# LABORATORY AND FIELD EVALUATION OF PAN FLASHING/SILL PROTECTION AND WATER RESISTIVE BARRIERS

field evaluation

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# FINAL REPORT

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## April 2006

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**About the NAHB Research Center, Inc…**

The NAHB Research Center, Inc. is a not-for-profit subsidiary of the National Association of Home Builders (NAHB). The NAHB has over 205,000 members who build more than 80 percent of new American homes. NAHB Research Center, Inc. conducts research, analysis, and demonstration programs in all areas related to home building and carries out extensive programs of information dissemination and interchange among members of the industry and between the industry and the public.

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## INTRODUCTION

Water intrusion in building walls is an ongoing problem for the homebuilding industry. Intrusion can occur in all types of buildings and in most climates, often through windows, doors and other through-the-wall penetrations.

One of the most critical areas for water intrusion is below window units in typical wall assemblies. This area is often poorly addressed, detailed, and executed. To mitigate water intrusion problems, manufacturers in the past few years have introduced numerous new flashing products for homebuilders.

This project focused on managing water intrusion in residential building envelopes with a combined pan flashing/sill protection strategy. It also included a survey of all available pan flashing products, and laboratory and field evaluations of various pan flashing systems used with wood framing and sheathing.

Williams Building Diagnostics Inc. (WBD), a participant in PATH Field Evaluations, worked as a subcontractor to the NAHB Research Center (Research Center) for this study. WBD conducted the survey and the laboratory and field evaluations under direction from the Research Center.

## DEFINITIONS AND ABBREVIATIONS

**CAPs:** corner accessory pieces.

**HDPE:** flexible high-density polyethylene film.

**Pan flashing:** a water-impervious material that is installed on the sill within the rough opening of a window or door, and is lapped over a weather-resistive barrier. It is designed to direct water entering the window cavity out of the wall without penetrating the weather-resistive barrier.

**SAM:** self-adhering membrane.

**Sill protection:** a water-resistant covering provided for sills of rough openings that lacks a true pan feature.

**WRB:** water-resistive barrier.

## OBJECTIVES

The primary objectives of PATH laboratory and field evaluations are to provide the homebuilding industry with information on new technologies and techniques, and to provide feedback to homebuilders and product manufacturers to help them incorporate those technologies.

Specific objectives of this study included:

- Conducting background research to address water management technologies and techniques for exterior walls.
- Selecting a pan flashing/sill protection approach.
- Conducting laboratory and field studies to evaluate the pan flashing/sill protection approach.
- Conducting an industry-wide survey of products that address water management beneath windows.
- Promoting industry awareness of the study results.

# BACKGROUND RESEARCH

## General

WBD has more than 25 years of experience performing architectural and building diagnostic investigations that have revealed the consequences of ineffective water management in light frame construction.

While performing field investigations, WBD researchers often interact with other forensic exterior wall consultants and remedial contractors. This background research benefited from the experiences of these consultants and contractors.

Additionally, WBD conducted extensive background research for this project to assess the issue of water infiltration in exterior walls in residential buildings and to evaluate technologies and techniques for mitigating it. This included reviewing several hundred case studies from throughout the U.S. that documented water-induced deterioration in light frame construction.

## Scope of the Problem

Water intrusion is a pervasive problem for the homebuilding industry throughout the U.S. It can occur in all types of buildings and in most climates, and is not limited to a single type of exterior wall cladding.

Consultants and contractors have reported working on other projects throughout the U.S. that had experienced water intrusion and entrapment. In a recent issue of *The Journal of Light Construction*, one contractor noted that he had remediated "hundreds" of homes clad with different types of stucco systems,[1] and "at least a hundred" homes clad with other veneer.[2]

WBD's previous field investigations have revealed that water related problems can occur behind barrier-type wall claddings in mixed and humid climates. Water intrusion,

[1] McCoy, Dennis, 2003. "A Close Look At Stucco," *Journal of Light Construction* (September), at page 74.
[2] McCoy, Dennis, 2004. "Manufactured-Stone Nightmares," *Journal of Light Construction* (December), at pages 51-52.

entrapment, and deterioration can also occur behind other types of claddings on buildings in most climates.

## Zone of Weakness

The most significant area regarding water management lies within a "zone" located below window units in the typical wall assembly.

According to one estimate, 90 percent of leakage problems occur at transitions between building envelope components, such as windows, doors, and other through-the-wall penetrations, although these transitions comprise only one percent of the envelope's area.[3]

In WBD's experience, windows and their interfaces are the top leakage source. In 1997 and 1998, WBD investigated windows and exterior insulation and finish system (EIFS) claddings in 100 single-family homes in North Carolina. Approximately 45% of all moisture damage incidents originated at locations under/around windows.[4]

WBD also performed laboratory tests on standard production window mockups, with a variety of wood, clad wood, and vinyl configurations. Over three-quarters of the units failed a common field test of water penetration resistance (AAMA 502-90). A similar percentage failed another standard water penetration test that used an air pressure differential (ASTM E-547). During these tests, water intrusion often occurred at the sill/jamb condition.[5]

RDH Engineering, Ltd. recently conducted a study that analyzed approximately 240 laboratory and field tests of windows in British Columbia and eastern Canada. The study found that more than 50% of newly manufactured windows allowed water to intrude past the operable glazing during factory tests.[6] In tests of newly-installed windows, leakage occurred in 48% of units, through joints in the window itself, the interface between the window and the wall assembly, or both.

In 2003, building scientist Joe Lstiburek surveyed over 3,500 vinyl windows that were less than two years old, and found that 20 percent had already begun to leak. According to Lstiburek, "if you build a house with 20 vinyl windows, the odds are that 4 will leak right away [and] others will leak later…so we have to assume that every window leaks and build accordingly."[7]

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[3] Kubal, M.T., 1993. *Waterproofing the Building Envelope.* NY: McGraw-Hill, at page 196.
[4] Williams, M.F., and B.L. Williams, "Single Family Residences Clad with Exterior Insulation and Finish Systems (EIFS): Investigative and Remedial Update," in: *The Applicator* (Sealant, Waterproofing and Restoration Institute), Vol. 21, No. 3, Autumn 1999, at pages 2 –11.
[5] Knowledge of the undersigned.
[6] *Water Penetration Resistance of Windows – I: Study of Manufacturing, Building Design, Installation, and Maintenance Factors; II: Study of Codes, Standards, Testing, and Certification.* Vancouver, B.C.: RDH Engineering, Ltd.
[7] Lstiburek, J. 2003. "Water-Managed Wall Systems," *Journal of Light Construction* (March), at page 61.

### Causes

The zone located below window units is often poorly addressed, detailed, and executed. Additionally, in a 2003 survey conducted by the National Association of Home Builders (NAHB) and the American Society of Home Inspectors (ASHI), 92% of responding home inspectors identified poor flashing installation as a problem. Thirty-three percent of respondents noted that flashing was "missing altogether" at windows and doors.[8]

However, constructing and maintaining a perfect exterior wall surface is impossible. Even if the exterior surface is initially watertight, the barrier may degrade as it experiences precipitation, temperature cycling, solar radiation, impact damage, and movement between different building components.

### Preventive Measures

Long-term performance of exterior walls depends on a wide variety of conditions and interactions between the building's design and construction, related components (e.g., windows, doors, and louvers), and maintenance.

RDH Engineering, Ltd. recommended using "subsill drainage" for all windows.

In 2004, Lstiburek stated, "Windows and doors without pan flashing create a water injection system…[they need] pan flashing, with a back dam, end dams, and a slope to the outside."[9]

Numerous new flashing products have entered the market in the last few years that can improve this critical window/wall interface seal. In WBD's experience, the proper selection and use of exterior wall flashings and membranes, to redirect moisture away from the building interior, will improve exterior wall performance.

# PROJECT IMPLEMENTATION

WBD selected a combination pan flashing/sill protection approach to use in the laboratory and field tests. This approach used self-adhering membrane (SAM) materials and preformed HDPE CAPs, which are integrated with various water resistive barrier (WRB) materials and techniques. WBD researchers selected this approach because of their experience with the products.

## A. Small-Scale Pan Flashing (Natural Weathering, All Exposures)

This evaluation tested self-adhering flashing material and its attachment to CAPs during exposure to outdoor weather conditions, including precipitation, over a period of nine

[8] "Survey of Home Inspectors Helps Builders Identify Potential Trouble Spots," *Nation's Building News Online,* September 13, 2004. Available at www. nbnnews.com/NBN/textonly/2004-09-13/printall.html. Accessed November 23, 2005.
[9] Lstiburek, J. 2004. "Built Wrong From The Start: Top 10 Blunders That Rot Your House, Waste Your Money, and Make You Sick," *Fine Homebuilding* (April/May), at pages 52-57.

months. Sensors allowed researchers to monitor the water resistance performance of these configurations.

WBD erected four vertical plywood wall panels, each featuring several small sill pan mockups, outside its testing facility in Maple Glen, Pa. Each panel faced north, south, east or west. The sill pan mockups simulated the types of pan flashings that might be installed in a window rough opening at the sill by using two CAPs joined together with self-adhering flashing membranes. Moisture sensors were placed at the bottom of each sill pan and covered with the flashing membrane.

**Figure 1. Small-Scale Pan Flashing: Natural Weathering Panels**

**A. Overall view of panels** **B. Mid-range view** **C. Close-up view of pan installation**

**Series 1.** An initial test series, Series 1, used mockups with a single ply of self-adhering membrane applied by hand at room temperature. The mockups were exposed to outdoor weather conditions for eight weeks beginning in January 2005.

***Results.*** After five weeks, membrane wrinkling occurred in some of the mockups, allowing a small amount of water to intrude between the membrane and the substrate. WBD continued the series for another three weeks, and then terminated it due to water-intrusion caused by wrinkling. See Appendix A.

