Window Classification

- **AAMA 101**
  - **Performance Class**
    - **R**: commonly used in one- and two-family dwellings.
    - **LC**: commonly used in low-rise and mid-rise multi-family dwellings and other buildings where larger sizes and higher loading requirements are expected.
    - **CW**: commonly used in low-rise and mid-rise buildings where larger sizes, higher loading requirements, limits on deflection, and heavy use are expected.
    - **AW**: commonly used in high-rise and mid-rise buildings to meet increased loading requirements and limits on deflections, and in buildings where frequent and extreme use of the fenestration product is expected.
Window Classification

- **AAMA 101**
  - Performance Grade
  - Operating force (if applicable)
  - Air leakage resistance
  - Water penetration resistance
  - Uniform load deflection test
  - Uniform load structural test
  - Forced-entry resistance (if applicable)

Performance Grade (PG)
- PG “number” is a function of the following tests and based on specific design pressures (DP).
  - Water penetration resistance (ASTM E547 and ASTM E331)
  - Uniform load deflection test (ASTM E330)
- Other tests with minimum performance are also required (more associated with performance class than grade)
- The DP ratings can be used as a secondary designator

Design Pressure (DP)
- Water penetration resistance (ASTM E547 and ASTM E331)
  - Tested at 15% of the DP for R, LC, CW
  - Tested at 20% of the DP for AW
- Uniform load deflection test (ASTM E330)
  - Tested at 150% of the DP
  - Permanent deformation:
    - 0.4% of the span for R and LC
    - 0.3% of the span for CW
    - 0.2% of the span for AW
Window Classification

<table>
<thead>
<tr>
<th>Performance Class</th>
<th>Minimum Performance Grade (IG)</th>
<th>Minimum Design Pressure (ESP)</th>
<th>Minimum Structural Test Pressure (SPI)</th>
<th>Minimum Water Penetration Resistance Test Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>15</td>
<td>720 (13.04k)</td>
<td>1060 (22.56)</td>
<td>140 (2.59)</td>
</tr>
<tr>
<td>LC</td>
<td>25</td>
<td>1200 (25.06k)</td>
<td>1800 (37.59)</td>
<td>180 (3.76)</td>
</tr>
<tr>
<td>CW</td>
<td>30</td>
<td>1440 (30.08k)</td>
<td>2160 (46.11)</td>
<td>220 (4.59)</td>
</tr>
<tr>
<td>AW</td>
<td>40</td>
<td>1200 (26.10k)</td>
<td>2880 (62.15)</td>
<td>290 (6.15)</td>
</tr>
</tbody>
</table>

Note: The IP equivalents identified are for approximate reference only and do not imply any degree of accuracy to the measurement or the equipment. See Clause 1.1. Precision and bias statements are provided in the applicable test methods referenced in this Standard/Specification.

Laboratory Test

Designation: E 331 – 00

Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference

Designation: E 547 – 00

Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference

Figure 9.2 of AAMA 101-11
Laboratory testing completed under face sealed installation

- Real construction is often not face sealed
  - Residential windows are often flanged windows typically installed in pan flashed and drained opening
  - Commercial glazing can be any number of configurations
- Field tests may or may not be completed under face sealed conditions
BIG RANT HERE
Laboratory Test

END RANT

Laboratory Test

- Failure Criteria

“So… you’re telling me a window can leak and pass?”

Failure Criteria

3.2.3 water penetration, n—penetration of water beyond a plane parallel to the glazing (the vertical plane) intersecting the innermost projection of the test specimen, not including interior trim and hardware, under the specified conditions of air pressure difference across the specimen. For products with non-planer glazing surfaces (domes, vaults, pyramids, etc.) the plane defining water penetration is the plane defined by the innermost edges of the unit frame.
It just got better....

Specifying a Performance Class of window sets minimum gateway requirements.
Specifying a Performance Grade builds off the minimum gateway requirements.
Specifying a Minimum DP should also be considerate of the building cladding loads.
Specifying a Minimum Test Pressure should at least meet the PG or DP for the PC....???

What if you don't know what you want?

...Go with the building loads.

Typically specify a water infiltration resistance test pressure equal to 20% of the largest positive wind design load.
Window Specifications

- Sample Text

“Product shall not exhibit water infiltration when tested in accordance with ASTM E547 (and/or ASTM E331) when tested at a test pressure equal to or greater than 20% of the maximum positive wind design pressure for the project”

Window Specifications

- Product Performance Specifications are NOT the same as Field Verification Performance Specifications

- Products should be field tested to the wind design pressure of the project.

- Field Tests are typically done at 2/3rd (0.667) the specified laboratory test pressure
Field Testing

- ASTM E1105 Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference

- This is a test of the window system, and not the window to wall interface
- We often use this test to evaluate both
- Is this a reasonable test?

