum Test Size Requirements

Test Sample Requirements
(Example: Casement Windows)

<table>
<thead>
<tr>
<th>Window Designation</th>
<th>2008 Minimum Frame Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-PG15-C</td>
<td>24&quot; (600 mm) x 60&quot; (1500 mm)</td>
</tr>
<tr>
<td>LC-PG25-C</td>
<td>32&quot; (800 mm) x 60&quot; (1500 mm)</td>
</tr>
<tr>
<td>CW-PG30-C</td>
<td>32&quot; (800 mm) x 60&quot; (1500 mm)</td>
</tr>
<tr>
<td>AW-PG40-C</td>
<td>36&quot; (900 mm) x 60&quot; (1500 mm)</td>
</tr>
</tbody>
</table>

The test sizes may vary according to the version of the standard being referenced. In general, it can be stated that minimum test sizes have increased for several of the most common window types in the more recent versions of the standard. Because the smallest size can more easily pass the tests, this has the effect of ratcheting up the minimum structural performance requirements.
Minimum Test Sizes

Product test sizes are selected so that the size includes the largest product width and height dimensions for which compliance is sought. Note that the position and length of intermediate framing members is selected such that the worst or most stringent structural exposure is included. Only those structural framing members actually tested are in compliance with the standard.
This brings us back to the maximum size tested (MST).

When looking at the label, you will see an indication of the maximum size tested, or MST. This is different than the minimum test size we just discussed. Remember, a minimum test size is specified by the standard for each performance class to ensure that test results are representative of the actual product’s performance.
The maximum size tested, shown on the label, is up to the manufacturer, who will typically select a product test size so that the size represents the largest product width and height dimensions in the product line for which compliance is sought. When this largest unit complies, all smaller units of the same design and performance class - that is, all units in that particular product line - automatically qualify as well.
Higher Performance Grades?

That covers the basic specification of windows using NAFS-08 and its predecessors – the 1997, 2002 and 2005 versions.

But life isn’t always that straightforward. For example, what if you want to specify a higher performance level than the minimum for the class of window you want?
## Optional Performance Grades

<table>
<thead>
<tr>
<th>Optional Performance Grade</th>
<th>Applicable Performance Class</th>
<th>Design Pressure</th>
<th>Structural Test Pressure</th>
<th>Water Resistance Test Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>psf (Pa)</td>
<td>psf (Pa)</td>
<td>psf (Pa) psf (Pa)</td>
</tr>
<tr>
<td>20</td>
<td>R</td>
<td>20.0 (960)</td>
<td>30.0 (1440)</td>
<td>3.00 (150) -</td>
</tr>
<tr>
<td>25</td>
<td>R</td>
<td>25.0 (1200)</td>
<td>37.5 (1800)</td>
<td>3.75 (180) -</td>
</tr>
<tr>
<td>30</td>
<td>R,LC</td>
<td>30.0 (1440)</td>
<td>45.0 (2160)</td>
<td>4.50 (220) -</td>
</tr>
<tr>
<td>35</td>
<td>R,LC,CW</td>
<td>35.0 (1680)</td>
<td>52.5 (2520)</td>
<td>5.25 (260) -</td>
</tr>
<tr>
<td>40</td>
<td>R,LC,CW</td>
<td>40.0 (1920)</td>
<td>60.0 (2880)</td>
<td>6.00 (290)</td>
</tr>
<tr>
<td>45</td>
<td>R,LC,CW,AW</td>
<td>45.0 (2160)</td>
<td>67.5 (3240)</td>
<td>6.75 (330) 9.00 (440)</td>
</tr>
<tr>
<td>50</td>
<td>R,LC,CW,AW</td>
<td>50.0 (2400)</td>
<td>75.0 (3600)</td>
<td>7.50 (360) 10.00 (480)</td>
</tr>
<tr>
<td>55</td>
<td>R,LC,CW,AW</td>
<td>55.0 (2640)</td>
<td>82.5 (3960)</td>
<td>8.25 (400) 11.00 (530)</td>
</tr>
<tr>
<td>60</td>
<td>R,LC,CW,AW</td>
<td>60.0 (2880)</td>
<td>90.0 (4320)</td>
<td>9.00 (440) 12.00 (580)</td>
</tr>
</tbody>
</table>

Optional Performance Grades higher than those shown on the table may be used in increments of 5 psf. Water resistance test pressures are capped at 12 psf in the 2008 versions of the standard. Ratings are capped at 100 psf in the 2008 version of the standard, except for the AW class.
## Optional Performance Grades (cont'd)