**Series 2.** A new mockup test series, Series 2, modified this approach by using two different brands of flashing membrane, both composed of a layer of rubberized asphalt combined with a flexible HDPE film, and both were approximately 20 mils thick. No differences existed between the two products, other than proprietary differences in the manufacturing process. WBD selected these two brands because of their familiarity with them.

Each plywood wall panel featured four sill pan mockups, each with a different configuration:

- Configuration A = CAPs with one layer of membrane applied at room temperature.
- Configuration B = CAPs with two layers of membrane applied at room temperature.

- Configuration C = CAPs with one layer of membrane applied with aid of a heat gun.
- Configuration D = CAPs with one layer of membrane applied over a primer.

Testing began in March 2005. WBD conducted weekly observations for 37 weeks, recording average weather conditions for each seven-day period and obtaining moisture readings from the sensors with a Delmhorst moisture meter.

***Results.*** See Appendix B for weekly weather conditions and moisture readings.

During weeks 1 and 2, no elevated moisture levels occurred in any of the mockups. In weeks 3-7, patterns of elevated moisture readings occurred in some of the mockups (see Appendix B). Moisture readings above 20 percent, which are associated with mold growth and other deterioration of wood products, occurred mostly in configurations A and B, particularly those facing south, east, and west.

During weeks 1-7, more high readings occurred in the second membrane product than the first (see Table 1), indicating that the first product is more resistant to moisture intrusion than the second. However, this disparity between the two products disappeared after seven weeks, and all mockup readings for both membrane products returned to “dry” levels (between 6% and 8%) and remained at these low levels for the remaining 30 weeks.

The data also showed that membranes performed best when sealed with a heat gun or a primer, as in configurations C and D. These results indicate that a single layer of membrane will likely provide sufficient watertight performance if sealed with a heat gun or primer.

Self-adhering membranes sometimes develop “wrinkles” after being applied to the substrate and wrinkling can form pathways for water intrusion. Wrinkling occurred more often when the product was applied 1) without use of a roller, 2) without a primer, or 3) without supplementary heat. However, the pathways caused by wrinkling had little effect after an initial period, once the membranes had a chance to become further bonded to the substrate. Two membrane layers, one applied atop the other, as in configuration B, can provide additional protection.

**Table 1. Field Test 1, Series 2.**
**Weeks 1-7: Number of high moisture readings**
**(over 20%) by configuration.**

| Configuration | No. of High Readings: Total | No. of High Readings: Product 1 | No. of High Readings: Product 2 |
|---|---|---|---|
| **A** | 24 | 6 | 18 |
| **B** | 17 | 2 | 15 |
| **C** | 0 | 0 | 0 |
| **D** | 0 | 0 | N/A |
| **All** | 41 | 8 | 33 |

## B. Full-Scale Window/Wall Chamber (Natural Weathering, West Exposure)

In February 2005, WBD constructed a full-scale window/wall chamber at its facility to investigate how pan flashing/sill protection approaches work together under real-world conditions. The chamber allowed researchers to test assemblies in an accurate window/wall construction, while still giving them full access to inspect and evaluate performance.

**Figure 2. Full-Scale Window Wall Chamber**

Construction of the mockup chamber included painted gypsum wallboard, wood studs, fiberglass batt insulation, OSB sheathing, and a wood floor deck, with a climate controlled interior. The steep sloped roof ended near the face of the exterior wall, with no projecting roof overhang. This allowed rainwater runoff to sheet down the exterior face of the mockup's wall and window assemblies.

On the west-facing wall, WBD installed four complete window/wall test assemblies: Panels A, B, C, and D. The panels offered four sets of typical conditions, by combining two different window installation methods with two different window types and two different WRB types (see Table 2).

Researchers could access the back of each panel from inside the chamber to inspect for water intrusion.

**Results.** The interior of the chamber was visually inspected over a period of 37 weeks. No evidence of water intrusion appeared in any of the panels over this period. For weather conditions over this period, see Appendix C.

**Table 2. Panel Treatments**

| **Installation Method #1**<br>**Panels A and C**<br>**WRB installed before window unit** | **Installation Method #2**<br>**Panels B and D**<br>**Window unit installed before WRB** |
|---|---|
| 1. Install sill protection:<br>a.) Place sill wedge for slope.<br>b.) Apply self adhering membrane sill apron (extends 6" over sheathing below sill).<br>c.) Install 2 CAPs (1 at each sill/jamb corner).<br>d.) Create sill pan and integrate with CAPs with additional membrane strips.<br>2. Install WRB on sheathing, wrap into rough opening.<br>3. Install window unit with flange clips at sill<br>4. Tape WRB to window flanges. | 1. Install sill protection:<br>a.) Place sill wedge for slope.<br>b.) Apply self adhering membrane sill apron (extends 6" over sheathing below sill).<br>c.) Install 4 CAPs (1 at each corner of rough opening).<br>d.) Create sill pan and integrate with CAPs with additional membrane strips.<br>2. Install window unit with flange clips at sill<br>3. Install WRB on sheathing.<br>4. Tape window flanges to WRB. |

| **Window Type #1** | **Window Type #2** |
|---|---|
| Full-depth vinyl single hung flanged window | Partial-depth vinyl single hung flanged window |

| | **Panel A** | **Panel B** | **Panel C** | **Panel D** |
|---|---|---|---|---|
| **Installation Method #:** | 1 | 2 | 1 | 2 |
| **Window Type #:** | 1 | 1 | 2 | 2 |
| **WRB:** | Self-adhering membrane WRB (40 mil) | Self-adhering membrane WRB (40 mil) | Housewrap WRB | Housewrap WRB ("I" cut at window opening) |

## C. Additional Mockup Testing

WBD is currently working with a team of investigators at the Canadian National Research Council's Institute for Research in Construction (NRC/IRC) for a program entitled, "Evaluating the Effectiveness of Wall/Window Interface Details to Manage Rainwater."

This project involves testing full-scale wall/window/component mockups in NRC/IRC's state-of-the-art Wall Test Facility in Ottawa. Preliminary results demonstrated that pan flashing and drainage mediums are very useful components for managing unwanted water in wall assemblies, provided that these components are properly integrated with the water resistive barrier.

Additional testing is underway and a detailed summary of observations will be available in 2007.

## D. Field Evaluations

WBD also monitored reconstruction of two case study buildings—a single-family residence and a small-scale health care facility—that had experienced water-related deterioration.

Both structures are in southeastern Pennsylvania, a temperate (mixed/humid) climate zone. The area experiences approximately 4,900 heating degree days and approximately 41 inches of precipitation, including 28 inches of snow, per year. Average monthly winter exterior air temperatures fall below 45° F (7.2° C).

### D1. Field Trial, Ambler, PA

This project consisted of retrofitting and monitoring a single-family residence that had experienced water intrusion.

**Figure 3. Field Investigation. Single-family Residence in Ambler, PA**

The two-story home was built in 1996 and has an attached garage. Prior to remediation, its front elevation was clad with stucco and manufactured stone veneer. The home's underlying wall construction includes oriented strand board (OSB) sheathing attached to wood stud framing, and a WRB installed over the sheathing. The windows are extruded vinyl, single hung, and have insulated glazing. The roof is covered with asphalt shingles and features aluminum gutters and downspouts.

In 2004, the homeowner reported water intrusion near some of the home's windows. During the course of corrective repairs, contractors found additional evidence of water intrusion, entrapment, and material deterioration in the exterior wall.

Further investigation revealed that water had entered the wall assembly primarily at window penetrations. Windows did not include pan flashing or other sill protection, and the WRB had not been wrapped into the rough openings prior to window installation. These omissions had apparently allowed water to penetrate behind the WRB, where it became trapped between the WRB and the OSB sheathing in several locations.

The sheathing had moderate to severe deterioration originating primarily at window corners. Moisture-related damage occurred below many windows, most notably on those at the first floor level, where rot had damaged the sheathing and some of the wood wall and floor structural members beneath the windows.

Remediation began in November 2004. Contractors:

- Removed and discarded all existing cladding (stucco and manufactured stone veneer), lath, and WRB materials;
- Removed and set aside existing windows for reuse;
- Replaced deteriorated exterior sheathing and framing components;
- Installed a new WRB layer over the sheathing, and integrated it with rough opening flashings; secured the edges of the WRB with fasteners and then wrapped it with SAM;
- Equipped each opening with a sill pan flashing system consisting of a sill wedge, CAPs, and SAM;
- Reinstalled windows into the wrapped rough openings—this included:
    - Installing a proprietary spacer material drainage mat immediately below the sill of the rough opening prior to reinstalling the window to allow the sill pan to drain;
    - Fastening the window mounting flange through the strip of drainage medium at this location, leaving a slot for water to escape; and
    - Fastening the remaining perimeter mounting flanges to the sheathing and sealing them with additional SAM;
- Installed a weep screed at the bottom sheathing termination of the wall and flashed it with additional SAM;

- Placed a drainage mat over the entire wall surface;
- Installed a second WRB over the drainage mat;
- Installed metal lath, followed by a stucco scratch coat;
- Finished the wall with stucco or manufactured stone veneer.

WBD implanted four sensor wires, Sensors 1-4, in the edge of the replacement sheathing below the left and right jamb/sill corners on the two ground-floor windows. This allowed for long-term monitoring of moisture penetration at the sheathing plane. Using a moisture meter connected to the sensors, researchers obtained moisture readings weekly (typically after the most significant weather event) for 40 weeks, from November 21, 2004 until September 3, 2005.

In September 2005, WBD added ten additional sensors to the front elevation of the project. Researchers obtained moisture readings from these sensors and the original four sensors for an additional 11 weeks, from September 4 to November 19, 2005.

The original series, Sensors 1-4, remained below ground-floor window corners in the stucco wall area of the home, located on the south end of the east elevation. WBD placed new sensors 5-10 at second-floor windows within the manufactured stone veneer wall area, and new sensors 11-14 below the first floor garage windows, in the stucco clad wall.

