Field Testing and Forensic Analysis for Manufacturers

AAMA Special Event Webinar
April 28, 2015
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Session Objectives

• Comparison of the AAMA/WDMA/CSA 101/I.S.2/A440-11 lab test (referred to as NAFS-11) to the AAMA 502 field test and the AAMA 511 forensic evaluation

• Determination of appropriate air and water test pressures, test durations and water applications via NAFS-11, AAMA 502, 503 and 511

• How to specify project-specific field testing

• The proper use of AAMA 511 for forensic evaluations
Introduction

Types of Water Penetration Resistance Tests

• NAFS-11 Lab Testing
  ▪ Prototype specimen to validate product performance ratings

• 502 Field Testing
  ▪ Newly installed products to verify installed performance of the product and the installation

• 503 Field Testing
  ▪ Newly installed storefronts, curtain walls and sloped glazing systems

• 511 Forensic Testing
  ▪ Wall assemblies with known water control problems as a means to accurately identify suspect wall construction components and details
NAFS Overview

NAFS 2011 —
North American Fenestration Standard/Specification for windows, doors, and skylights

AAMA/WDMA/CSA
101/I.S.2/A440-11
NAFS-11 Laboratory Testing

- Utilizes ASTM E283 for air leakage testing
- Utilizes ASTM E547 and/or E331 for water penetration resistance testing
- Testing is performed under controlled environmental conditions
- Test sample is installed strictly per the manufacturer’s instructions in a precise test buck opening
Design Pressure Conversion to Water Test Pressure

Conversion as per NAFS-11
• 15% for R, LC, CW (2.9 psf minimum)
• 20% for AW
• Water Resistance Test Pressure is capped at 12.00 psf for the U.S. and 15.00 psf for Canada

<table>
<thead>
<tr>
<th>Performance Class</th>
<th>Minimum Design Pressure (psf)</th>
<th>Minimum Structural Test Pressure (psf)</th>
<th>Minimum Water Resistance Test Pressure (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>15.0</td>
<td>22.5</td>
<td>2.90</td>
</tr>
<tr>
<td>LC</td>
<td>25.0</td>
<td>37.5</td>
<td>3.75</td>
</tr>
<tr>
<td>CW</td>
<td>30.0</td>
<td>45.0</td>
<td>4.50</td>
</tr>
<tr>
<td>AW</td>
<td>40.0</td>
<td>60.0</td>
<td>8.00</td>
</tr>
</tbody>
</table>
AAMA 502-12

Voluntary Specification for Field Testing of Newly Installed Fenestration Products

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION
AAMA 502
ASTM Reference Documents

- ASTM E783
  - Field Measurement of Air Leakage through Installed Exterior Windows and Doors

- ASTM E1105
  - Field Determination of Water Penetration of Installed Exterior Windows, Curtain Walls and Doors by Uniform or Cyclic Static Air Pressure Difference
    - Procedure A (uniform static) used for AW Class products
    - Procedure B (cyclic static) used for other Performance Classes
THE CHAMBER SHALL NOT BE PERMITTED TO MAKE ANY CONTACT WITH THE FENESTRATION PRODUCT

CALIBRATED WATER SPRAY RACK

PRESSURE GAUGE VALVE

ALTERNATE TEST CHAMBER

INNERMOST PLANE FOR WATER PENETRATION (REFERENCE PARAGRAPH 4.3.4)

TO OUTSIDE BAROMETRIC PRESSURE

PRESSURE MEASURING DEVICE

TEST CHAMBER

EXHAUST VALVE

AIR SYSTEM

THE CHAMBER SHALL NOT BE PERMITTED TO MAKE ANY CONTACT WITH THE FENESTRATION PRODUCT

AAMA 502 Test Chamber Arrangement
AAMA 502 Air Leakage Testing

• The default air leakage for field testing is 1.5 times the applicable laboratory standard for the product type and performance class.
AAMA 502 Field Testing

• Requires testing agency to report and make adjustments for ambient conditions
• Test is performed on the entire fenestration product opening including the perimeter seals
Determining the Proper Field Water Test Pressure (WTP)

- Default field test conditions are not the same as NAFS requirements for lab testing.
- The water test pressure shall not be less than 91 Pascals (1.9 psf).
- Tests shall be conducted at a static test pressure equal to two-thirds of the tested and rated laboratory performance per AAMA/WDMA/CSA 101/I.S.2/A440.
1) Newly installed fenestration product(s) shall be field tested in accordance with AAMA 502, "Voluntary Specification for Field Testing of Newly Installed Fenestration Products."