<table>
<thead>
<tr>
<th>Optional Performance Grade</th>
<th>Applicable Performance Class</th>
<th>Design Pressure</th>
<th>Structural Test Pressure</th>
<th>Water Resistance Test Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>psf</td>
<td>Pa</td>
<td>psf</td>
</tr>
<tr>
<td>65</td>
<td>R,LC,CW,AW</td>
<td>65.0</td>
<td>3120</td>
<td>97.5</td>
</tr>
<tr>
<td>70</td>
<td>R,LC,CW,AW</td>
<td>70.0</td>
<td>3360</td>
<td>105.0</td>
</tr>
<tr>
<td>75</td>
<td>R,LC,CW,AW</td>
<td>75.0</td>
<td>3600</td>
<td>112.5</td>
</tr>
<tr>
<td>80</td>
<td>R,LC,CW,AW</td>
<td>80.0</td>
<td>3840</td>
<td>120.0</td>
</tr>
<tr>
<td>85</td>
<td>R,LC,CW,AW</td>
<td>85.0</td>
<td>4080</td>
<td>127.5</td>
</tr>
<tr>
<td>90</td>
<td>R,LC,CW,AW</td>
<td>90.0</td>
<td>4320</td>
<td>135.0</td>
</tr>
<tr>
<td>95</td>
<td>R,LC,CW,AW</td>
<td>95.0</td>
<td>4560</td>
<td>142.5</td>
</tr>
<tr>
<td>100</td>
<td>R,LC,CW,AW</td>
<td>100.0</td>
<td>4800</td>
<td>150.0</td>
</tr>
</tbody>
</table>

Optional Performance Grades higher than those shown on the table may be used in increments of 5 psf. Water resistance test pressures are capped at 12 psf in the 2008 versions of the standard. Ratings are capped at 100 psf in the 2008 version of the standard, except for the AW class.
In reference to the tables on the previous two slides, the standard makes it possible to specify higher structural load and water penetration test pressures than the required performance class gateway minimums – such as might be needed in a hurricane zone, for example.

Products can be tested to meet any design load above the gateway minimum in increments of 5 psf.

In addition to the primary performance requirements and the increased design and structural test loads, products must meet a water test pressure of 15% of the design pressure (20% for AW products), up to a maximum of 12 psf – 15 psf when the standard is used in Canada.

NAFS-08 caps these higher grades at 100 psf for R, LC and CW classes, with no cap for AW products, for which there is no maximum.
Optional Performance Grades

Note that all products tested under optional performance grades must first conform to all of the minimum requirements for the product class designation under consideration. Only after successful entry into the performance class at the minimum performance grade tested and at the minimum test specimen size can additional optional performance grade testing be conducted.
Optional Performance Grades Examples

1. Tested Design Pressure @ 80 psf
   Tested Water Resistance @ 8.00 psf

   AW40 / HC50 97/02/05
   AW-PG40 / CW-PG50 2008

This window is an AW-PG40 since it only meets the 8 psf water test (20% of 40 = 8 psf). Also this window is a CW-PG50 since it only meets the 8 psf water test (15% of 50 = 7.5 psf).

*The performance grade assigned must be consistent with the lowest test level achieved.*
The performance grade assigned must be consistent with the lowest test level achieved.

This window is either an AW-PG50 or a CW-PG50 since it exceeds the water test pressure at both the 15% and 20% level. (15% of 50 = 7.5 psf and 20% of 50 = 10 psf) and since it meets the maximum 12 psf water test for both classes.
Optional Performance Grades Examples

3. Tested Design Pressure @ 75 psf
   Tested Water Resistance @ 12.00 psf

Per the 2008 version, this window is either an AW-PG75 or a CW-PG75.

This is very important. You can’t meet one condition and not the other. For example, you cannot stipulate that you have an AW-80 product which meets an 80 psf design pressure but only meets the minimum AW water pressure of 8 psf. In this case the highest you could rate the product is as an AW40 window.

The performance grade assigned must be consistent with the lowest test level achieved.
Special Requirements Per Window Type?

In addition to the primary gateway performance requirements of structural strength and resistance to water penetration, air infiltration and forced entry that apply to all window types, each operator type has additional unique requirements.
Another special requirement, applicable to all products in which the sash is operated by pulling on the edge of the sash, is testing for resistance to deglazing during operation. This testing is conducted per ASTM E 987.

The deglazing test is not applicable to all products. It is only for operable products whose mode of operation is either vertical or horizontal sliding and to secondary sash in dual windows or dual doors.
In addition, all operable AW class products are required to undergo life cycle testing according to AAMA 910.
AAMA 910 Life Cycle Testing

Procedures from AAMA 910, "Voluntary Life Cycle Specifications and Test Methods for Architectural Grade Windows and Sliding Glass Doors" are designed to simulate load conditions which may occur during normal operation as well as maintenance and cleaning. Testing also addresses misuse or abuse by the operators.

When so tested, there must be no damage to fasteners, hardware parts, sash balances or other components that would cause the window to be inoperable. This is a pass/fail specification, and the fenestration product either meets all of the requirements or it fails to pass as an AW class product.