**Results.** None of the sensors recorded any water intrusion at any location, and neither the homeowner nor project personnel noticed any evidence of water intrusion during visual observations. Refer to the data tables in Appendix D.

### D2. Field Trial, Eagleville, PA

This project consisted of retrofitting and monitoring a health care facility. The structure had experienced water intrusion at numerous locations in the exterior walls and windows, which damaged studs and interior finishes.

The facility was constructed in the early 1990s. Its exterior walls consist of barrier EIFS on steel stud framing and its roofs were either standing seam metal construction or low-slope membrane systems.

Remediation, which began in September 2004 and was completed in February 2005, included removing existing barrier EIFS and installing a drainable EIFS design. Contractors:

- Mechanically attached metal lath to a self-adhering membrane WRB to provide a drainage plane over fiberglass-faced gypsum sheathing;
- Removed existing windows, and wrapped WRB into the rough openings;
- Installed sill wedges for slope, CAPs, and pan-flashing membrane at sills;
- Reinstalled windows, and installed flashing with weeps at window heads.

WBD installed Sensors 1-16 at eight windows on the north elevation and Sensors 17-24 at four windows on the west elevation. Each window received two sensors. Sensor #12 on the north elevation malfunctioned and provided no data, resulting in data collection from 23 sensors. WBD installed each sensor on the sheathing plane directly below the window corners. WBD researchers continue to obtain moisture readings weekly.

The sensors allowed monitoring of moisture penetration at the windows for 41 weeks between December 19, 2004 and November 19, 2005. During the week of December 9, 2004, data was only available from the west elevation sensors; and during the week of January 9, 2005, data was only available from north elevation sensors. Otherwise, weekly readings are available for both elevations (See Appendix D).

**Figure 4. Field Investigation. Health Care Facility in Eagleville, PA**

**Results.** No sensors recorded any water intrusion, and neither the building's owner nor project personnel observed any evidence of water intrusion. Refer to the data tables in Appendix D.

## E. Cost Analysis

The product survey matrix (see Appendix E) includes 23 pan flashing/sill protection products. The approximate retail cost of these products ranges from $6.00 to $20.00 per unit, and each involves minimal labor to install.

According to a 2003 survey by the NAHB, a 2,085 sf single-family home includes an average of 15 windows.

At an approximate product first cost of $10/unit, 15 windows will cost $150 for materials. Each product takes about 20 minutes to install, so 15 windows will require 5 hours to prepare all window openings. At an estimated labor cost of $35 per hour, installation will cost $175 for labor. Therefore, the average cost for this example is $150 for materials and $175 for labor, for a total of $325 ($21.67 per window).

This first cost is worthwhile considering the potential costs of structural damage, mold growth, remediation work, and litigation. Typical water-related repair costs for a single family home can be over $40,000. Such costs would be correspondingly higher in commercial construction, based upon larger buildings and a greater scope of work.

## CONCLUSIONS

1. **Water intrusion problems can occur in any type of building, and in most climates.** Windows, doors, and louvers are an ongoing source of water intrusion, for many different reasons.
2. **The risk of water intrusion can be reduced by using durable pan flashing/sill protection products, in conjunction with other water management techniques.** Many such products have come on the market in the last few years, providing a wide range of materials and cost levels.

   The pan flashing system evaluated in this study demonstrated successful performance in all three modes:

   - Small-scale pan flashing evaluation: all mockups in this series have remained watertight, although sensors have recorded some minor fluctuations in moisture readings.
   - Full-scale window/wall chamber evaluation: to date, no water intrusion has been observed within any portion of the full-scale window/wall chamber.
   - Field investigations: the pan flashing/sill protection assemblies used in the field evaluations have performed satisfactorily over several months of exposure to indoor/outdoor conditions.
3. **The first cost of pan flashing/sill protection installation is worthy of consideration given the potential costs of structural damage, mold growth, remediation work, and litigation.** An estimated average first cost for a home with 15 windows is $150 for materials and $175 for labor, for a total of $325, or $21.67 per window.
4. **Following certain steps during installation can enhance water penetration resistance performance.** These steps include carefully integrating pan flashings with other wall components; adding redundancy in self adhering membrane layers;

incorporating slope to the sill pans; and using supplementary heat or a primer to improve adhesion of membrane products.

## RECOMMENDATIONS

As a result of this study, the NAHB Research Center and Williams Building Diagnostics offer several recommendations.

1. **Use pan flashing/sill protection approaches to help protect structures against water damage.** Although it is impossible to build and maintain a perfect exterior wall surface, pan flashing/sill protection approaches have demonstrated their effectiveness in preventing water intrusion at the critical area below window units in typical wall assemblies. The additional cost of installing pan flashing/sill protection approaches is only a small fraction of the potential costs for remediating damage caused by water intrusion.
2. **Carefully integrate pan flashings with other wall components.**
3. **Add redundancy in self adhering membrane layers.** Although one layer may be sufficient, adding redundancy adds additional protection.
4. **Incorporate slope to the sill pans.** This allows water to drain away from the wall.
5. **Use supplementary heat or a primer when applying membrane products.** These techniques help improve adhesion of the membrane to the substrate.

**Additional Industry Recommendations and Considerations.** Additionally, many members of the building community are aware of the need for a comprehensive approach to managing water in the building enclosure. Some members of the window industry have responded proactively to the challenge of managing unwanted water in and around window units. The “Installation Masters” training program, initiated by the American Architectural Manufacturers Association (AAMA) in 2000, recommends the use of pan flashings beneath various types of windows.

Some window manufacturers recommend using pan flashing with their products, whereas others simply recommend flashing without specifying the important upturned leg configuration to protect the underlying construction. The ASTM E-2112-01, *Standard Practice for Installation of Exterior Windows, Doors and Skylights*, a significant advance in raising user awareness, recommends the use of sill pans with various types of windows.

Building Codes may need to further address the issue of water intrusion through the exterior building envelope. Certain flashing requirements set forth in the 1999 BOCA National Building Code (Section 1406.3.10) directed that flashing beneath sills include an “upturned leg on the interior side and at the ends of the flashing” to prevent water from flowing off the flashing into the wall assembly. However, the “upturned leg” requirement was not included in the 2000 and 2003 International Building Code (Section 1405.3) and the 2000 and 2003 International Residential Building Code (Section R703.8). Although the 2000 and 2003 IRC exempted "flanged/self-flashing" windows from the requirement for additional flashing (Section R703.8.1), amendments to the 2006 IRC will no longer exempt these "flanged" windows. While the new language requires additional measures, it still does not clearly state how to accomplish the overall objective.

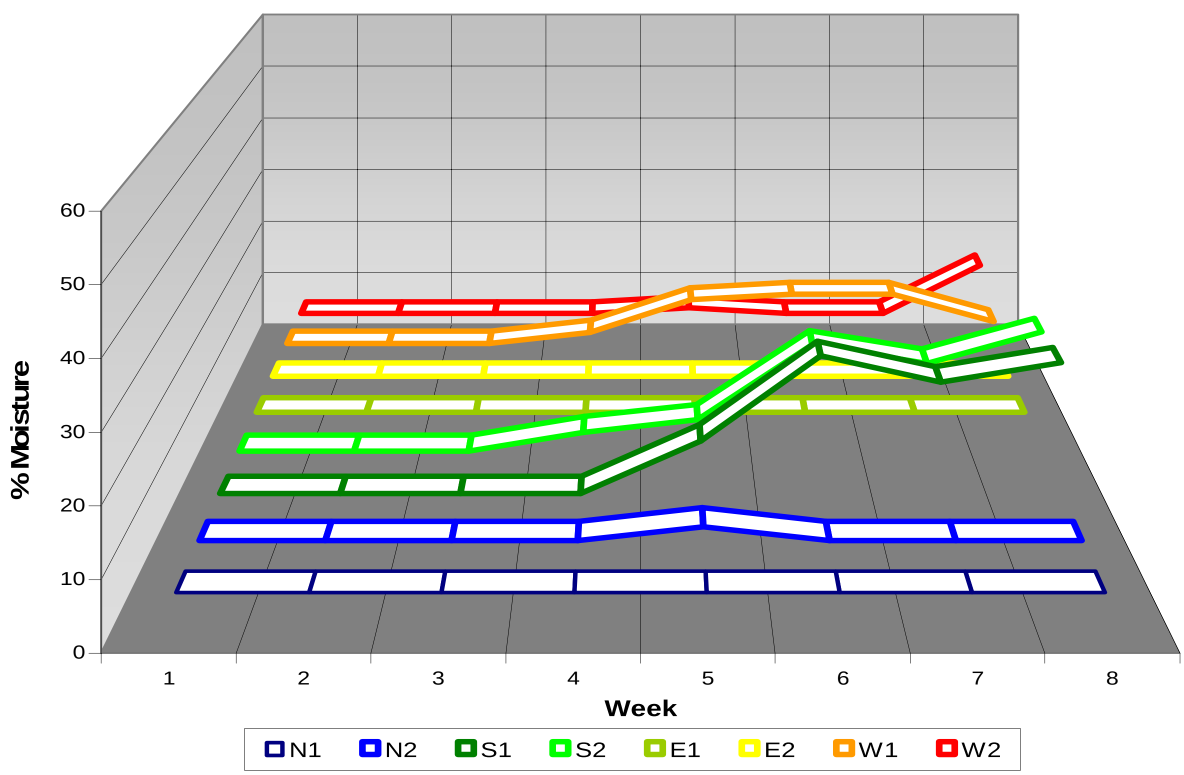
# APPENDIX A
## DATA – SMALL SCALE PAN FLASHING – EXTERIOR WEATHERING (SERIES 1)
## Data as of March 9, 2005

Mockup Type "A" = Corner Accessory Pieces (CAPs) with
1 layer of membrane applied at room temperature.