2) Test three (unless otherwise specified) of the fenestration product specimens after the products have been completely installed for air leakage resistance and water penetration resistance as specified.

3) Air leakage resistance tests shall be conducted at a uniform static test pressure of ___ Pa (___ psf). The maximum allowable rate of air leakage shall not exceed L/s•m² (___ cfm/ft²)

4) Water penetration resistance tests shall be conducted at a static test pressure of ___Pa (___ psf). No water penetration shall occur as defined in Section 5.3.4 of AAMA 502
AAMA 503

American Architectural Manufacturers Association

AAMA 503-14 (editorially revised)

Voluntary Specification for Field Testing of Newly Installed Storefronts, Curtain Walls and Sloped Glazing Systems
Evolution of the AAMA 503 Field Testing Standard

- AAMA 503 was originally published in 1992
- AAMA 503 is a similar document to AAMA 502 for storefronts, curtain walls and sloped glazing systems
- Updated in 2003, 2008, and 2014
- AAMA 503-08 defined “newly” installed as prior to issuance of the occupancy permit, not to exceed six months after issuance of the permit
Chamber Arrangement: Storefront
Chamber Arrangement: Curtain Wall
Chamber Arrangement: Sloped Glazing Systems
AAMA 511: Forensic Investigation

AAMA 511-08

Voluntary Guideline for Forensic Water Penetration Testing of Fenestration Products

AMERICAN ARCHITECTURAL

MANUFACTURERS ASSOCIATION

• Describes methods for determining and evaluating water leakage of exterior walls
  ▪ A wall is considered a system including its exterior and interior finishes, fenestration and structural components
AAMA 511 Forensic Evaluation

- Involves more than just testing
- The purpose of diagnostic testing is to recreate water leaks that are known to occur
- AAMA 511 testing either follows up on AAMA 502 and 503 testing or is used in a water intrusion investigation
AAMA 511 Objective

“…The ultimate goal of 511 diagnostic testing is to recreate existing leakage behavior that occurs under in-service conditions.”
AAMA 511: Seven Steps

1) Review of project documents
2) Evaluation of design concept
3) Determination of service history
4) Inspection
5) Investigative Testing
6) Analysis
7) Report
AAMA 511: Step 1

Step 1: Review Project Documents

- Architectural drawings
- Structural drawings
- Shop drawings
- Installation instructions
- Contracts
- Purchase orders
- Specifications
- Warranties
AAMA 511: Step 2

Step 2: Evaluation of Design Concept

- Water management concept
- Critical details
- Test reports
- Flashing
- Sealants
- Weep holes
AAMA 511: Step 3

Step 3: Determination of Service History

- Review maintenance records
- Interview knowledgeable personnel
- Research leak history
Step 4: Inspection

- Interior observations
- Exterior observations
- Observe workmanship
- Observe product deficiency
- Develop a hypothesis for the source of the water intrusion
Testing above AAMA-Rated Performance
AAMA 511: Step 5

Determination is based on:

• Field standards
• Laboratory standards
• Prior testing
• Weather data
• Experience
AAMA 511: Step 5

- Simulate the weather events
- Obtain wind speed
- If calculated wind speed is greater than two-thirds of the rated WTP for the product, it may be that the product was not the most appropriate for the project
- At least one pressure difference test must be done at the two-thirds pressure
Using ASCE-7 to Approximate Wind Driven Rain Pressures

ASCE-7 accounts for:

• Exposure
• Height above grade
• Basic wind speed (or weather data)
• Location of specimen within façade
The objective of testing is to identify the leak paths, whether through the window or the wall.
AAMA 511 Example Case Study

• Consistent leaks for more than one year
• Heaviest leakage twice during September 2005
• Class II
• Building height is 33 feet, window (z) is 27 feet above ground
• Window is 4 feet high by 4 feet wide, wind area (A) of 16 square feet
• AAMA rating C35
### Table 3
Optional performance grades (design pressure)
(Reproduced from Clauses 4.4.2.6.2 and 4.4.3.4 of the referenced specification)