Test units must also meet air and water performance requirements both before and after undergoing life cycle testing.
Concerns Addressed by AAMA 910
Life Cycle Testing

- Carelessness by the occupants or maintenance personnel
- Lack of awareness of proper operating or maintenance procedures
- Operating force beyond the limits of normal physical ability
- Attempted operation without proper keys or devices
AAMA 910 Life Cycle Testing Exclusions

Items and conditions that are specifically excluded from the normal use and abuse conditions are listed here:

- Vandalism
- Improper installation/handling practices
- Intentional abuse
- Detention or psychiatric applications

Environmental conditioning or cycling such as temperature, UV exposure are addressed in AAMA 910.
NAFS-08 imposes additional requirements on intermediate framing members such as mullions, used to create combination units.
Mullions and Other Structural Members

The most important requirement for mullions and similar structural members is that they must be designed to withstand the full windload for the project, regardless of the performance class of the individual products.

NAFS-08 states that mullions for all AW products must not exceed a deflection limit of $1/175^{th}$ of the mullion span length. Evidence of compliance may be by structural analysis or AAMA 450.

Option #3 (Structural Calculations by P.E.) within AAMA 450 requires that all mullions meet a deflection requirement of $L/175$ during the application of the design pressure load.
Glass and Glazing Materials

Glass selection is per ASTM E 1300, “Standard Practice for Determining the Minimum Thickness and Type of Glass Required to Resist a Specified Load.” Glass selection can also comply with CAN/CGSB 12.20. Glass furnished by the manufacturer must meet the values given in ASTM E 1300 for the design pressure rating and dimensions of the product.

Performance testing in this standard is required to be performed on units glazed with the minimum thickness and strength of glazing specified in ASTM E 1300 for the design load of the product.

This is done so that the glazing cannot artificially increase the performance of the product being tested.
NAFS-05 achieved a new milestone with the inclusion of performance requirements for exterior side-hinged doors. These are carried forward into NAFS-08, although specific testing requirements are adjusted to address the CW performance class.

The 2009 I-codes, which include the International Residential Code (IRC) and the International Building Code (IBC), exclude these requirements until a suitable means for accommodating field substitution of components is finalized, but certification to these requirements is currently available to manufacturers.
We have talked a lot about testing in this course, as laboratory testing is the only way to verify that a given product meets the requirements of the standard. Keep in mind, it is important that testing of fenestration products be conducted by an independent, AAMA accredited laboratory both in the laboratory and in the field.

AAMA maintains a list of more than 40 laboratories in the United States and Canada for this purpose. These laboratories are not permitted to be affiliated with manufacturers and are inspected on a regular basis to determine that their equipment is properly calibrated and that their technicians are properly trained.
Laboratory testing to 101/I.S.2-97, 101/I.S.2/NAFS-02, 101/I.S.2/A440-05 or NAFS-08 verifies the performance of a specimen of the fenestration product itself. But how can an architect or specifier be sure that the specified performance will be realized after installation?

When properly applied, field testing can be a useful way to verify actual installed performance during construction and prior to occupancy of a building. The key is testing in conditions that accurately simulate the real-world environment and ensuring that the appropriate test method is applied to the specific installation.
Once the product selection is complete, and a product designation is determined and appropriate compliance testing decided, it only remains to document the selection for the project at hand.

NAFS-08 and its predecessors provide assistance with this by presenting a recommended short form, fill-in-the-blank specification. Simply add the specific designation and the preferred manufacturer.

All (windows) (doors) (tubular daylighting devices) (unit skylights) shall conform to the _____________ requirements of the voluntary specification(s) in AAMA/WDMA/CSA 101/I.S.2/ A440-08, be labeled with the AAMA, CSA or WDMA label, have the sash arrangement(s), leaf arrangement(s), or sliding door panel arrangement(s) and be of the size(s) shown on the drawings and be as manufactured by __________________ or approved equal.
Short Form Specification

An example of a completed short form specification is given here. The specifier is not constrained by the standard’s requirements, as he/she can still write in more stringent exceptions.

All (windows) (doors) (unit skylights) shall conform to the LC PG25-HS voluntary specification(s) in AAMA/WDMA/CSA 101/I.S. 2/A440-08, be labeled with the AAMA, CSA or WDMA label, have the sash arrangement(s), leaf arrangement(s), or sliding door panel arrangement(s) and be of the size(s) shown on the drawings and be as manufactured by XYZ Windows or approved equal.
This is not to minimize the task of the specification writer. He or she is burdened with the responsibility for a great many building elements.

The product designation system, performance requirements and methodology included in the 2008 standard and its predecessors is designed to lighten that burden without sacrificing completeness or quality.
Seminar Evaluation

This concludes the American Institute of Architects Continuing Education System Program.

Thank you!