**WEATHER CONDITIONS: MAPLE GLEN, PA**

| WEEK (Date Sampled) Jan. 16 – Mar. 9, 2005 | | PRECIP | PRECIPITATION TYPE (# Days during Week) | | | | | | HUMIDITY | AVG TEMP HIGH/LOW °F (°C) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | RAIN | TSTORM | RAIN/ TSORM | RAIN/ FOG | FOG | RAIN/ SNOW/ FOG | | |
| 1 | 1/16-1/22 (1/21) | 0.17" | 1 | 0 | 0 | 0 | 0 | 1 | 24-100% | 14/44° (-10/6°) |
| 2 | 1/23-1/29 (1/26) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26-69% | 29/45°(-1/7°) |
| 3 | 1/30 –2/5 (2/3) | 0.69" | 0 | 0 | 0 | 1 | 0 | 0 | 31-97% | 35/46° (1/7°) |
| 4 | 2/6-2/12 (2/10) | 3.17" | 1 | 0 | 0 | 3 | 0 | 0 | 30-100% | 40/55° (4/12°) |
| 5 | 2/13-2/19 (2/17) | 0.18" | 3 | 0 | 0 | 0 | 0 | 0 | 20-100% | 46/67° (8/16°) |
| 6 | 2/20-2/26 (2/24) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21-79% | 36/61° (3/16°) |
| 7 | 2/27-3/5 (3/2) | 0.42" | 2 | 0 | 1 | 0 | 0 | 0 | 57-100% | 50/70° (9/21°) |
| 8 | 3/6-3/12 (3/9) | 0.02" | 2 | 0 | 0 | 1 | 0 | 0 | 25-100% | 45/58° (7/14°) |

**Small-Scale Pan Flashing: Exterior Weathering Series 1**



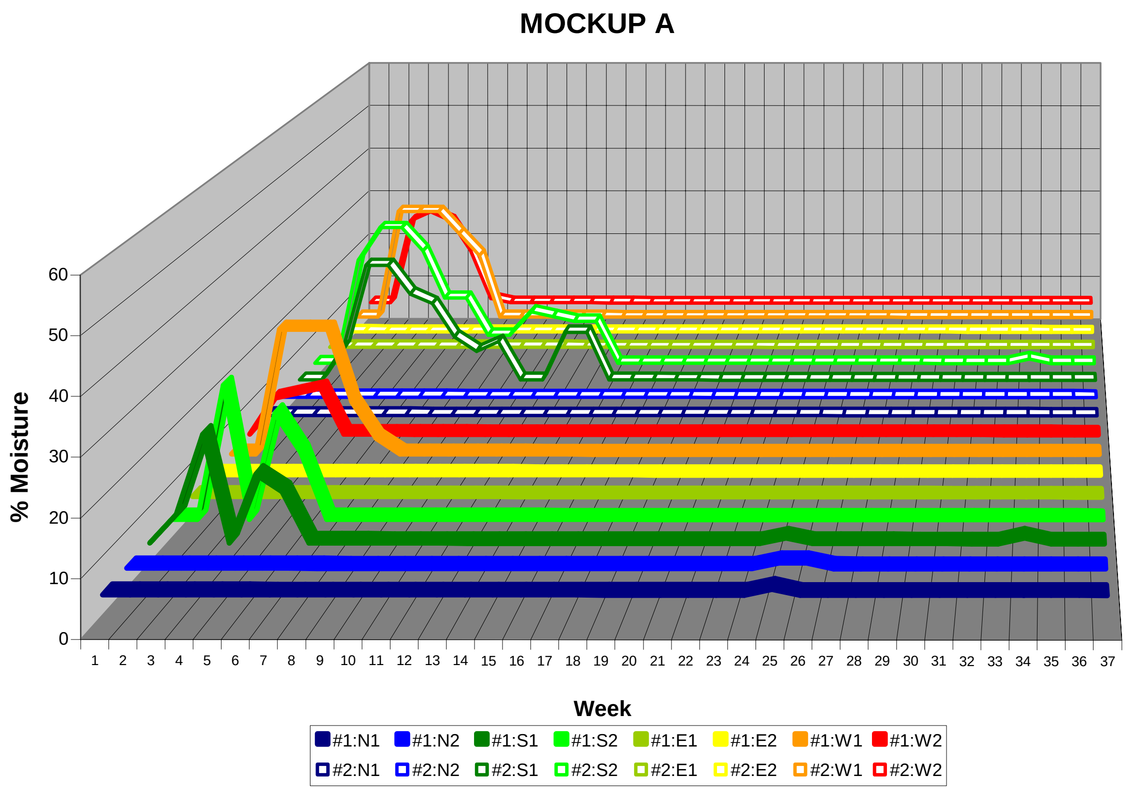
# APPENDIX B
# DATA – SMALL SCALE PAN FLASHING EXTERIOR WEATHERING (SERIES 2)

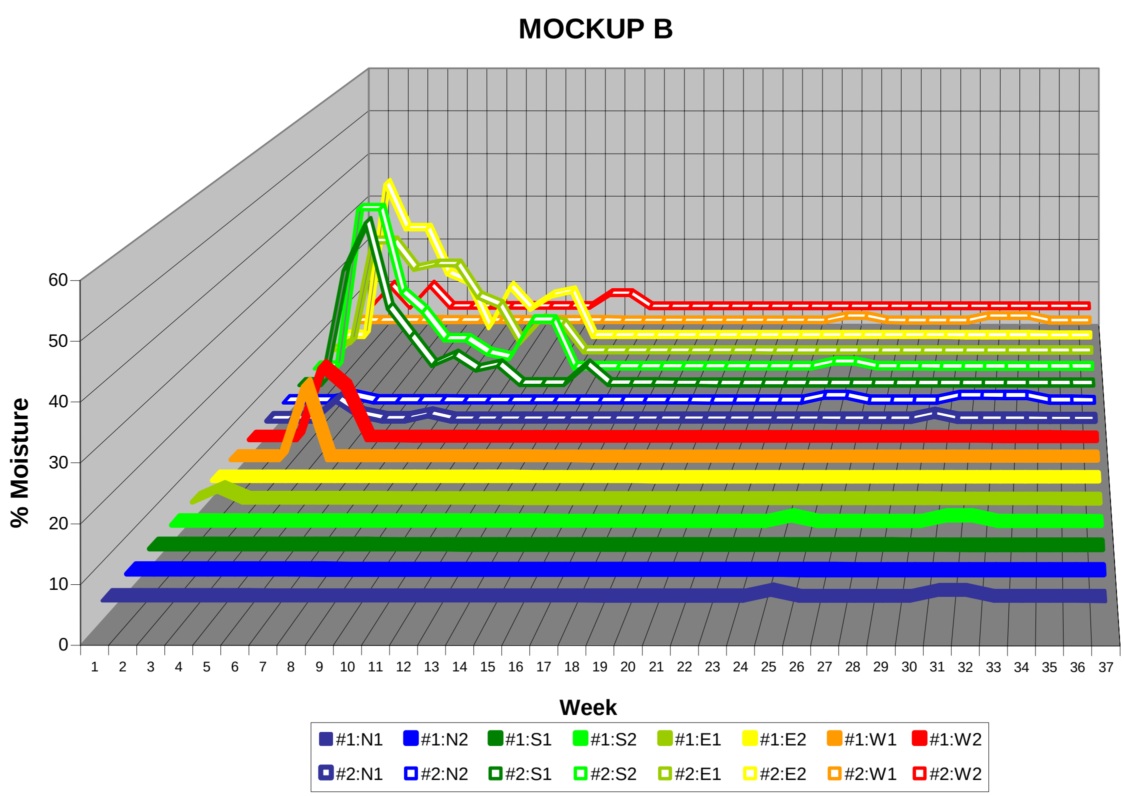
## Data as of November 18, 2005

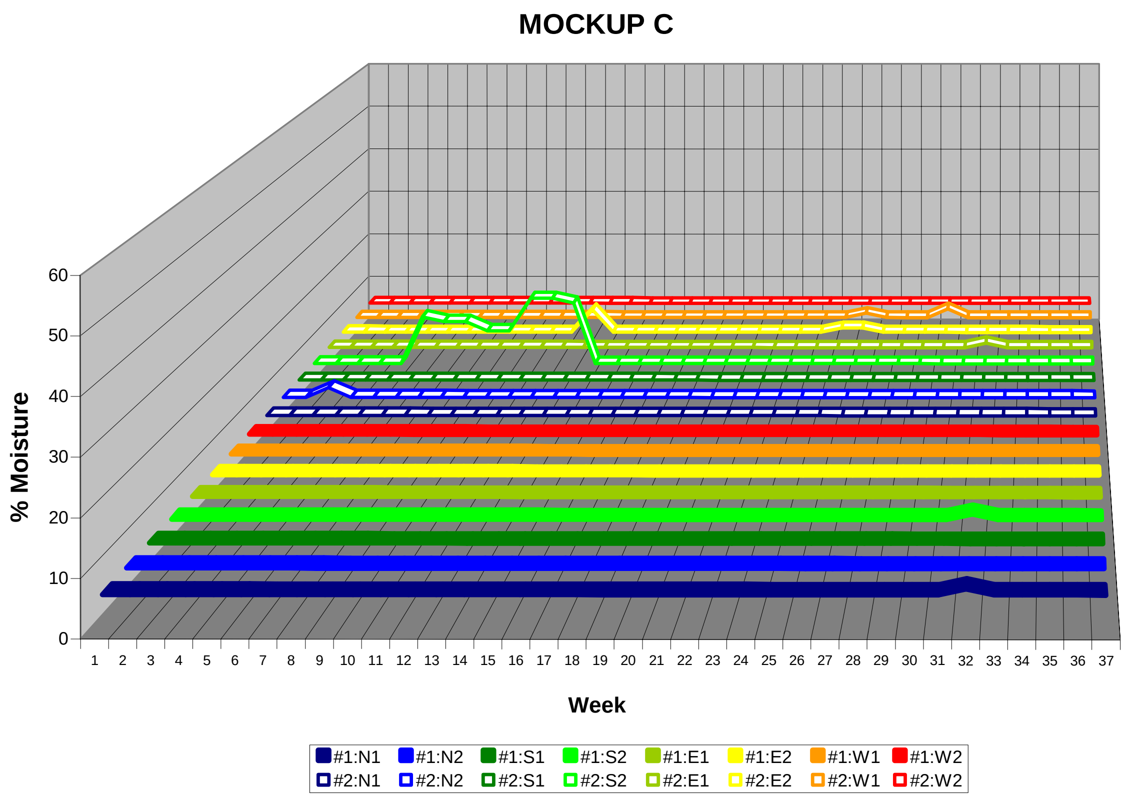
Mockup Type "A" = CAPs with 1 layer of membrane applied at room temperature.
Mockup Type "B" = CAPs with 2 layers of membrane applied at room temperature.
Mockup Type "C" = CAPs with 1 layer of membrane applied with aid of a heat gun.
Mockup Type "D" = CAPs with 1 layer of membrane applied over a primer.