Field Testing

- AAMA 502-11 Voluntary Specification for Field Testing of Newly Installed Fenestration Products
- AAMA 503-08 Voluntary Specification for Field Testing of Newly Installed Storefronts, Curtain Walls and Sloped Glazing Systems
- These documents both reference ASTM E1105 Standard Test Method for Field Determination of Water Penetration

- ASTM E1105
  - 15 minute static test or 5 minute cyclical test (4 cycles)
  - Specified water test pressure x 0.677
  - Water delivery at 5.0 gal/ft2.hr
- Let's look at this…
Assume DP50 window
- 50psf x 15% x 0.677 = 5.0psf or 0.96in of water
- 5.0psf is roughly equivalent to 45mph wind
- 5.0gal/ft2.hr is roughly equivalent to 8.0in of rainfall per hour
  - From E1105 the greatest recorded rainfall in the contiguous United States is 5.0in
  - These conditions are maintained for 15 minutes or for four 5 minute cycles with a 1 minute break in between
- Aggressive test and not necessarily indicative of the in-field performance of the assemblies
- Good test to check potential pathways

How much testing?
- Punched windows and doors - test 1% to 2% of the total number of units installed
  - 500 windows = 5 to 10 test
  - 5 to 10 test @ 2 to 3 tests a day
  - 2 to 5 days of testing

How much testing?
- Storefronts and Ribbon windows - 1 test for every 2,500ft2 to 5,000ft2 installed
  - Assume test chamber is 5’x5’ to 7’x7’ (25ft2 to 50ft2)
  - 2,500ft2 to 5,000ft2 divided by 25ft2 to 50ft2
  - 1% to 2%

How much testing?
- Curtain Wall systems - 1 test for every 5,000ft2 to 10,000ft2 installed
  - Assume test chamber is 7’x7’ to 10’x10’ (50ft2 to 100ft2)
  - 5,000ft2 to 10,000ft2 divided by 50ft2 to 100ft2
  - 1% to 2%
Field Testing

- How much testing?

This should be indicated in the project specifications

Field Testing

- What is considered a fail?
  - AAMA 502 – per ASTM E1105 – no water passing the interior parallel plane.
  - AAMA 503 – not more than 0.5oz during the 15 minute test and not passing the interior parallel plane.

Mock Up Testing

- In Situ
  - Should be scheduled and completed as soon as possible in the project in order to troubleshoot any issues
- Free Standing
  - More useful on complicated buildings and details, but hard to get done as a performance mock up that is able to be tested.

This should be indicated in the project specifications
Field Testing

- Who pays for the retest?
  - AAMA 502 – should be listed in the Specifications
  - AAMA 503 – no mention

Should be the party that is responsible for the failure

Physics of Testing

\[ P_1 = 0 \; \text{in} \; H_2O \]
\[ P_2 = 0 \; \text{in} \; H_2O \]
Physics of Testing

- $P_1 = 1$ in H$_2$O
- $P_2 = 0.5$ in H$_2$O
- $P_3 = 0$ in H$_2$O

Physics of Test

- Methods of Water Transport
  - Friction (air drag)
  - Pressure on a film
Physics of Test

- The “Slider” Example
  \[
  P_1 = 0.5 \text{ in H}_2\text{O} \\
  P_2 = 0 \text{ in H}_2\text{O}
  \]

Test Set Up

- Chambers
  - Not permitted to touch the frame
  - Must be air tight enough to get to the negative pressure
- Spray Rack
  - Calibrated to a certain water pressure
  - Need to have adequate water pressure
- Set up and TEST EVERYTHING the day before the scheduled testing

Physics of Test

- The “Slider” Example
  \[
  P_1 = 1.0 \text{ in H}_2\text{O} \\
  P_3 = 0 \text{ in H}_2\text{O}
  \]

Test Set Up
Test Set Up

[Diagram of test setup]

BSC Experts Session

November 20, 2014

Windows and Water Leakage Testing

Baker

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Test Set Up

- Procedure

- Method A – 15min static test - for AW Windows, Storefront, Curtain Walls, Skylights

- Method B – 5 minute static cyclical test (4 cycles typically) for all other windows

Window Failures

- What is the most common failure?

  The Windows
  The Doors

Window/Door Failures

- What is the most common failure?
  - Corner welds
  - Corner seals
  - Mulled joints
  - Meeting rails
  - Glazing seals
  - Glazing units
  - Hardware
  - Screw fasteners
### Windows/Doors

- **Physics/Strategies**
  - Gravity
  - Pressure Moderation (Two-stage joints)
- **Three seals**
  - Primary
  - Interior
  - Exterior
- Pan flashed and drained openings
- Dealing the window industry (they are a force unto themselves)

### Windows/Doors

- **Window Seals**
  - **Recommend Three Seal Locations**
    - Primary – integrated with the wall water control layer
    - Interior – interior air seal for pressure moderation
    - Exterior – weather/aesthetic seal at the window to cladding interface

### Windows/Doors

- **Window Seals**
  - For flanged windows the primary seal is made by taping the flanged to the wall WRB
  - For non-flanged windows, the primary seal will either be:
    - A backer rod and sealant joint
    - A membrane flange adhered directly to the window frame and WRB.
  - Interior Seal is typically a backer rod and sealant joint or a bead of low expansion foam
  - Exterior is typically a backer rod and sealant joint
Windows/Doors

- Window Installation
  - Three general types
    - Flush with WRB
    - Recessed opening
    - Bucked out opening
  - Flush with WRB is easiest, lowest cost and least risky
Commercial Glazing

- Physics/Strategies
  - Gravity
  - Pressure Moderation (Two-stage joints)
  - Three seals are ideal (usually only two is achievable)
    - Primary
    - Interior
    - Exterior
  - Pan flashed and drained openings
Questions?

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