<table>
<thead>
<tr>
<th>Performance class and optional performance grades</th>
<th>Design pressure</th>
<th>Structural test pressure</th>
<th>Water penetration resistance test pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design pressure</td>
<td>Structural test pressure</td>
<td>R, LC, C, HC</td>
</tr>
<tr>
<td></td>
<td>Pa (psf)</td>
<td>Pa (psf)</td>
<td>Pa (psf)</td>
</tr>
<tr>
<td>R 20</td>
<td>960 (20.00)</td>
<td>1440 (30.00)</td>
<td>150 (3.00)</td>
</tr>
<tr>
<td>LC 25</td>
<td>1200 (25.00)</td>
<td>1800 (37.50)</td>
<td>180 (3.75)</td>
</tr>
<tr>
<td>C 30</td>
<td>1440 (30.00)</td>
<td>2160 (45.00)</td>
<td>220 (4.50)</td>
</tr>
<tr>
<td>HC 35</td>
<td>1680 (35.00)</td>
<td>2520 (52.50)</td>
<td>260 (5.25)</td>
</tr>
<tr>
<td>AW</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>
Estimating the Test Pressure

- ASCE/SEI 7-05 analysis is used with the following information:
  - Location of building (Newark, NJ)
  - Building usage designation (Class II)
  - Exposure level (Exposure B)
  - Building design (enclosed structure with a flat roof)
  - Building height (33 feet)
  - Window area (16 square feet)

- From these features, the water resistance test pressure is, theoretically, 2.4 psf
**Weather Analysis**

Local weather data is analyzed by daily readings for September 2005, allowing the investigator to observe the weather condition, amount of precipitation and maximum wind speed for each day.

<table>
<thead>
<tr>
<th>Date</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Average</th>
<th>Barometric</th>
<th>Dew Point</th>
<th>Precipitation</th>
<th>Snowfall</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
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</thead>
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<tr>
<td>1</td>
<td>68</td>
<td>46</td>
<td>52</td>
<td>15.9</td>
<td>7</td>
<td>0.1</td>
<td>22</td>
<td>16</td>
<td>21</td>
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<tr>
<td>2</td>
<td>72</td>
<td>50</td>
<td>61</td>
<td>20.1</td>
<td>8</td>
<td>0.01</td>
<td>26</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>68</td>
<td>48</td>
<td>58</td>
<td>15.5</td>
<td>7</td>
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<td>78</td>
<td>58</td>
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<td>21.5</td>
<td>9</td>
<td>0.1</td>
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<td>12</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>72</td>
<td>60</td>
<td>72</td>
<td>23.5</td>
<td>7</td>
<td>0.1</td>
<td>14</td>
<td>11</td>
<td>10</td>
</tr>
</tbody>
</table>

*Note: The table continues with more data entries.*
Recreating the Leak

Need to determine:

- How to apply water
- How long to run test
- Whether or not to include differential pressure
  - How much air pressure
  - How to step or phase pressure
  - Use of dynamic or static pressure
General Procedure

- Start testing at lower elevations and work higher
- Start with a zero pressure differential
- Step pressures up from zero appropriately
- Introduce one element at a time into each new test
- Use isolation to protect features from water spray
- Do not turn water off at first moment a leak appears
- Trace leak from exterior to interior; use destructive wall probes as required to identify leak path
- Do not end non-leaking tests until confident the specimen is not contributing to leakage
AAMA 511: Steps During and After Testing
Optional Sill Dam Test

Interior weep holes

Water shall cover all horizontal surfaces expected to be wet

Tape applied over exterior weep

Test water head measured from bottom of exterior wrap
Common Obstacles

- No or limited leak history
- Reported as window leak when from another source
- Not enough water pressure
- Not able to achieve differential pressure
- Owner does not want to remove interior finishes
- No or limited access to concealed wall areas
- Inclement weather
- Isolation failures
Identifying the Source: Brick Veneer Cavity Wall
Identifying the Source: Multiple Leaks
Identifying the Source: Cannot See Through the Wall
Identifying the Source: Cannot See Through the Wall
Identifying the Source:
Enhanced Observations
AAMA 511: Step 6

• The forensic investigator has the responsibility to make every attempt to ascertain the exact path of water intrusion

• Conclusions are formed in this step on the basis of the inspection and testing data collected in the previous steps

• If conclusions cannot be fully supported by sound scientific principles then additional investigation is needed
AAMA 511: Step 7

• All reports must be self-contained documents
• Must include justification for deviations from the methodology described in the standard
• The reports must not include any unsubstantiated opinions or conclusions
• If results are not conclusive the forensic investigator should present options for obtaining conclusive results
Questions?

Following the live webcast, to:

customerservice@aamanet.org
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Coming in Early May

AAMA National Summer Conference Highlights

Tuesday
May 5, 2015
11:30 AM - 12:00 Noon Eastern Time
COMING LATER IN MAY

UPDATE TO NFRC 713-2015

NFRC INDEPENDENT VERIFICATION PROGRAM

SCOTT HANLON, NFRC

TUESDAY
MAY 19, 2015
11:00 AM - 12:00 NOON EASTERN TIME