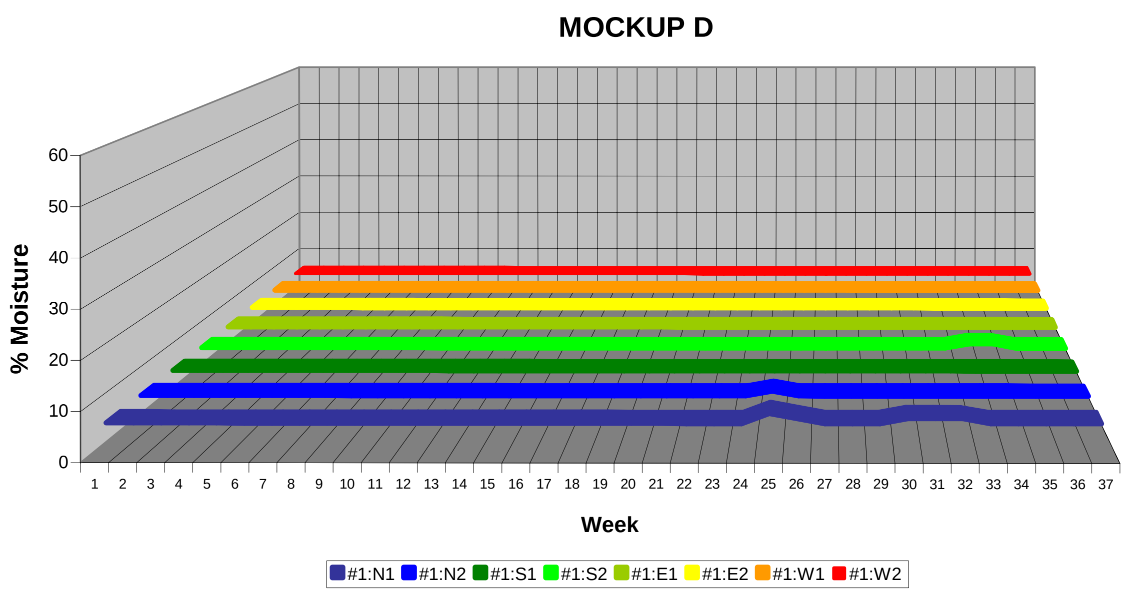
**WEATHER CONDITIONS: MAPLE GLEN, PA**

| WEEK (Date Sampled) Mar. 6-Nov.19, 2005 | | PRECIP | PRECIPITATION TYPE (# Days during Week) | | | | | | HUMIDITY | AVG TEMP HIGH/LOW °F (°C) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | RAIN | TSTORM | RAIN/ TSORM | RAIN/ FOG | FOG | RAIN/ SNOW/ FOG | | |
| 1 | 3/6-3/12 (3.10) | 0.17" | 1 | | | | | 1 | 24-100% | 14/44° (-10/6°) |
| 2 | 3/13-3/19 (3.17) | 0 | | | | | | | 26-69% | 29/45°(-1/7°) |
| 3 | 3/20-3/26, (3.25) | 0.69" | | | | 1 | | | 31-97% | 35/46° (1/7°) |
| 4 | 3/27 – 4/2 (4.1) | 3.17" | 1 | | | 3 | | | 30-100% | 40/55° (4/12°) |
| 5 | 4/3 – 4/9 (4.7) | 0.18" | 3 | | | | | | 20-100% | 46/67° (8/16°) |
| 6 | 4/10 – 4/16 (4.13) | 0 | | | | | | | 21-79% | 36/61° (3/16°) |
| 7 | 4/17 – 4/23 (4.21) | 0.42" | 2 | | 1 | | | | 57-100% | 50/70° (9/21°) |
| 8 | 4/24 – 4/30 (4.27) | 0.02" | 2 | | | 1 | | | 25-100% | 45/58° (7/14°) |
| 9 | 5/1 – 5/7 (5.3) | 0 | 2 | | | 1 | | | 32-94% | 43/59° (6/15°) |
| 10 | 5/8 – 5/14 (5.13) | 0 | 1 | | | | | | 25-93% | 48/73°(9/22°) |
| 11 | 5/15-5/21 (5.19) | 0.56" | 3 | | | | | | 31-91% | 49/67° (9/19°) |
| 12 | 5/22 – 5/28 (5.23) | 0.14" | 3 | 1 | | | | | 31-93% | 51/66° (10/18°) |
| 13 | 5/29 – 6/4 (6.3) | 0.67" | 1 | | | | | | 36-100% | 54/72° (12/22°) |
| 14 | 6/5 – 6/11 (6.10) | 0.69" | 2 | 2 | | | | | 35-96% | 68/87° (20/30°) |
| 15 | 6/12 – 6/18 (6.17) | 0 | 1 | | | | | | 37-93% | 67/82° (19/27°) |
| 16 | 6/19 – 6/25 (6.23) | 0.01" | 1 | 1 | | | | | 30-93% | 59/76° (14/24°) |
| 17 | 6/26 – 7/2 (6.28) | 1.01" | 2 | 2 | | | | | 38-100% | 71/84° (21/28°) |
| 18 | 7/3 – 7/9 (7.7) | 1.10" | 1 | 2 | | | | | 41-97% | 68/78° (20/25°) |
| 19 | 7/10 – 7/16 (7.15) | 1.66" | 1 | 1 | | | | | 30-96% | 70/86° (21/29°) |
| 20 | 7/17 – 7/23 (7.22) | 1.11" | 1 | 1 | | | | | 31-100% | 73/88° (22/30°) |
| 21 | 7/24 – 7/30 (7.29) | 0.15" | | | 2 | | 1 | | 33-100% | 69/86° (20/29°) |
| 22 | 7/31 – 8/6 (8.2) | 0 | | | | | | | 35-100% | 71/88° (21/30°) |
| 23 | 8/7 – 8/13 (8.12) | 0.02" | 3 | 1 | | | | | 45-100% | 72/86° (22/29°) |
| 24 | 8/14 – 8/20 (8.19) | 0.08" | 3 | 1 | | | | | 39-96% | 68/82° (19/27°) |
| 25 | 8/21 – 8/27 (8.26) | 0 | 1 | | | | | | 31-94% | 63/82° (19/27°) |
| 26 | 8/28 – 9/3 (8.31) | 0.35" | 3 | | | 1 | | | 51-100% | 68/83° (19/28°) |
| 27 | 9/4 – 9/10 (9.8) | 0 | | | | | | | 24-94% | 60/80° (15/26°) |
| 28 | 9/11 – 9/17 (9.16) | 0.03" | 3 | | | | 1 | | 29-100% | 66/84° (18/28°) |
| 29 | 9/18 – 9/24 (9.22) | 0 | | | | | | | 24-90% | 63/82° (17/27°) |
| 30 | 9/25 – 10/1 (9.28) | 0.16" | 2 | | | | | | 28-94% | 54/74° (11/23°) |
| 31 | 10/2 – 10/8 (10.6) | 0.28" | 2 | | | | 1 | | 48-100% | 62/71° (16/21°) |
| 32 | 10/9 – 10/15 10.10) | 0.20" | 4 | | | | | | 44-100% | 56/62° (13/16°) |
| 33 | 10/16 – 10/22 (10.17) | 0.17" | 1 | | | | | | 37-90% | 51/61° (10/16°) |
| 34 | 10/23 – 10/29 (10.26) | 0.31" | 1 | | | | | | 41-96% | 40/49° (4/9°) |
| 35 | 10/30 – 11/5 (11.2) | 0 | | | | | | | 21-86% | 47/64° (7/17°) |
| 36 | 11/6 – 11/12 (11.10) | 0.01" | 2 | 1 | | | | | 36-100% | 46/60° (8/15°) |
| 37 | 11/13 – 11/19 (11.18) | 0.30 | 1 | | | | | | 26-93% | 41/54° (5/12°) |


MOCKUP A
% Moisture
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Week
#1:N1 #1:N2 #1:S1 #1:S2 #1:E1 #1:E2 #1:W1 #1:W2
#2:N1 #2:N2 #2:S1 #2:S2 #2:E1 #2:E2 #2:W1 #2:W2


MOCKUP B
% Moisture
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Week
#1:N1 #1:N2 #1:S1 #1:S2 #1:E1 #1:E2 #1:W1 #1:W2
#2:N1 #2:N2 #2:S1 #2:S2 #2:E1 #2:E2 #2:W1 #2:W2


MOCKUP C
% Moisture
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Week
#1:N1 #1:N2 #1:S1 #1:S2 #1:E1 #1:E2 #1:W1 #1:W2
#2:N1 #2:N2 #2:S1 #2:S2 #2:E1 #2:E2 #2:W1 #2:W2


MOCKUP D
% Moisture
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Week
#1:N1 #1:N2 #1:S1 #1:S2 #1:E1 #1:E2 #1:W1 #1:W2

# APPENDIX C
# DATA – FULL SCALE WINDOW/WALL CHAMBER

## DATA AS OF NOVEMBER 18, 2005

This evaluation included four complete window/wall test assemblies (Panels A, B, C, and D). No evidence of water intrusion appeared in any of the panels. Consequently, this Appendix does not include a chart of the results.

**WEATHER CONDITIONS: MAPLE GLEN, PA**

| WEEK (Date Sampled) Mar. 6 – Nov. 19, 2005 | | PRECIP | PRECIPITATION TYPE (# Days during Week) | | | | | | HUMIDITY | AVG TEMP HIGH/LOW °F (°C) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | RAIN | TSTORM | RAIN/ TSORM | RAIN/ FOG | FOG | RAIN/ SNOW/ FOG | | |
| 1 | 3/6-3/12 (3.10) | 0.17” | 1 | | | | | 1 | 24-100% | 14/44° (-10/6°) |
| 2 | 3/13-3/19 (3.17) | 0 | | | | | | | 26-69% | 29/45°(-1/7°) |
| 3 | 3/20-3/26, (3.25) | 0.69” | | | | 1 | | | 31-97% | 35/46° (1/7°) |
| 4 | 3/27 – 4/2 (4.1) | 3.17” | 1 | | | 3 | | | 30-100% | 40/55° (4/12°) |
| 5 | 4/3 – 4/9 (4.7) | 0.18” | 3 | | | | | | 20-100% | 46/67° (8/16°) |
| 6 | 4/10 – 4/16 (4.13) | 0 | | | | | | | 21-79% | 36/61° (3/16°) |
| 7 | 4/17 – 4/23 (4.21) | 0.42” | 2 | | 1 | | | | 57-100% | 50/70° (9/21°) |
| 8 | 4/24 – 4/30 (4.27) | 0.02” | 2 | | | 1 | | | 25-100% | 45/58° (7/14°) |
| 9 | 5/1 – 5/7 (5.3) | 0 | 2 | | | 1 | | | 32-94% | 43/59° (6/15°) |
| 10 | 5/8 – 5/14 (5.13) | 0 | 1 | | | | | | 25-93% | 48/73°(9/22°) |
| 11 | 5/15-5/21 (5.19) | 0.56” | 3 | | | | | | 31-91% | 49/67° (9/19°) |
| 12 | 5/22 – 5/28 (5.23) | 0.14” | 3 | 1 | | | | | 31-93% | 51/66° (10/18°) |
| 13 | 5/29 – 6/4 (6.3) | 0.67” | 1 | | | | | | 36-100% | 54/72° (12/22°) |
| 14 | 6/5 – 6/11 (6.10) | 0.69” | 2 | 2 | | | | | 35-96% | 68/87° (20/30°) |
| 15 | 6/12 – 6/18 (6.17) | 0 | 1 | | | | | | 37-93% | 67/82° (19/27°) |
| 16 | 6/19 – 6/25 (6.23) | 0.01” | 1 | 1 | | | | | 30-93% | 59/76° (14/24°) |
| 17 | 6/26 – 7/2 (6.28) | 1.01” | 2 | 2 | | | | | 38-100% | 71/84° (21/28°) |
| 18 | 7/3 – 7/9 (7.7) | 1.10” | 1 | 2 | | | | | 41-97% | 68/78° (20/25°) |
| 19 | 7/10 – 7/16 (7.15) | 1.66” | 1 | 1 | | | | | 30-96% | 70/86° (21/29°) |
| 20 | 7/17 – 7/23 (7.22) | 1.11” | 1 | 1 | | | | | 31-100% | 73/88° (22/30°) |
| 21 | 7/24 – 7/30 (7.29) | 0.15” | | | 2 | | 1 | | 33-100% | 69/86° (20/29°) |
| 22 | 7/31 – 8/6 (8.2) | 0 | | | | | | | 35-100% | 71/88° (21/30°) |
| 23 | 8/7 – 8/13 (8.12) | 0.02” | 3 | 1 | | | | | 45-100% | 72/86° (22/29°) |
| 24 | 8/14 – 8/20 (8.19) | 0.08” | 3 | 1 | | | | | 39-96% | 68/82° (19/27°) |
| 25 | 8/21 – 8/27 (8.26) | 0 | 1 | | | | | | 31-94% | 63/82° (19/27°) |
| 26 | 8/28 – 9/3 (8.31) | 0.35” | 3 | | | 1 | | | 51-100% | 68/83° (19/28°) |
| 27 | 9/4 – 9/10 (9.8) | 0 | | | | | | | 24-94% | 60/80° (15/26°) |
| 28 | 9/11 – 9/17 (9.16) | 0.03” | 3 | | | | | | 29-100% | 66/84° (18/28°) |
| 29 | 9/18 – 9/24 (9.22) | 0 | | | | | | | 24-90% | 63/82° (17/27°) |
| 30 | 9/25 – 10/1 (9.28) | 0.16” | 2 | | | | | | 28-94% | 54/74° (11/23°) |
| 31 | 10/2 – 10/8 (10.6) | 0.28” | 2 | | | | | | 48-100% | 62/71° (16/21°) |
| 32 | 10/9 – 10/15 10.10) | 0.20” | 4 | | | | | | 44-100% | 56/62° (13/16°) |
| 33 | 10/16 – 10/22 (10.17) | 0.17” | 1 | | | | | | 37-90% | 51/61° (10/16°) |
| 34 | 10/23 – 10/29 (10.26) | 0.31” | 1 | | | | | | 41-96% | 40/49° (4/9°) |
| 35 | 10/30 – 11/5 (11.2) | 0 | | | | | | | 21-86% | 47/64° (7/17°) |
| 36 | 11/6 – 11/12 (11.10) | 0.01” | 2 | | | | | | 36-100% | 46/60° (8/15°) |
| 37 | 11/13 – 11/19 (11.18) | 0.30 | 1 | | | | | | 26-93% | 41/54° (5/12°) |

# APPENDIX D
# DATA – AMBLER & EAGLEVILLE FIELD TRIALS
## D.1. Field Trials - Ambler, PA
## Data as of November 18, 2005

Exterior Wall Construction: Stucco or Manuf. Stone Veneer; 2.5 lb/yd$^2$ Metal Lath on Water Resistive Barrier (No. 15 Building Paper); Proprietary Drainage Plane; Housewrap; OSB Sheathing on Wood Studs.

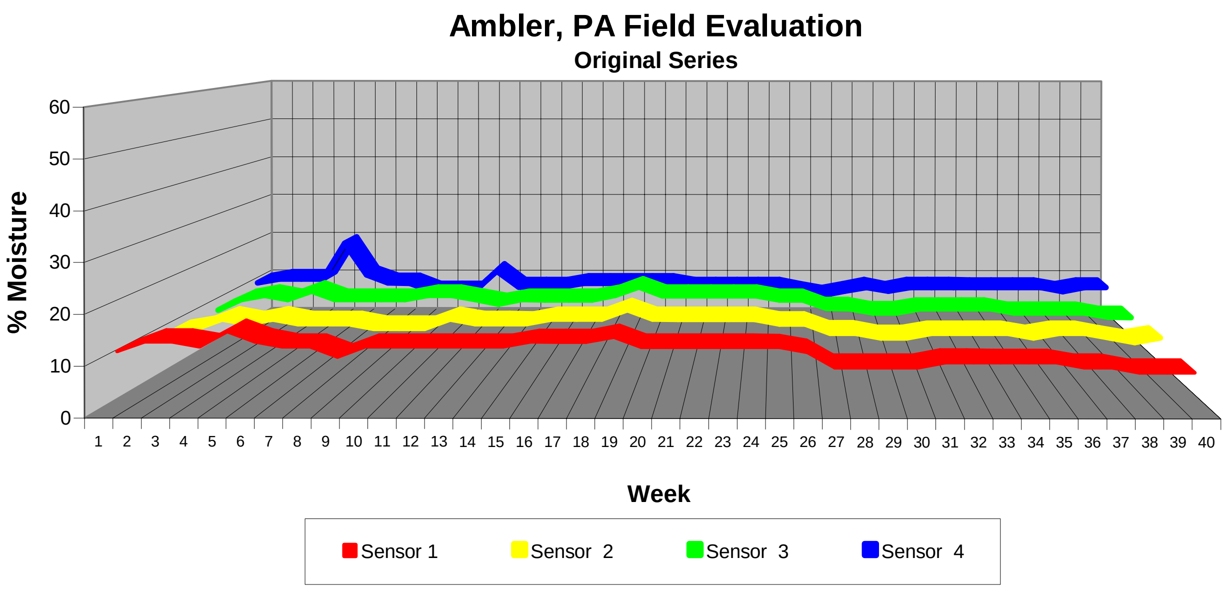
**WEATHER CONDITIONS: AMBLER, PA**
**ORIGINAL SERIES**

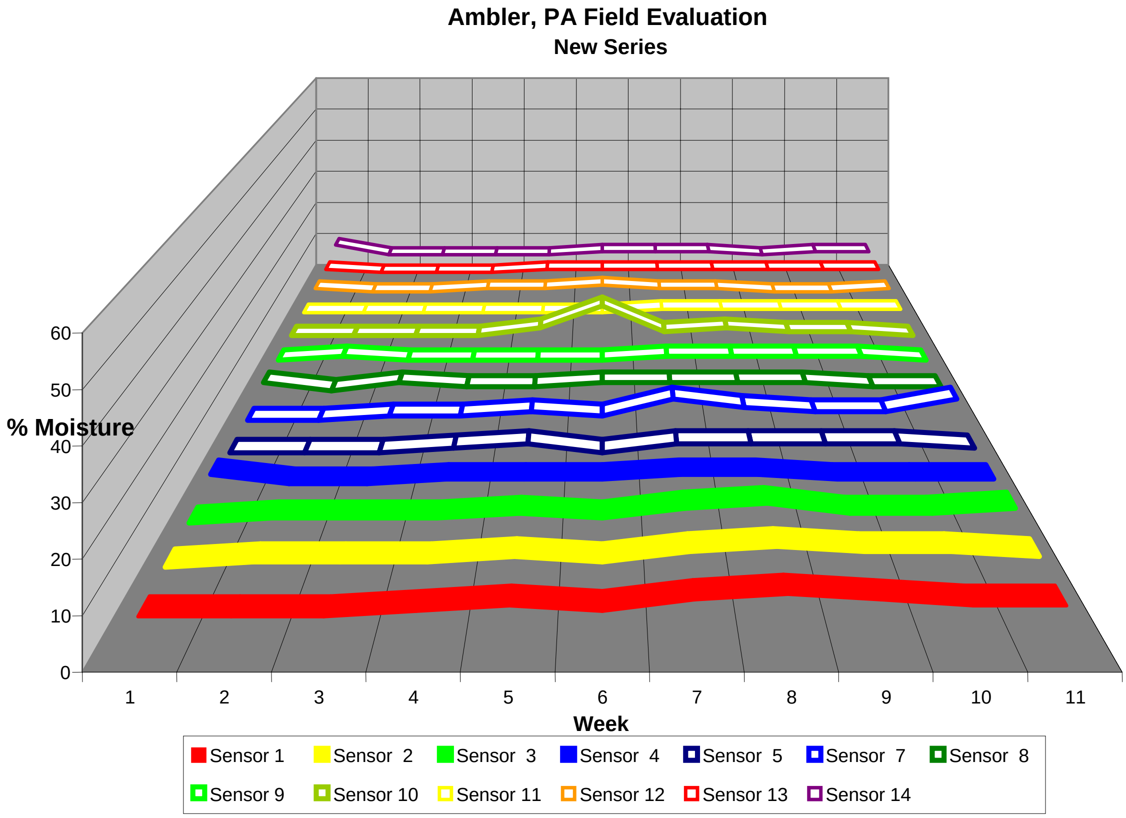
| WEEK (Date Sampled) Nov. 21, 2004 – Sep. 3, 2005 | | PREC | PRECIPITATION TYPE (# Days during Week) | | | | | | | | | HUMID. | AVG TEMP HIGH/LOW °F (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | RAIN | T-. STORM | RAIN/ T- STORM | RAIN /FOG | FOG | RAIN/ SNOW | RAIN/ SNOW/ FOG | SNOW /FOG | SNOW | | |
| 1 | 11/21-11/27 (11/23) | 0.23” | 1 | | | 1 | 1 | | | | | 46-100% | 45/53° (7/11°) |
| 2 | 11/28-12/4 (12/4) | 0.35” | 2 | | | | | | | | | 39-97% | 33/47° (1/8°) |
| 3 | 12/5 – 12/11 (12/10) | 1.19” | 2 | | | 3 | | | | | | 29-100% | 38/50° (3/9°) |
| 4 | 12/12-12/18 (12/16) | 0.05” | 1 | | | | | 1 | | | 1 | 30-93% | 27/41° (-3/5°) |
| 5 | 12/19-12/25 (12/23) | 0.78” | | | | 1 | | | 1 | | | 33-100% | 20/41° (-6/4°) |
| 6 | 1/2-1/8 (1/5) | 0.70” | 6 | | | 1 | | | | | | 47-100% | 38°/48° (3°/8°) |
| 7 | 1/9-1/15 (1/11) | 1.40” | 1 | | | | 1 | 1 | | | | 45-100% | 33/45° (0/7°) |
| 8 | 1/16-1/22 (1/21) | 0.08” | | | | | | | | 1 | 1 | 29-100% | 12/21° (-11/ -6°) |
| 9 | 1/23-1/29 (1/26) | 0.11” | | | | | | | | 1 | 1 | 29-84% | 11/29° (-11/-2°) |
| 10 | 1/30 – 2/5 (2/1) | 0.01” | | | | | | | | | 2 | 31-100% | 24/40° (-4/4°) |
| 11 | 2/6 – 2/12 (2/9) | 0.03” | 2 | | | | | 1 | | | | 19-92% | 32/47° (0/8°) |
| 12 | 2/13-2/19 (2/17) | 0.86” | 1 | | | | | 1 | | | | 22-97% | 30/43° (-1/6°) |
| 13 | 2/20-2/26 (2/24) | 0.01” | 1 | | | | | | | 1 | 2 | 39-89% | 24/36° (-4/2°) |
| 14 | 2/27-3/5 (3/3) | 0.23” | | | | | | | | 1 | 2 | 34-92% | 22/34° (-5/1°) |
| 15 | 3/6-3/12 (3/9) | 0.17” | 1 | | | | | | 1 | | | 35-100% | 14/44° (-10/6°) |
| 16 | 3/13-3/19 (3/17) | 0 | | | | | | | | | | 26-69% | 29/45° (-1/7°) |
| 17 | 3/20-3/26 (3/25) | 0.69” | 2 | | | 1 | | | | | | 31-97% | 35/46° (1/7°) |
| 18 | 3/27-4/2 (3/30) | 3.17” | 1 | | | 3 | | | | | | 30-100% | 40/55° (4/12°) |
| 19 | 4/3-4/9 (4/7) | 0.18” | 3 | | | | | | | | | 20-100% | 46/62° (8/16°) |
| 20 | 4/10-4/16 (4/13) | 0 | | | | | | | | | | 28-79% | 39/59° (3/14°) |
| 21 | 4/17 – 4/23 (4/21) | 0.42” | 2 | | 1 | | | | | | | 57-100% | 50/70° (9/21°) |
| 22 | 4/24-4/30 (4/27) | 0.02” | 2 | | | 1 | | | | | | 25-100% | 45/58° (7/14°) |
| 23 | 5/1-5/7 (5/4) | 0 | 2 | | | 1 | | | | | | 32-94% | 43/59° (6/15°) |
| 24 | 5/8-5/14 (5/13) | 0 | 1 | | | | | | | | | 25-93% | 48/73° (9/22°) |
| 25 | 5/15-5/21 (5/19) | 0.56” | 3 | | | | | | | | | 31-97% | 49/67° (6/19°) |
| 26 | 5/22-5/28 (5/23) | 0.14” | 4 | 1 | | | | | | | | 31-93% | 51/66° (10/18°) |
| 27 | 5/29-6/4 (6/3) | 0.67” | 1 | | | | | | | | | 36-100% | 54/72° (12/22°) |
| 28 | 6/5-6/11 (6/10) | 0.69” | 2 | 2 | | | | | | | | 35-96% | 68/87° (20/30°) |
| 29 | 6/12-6/18 (6/17) | 0 | 1 | | | | | | | | | 37-93% | 67/82° (19/27°) |
| 30 | 6/19-6/25 (6/23) | 0.01” | 1 | 1 | | | | | | | | 30-93% | 59/76° (14/24°) |
| 31 | 6/26-7/2 (6/28) | 1.01” | 2 | 2 | | | | | | | | 38-100% | 71/84° (21/28°) |
| 32 | 7/3-7/9 (7.7) | 1.10” | 1 | 2 | | | | | | | | 41-97% | 68/78° (20/25°) |
| 33 | 7/10-7/16 (7/15) | 1.66” | 1 | 1 | | | | | | | | 30-96% | 70/86° (21/29°) |
| 34 | 7/17-7/23 (7/22) | 1.11” | 1 | 1 | | | | | | | | 31-100% | 73/88° (22/30°) |
| 35 | 7/24-7/30 (7/29) | 0.15” | | | 2 | | 1 | | | | | 33-100% | 69/86° (20/29°) |
| 36 | 7/31-8/6 (8/2) | 0 | | | | | | | | | | 35-100% | 71/88° (21/30°) |
| 37 | 8/7-8/13 (8/12) | 0.02” | 3 | 1 | | | | | | | | 45-100% | 72/86° (22/29°) |
| 38 | 8/14-8/20 (8/19) | 0.08” | 3 | 1 | | | | | | | | 39-96% | 68/82° (19/27°) |
| 39 | 8/21-8/27 (8/26) | 0 | 1 | | | | | | | | | 31-94% | 63/82° (17/27°) |
| 40 | 8/28-9/3 (8/31) | 0.35” | 3 | | | 1 | | | | | | 51-100% | 68/83°(19/28°) |

**New Series.** In September 2005, ten additional sensors (Sensors 5-14) were added to the front elevation of this project. Sensors 1 through 4 (the original series, as recorded above) were located below first-floor window corners in the left-hand stucco wall area. New sensors 5 through 10 were located at the second-floor windows within the manufactured stone veneer wall area. New sensors 11 through 14 were located below the first floor garage windows, which are in a stucco clad wall. Sensor 6 experienced a sensor malfunction, and, as a result, no data is available from this sensor.

**WEATHER CONDITIONS: AMBLER, PA**
**NEW SERIES**

| WEEK (Date Sampled) Sep. 4 – Nov. 19, 2005 | | PREC | PRECIPITATION TYPE (# Days during Week) | | | | | | | | | HUMID. | AVG TEMP HIGH/LOW °F (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | RAIN | T-. STORM | RAIN/ T- STORM | RAIN /FOG | FOG | RAIN/ SNOW | RAIN/ SNOW/ FOG | SNOW /FOG | SNOW | | |
| 1 | 9/4-9/10 (9.8) | 0 | | | | | | | | | | 24-94% | 60/80° (15/26°) |
| 2 | 9/11-9/17(9.16) | 0.03” | 3 | | | | 1 | | | | | 29-100% | 66/84° (18/28°) |
| 3 | 9/18-9/24(9.22) | 0 | | | | | | | | | | 24-90% | 63/82° (17/27°) |
| 4 | 9/25-10/1(9.28) | 0.16” | 2 | | | | | | | | | 28-94% | 54/74° (11/23°) |
| 5 | 10/2-10/8 (10.6) | 0.28” | 2 | | | | 1 | | | | | 48-100% | 62/71° (16/21°) |
| 6 | 10/9-10/15 (10.10) | 0.20” | 4 | | | | | | | | | 44-100% | 56/62°(13/16°) |
| 7 | 10/16-10/22 (10.17) | 0.17” | 1 | | | | | | | | | 37-90% | 51/61° (10/16°) |
| 8 | 10/23-10/29 (10.26) | 0.31” | 1 | | | | | | | | | 41-96% | 40/49° (4/9°) |
| 9 | 10/30-11/5 (11.2) | 0 | | | | | | | | | | 21-86% | 47/64° (7/17°) |
| 10 | 11/6-11/12 (11.10) | 0.01” | 2 | 1 | | | | | | | | 36-100% | 46/60° (8/15°) |
| 11 | 11/13-11/19 (11.18) | 0.30” | 1 | | | | | | | | | 26-93% | 41/54° (5/12°) |


Ambler, PA Field Evaluation
Original Series
% Moisture
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Week
Sensor 1
Sensor 2
Sensor 3
Sensor 4


Ambler, PA Field Evaluation
New Series
% Moisture
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11
Week
Sensor 1
Sensor 2
Sensor 3
Sensor 4
Sensor 5
Sensor 7
Sensor 8
Sensor 9
Sensor 10
Sensor 11
Sensor 12
Sensor 13
Sensor 14

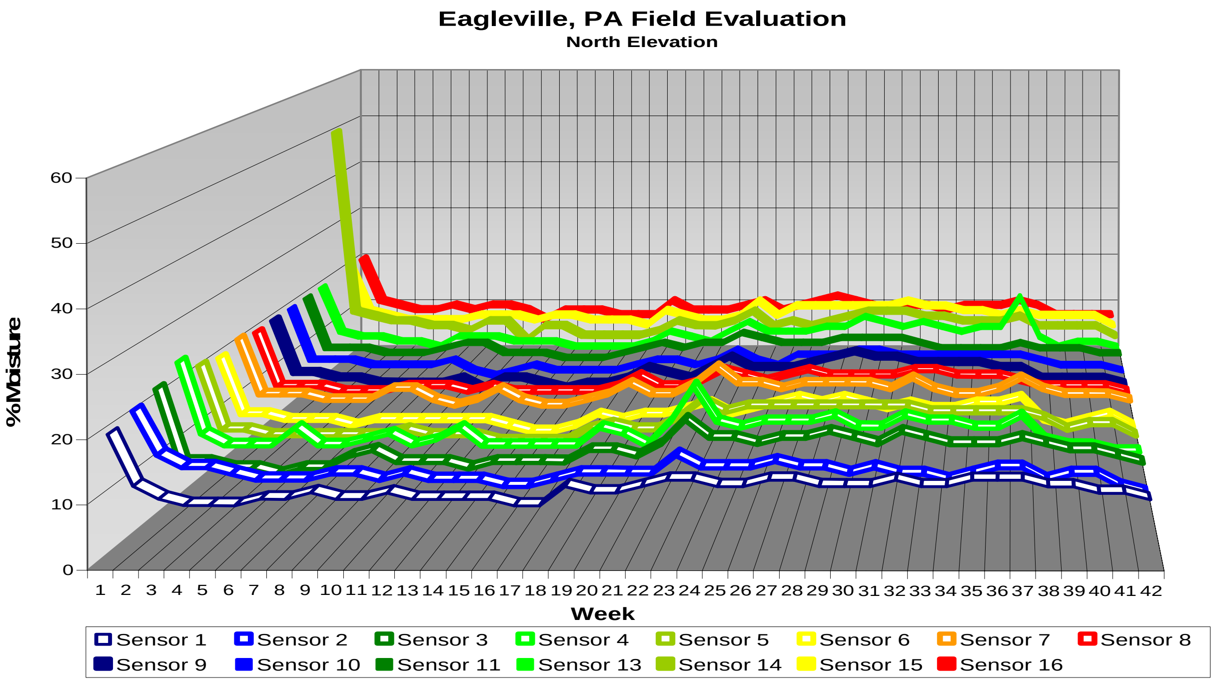
## D.2. Field Trial - Eagleville, PA
## Data as of November 18, 2005

**North Elevation – 8 Windows, 2 Sensors Each.** Exterior Wall Construction: Drainage EIFS; 2.5 lb/yd$^2$ Metal Lath on Self-Adhered Membrane Water Resistive Barrier; Fiberglass-Faced Gypsum Sheathing; Steel Stud Frame. Sensor #12 did not record data due to a malfunction; accordingly, it is not included.

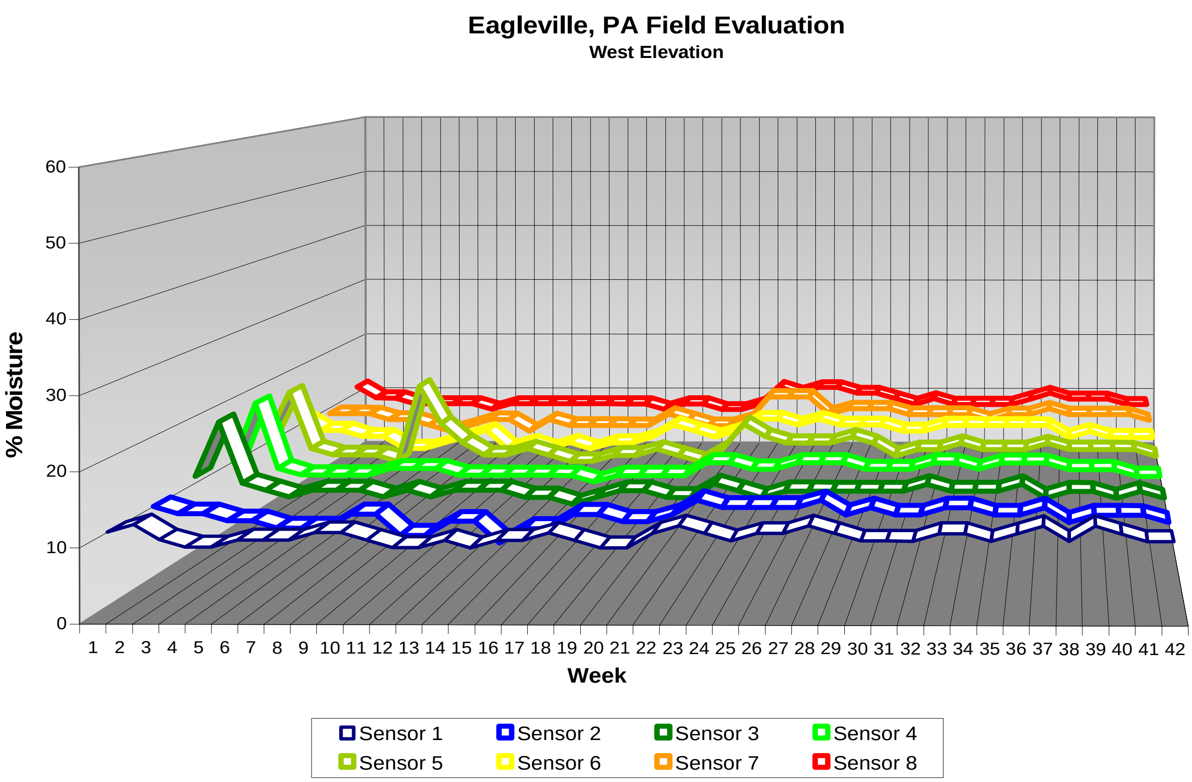
**West Elevation – 4 Windows, 2 Sensors Each.** Exterior Wall Construction: Drainage EIFS; 2.5 lb/yd2 Metal Lath on Self-Adhered Membrane Water Resistive Barrier; Fiberglass-Faced Gypsum Sheathing; Steel Stud Frame.

**WEATHER CONDITIONS: EAGLEVILLE, PA**

| WEEK (Date Sampled) Dec. 19, 2004 – Nov. 19, 2005 | | PREC | PRECIPITATION TYPE (# Days during Week) | | | | | | | | | HUMID. | AVG TEMP HIGH/LOW °F (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | RAIN | T-. STORM | RAIN/ T- STORM | RAIN /FOG | FOG | RAIN/ SNOW | RAIN/ SNOW/ FOG | SNOW /FOG | SNOW | | |
| 1a. | 12/19-12/23 (12/21) **(West elev. only)** | 0.78” | 2 | | | | 2 | | | | 1 | 48-100% | 20/41° (-6/14°) |
| 1b. | 1/9-1/15 (1/10) **(North elev. only)** | 0.70” | 2 | | | | 2 | | | | 1 | 47-82% | 28/54° (2/12°) |
| 2 | 1/30-2/5 (1/31) | 0.01” | | | | | | | | | 2 | 40-64% | 24/40° (-4/4°) |
| 3 | 2/6-2/12(2/8 & 2/11) | 0.03” | 3 | | | | | | | | 1 | 40-74% | 32/47° (0/8°) |
| 4 | 2/27-3/5 (3/3) | 0.23” | | | | | | | | | 3 | 42-87% | 22/34° (-5/1°) |
| 5 | 3/6-3/12 (3/9) | 0.17” | 1 | | | | | | 1 | | | 34-100% | 14/44° (-10/6°) |
| 6 | 3/13-3/19 (3/16) | 0 | | | | | | | | | | 26-69% | 29-45° (-1/7°) |
| 7 | 3/20-3/26 (3/25) | 0.69” | 2 | | | 1 | | | | | | 31-97% | 35/46° (1/7°) |
| 8 | 3/27-4/2 (3/30) | 3.17” | 1 | | | 3 | | | | | | 30-100% | 40/55° (4/12°) |
| 9 | 4/3-4/9 (4/7) | 0.18” | 3 | | | | | | | | | 20-100% | 48/62° (8/16°) |
| 10 | 4/10 –4/16 (4/14) | 0 | | | | | | | | | | 28-79% | 39/59° (3/14°) |
| 11 | 4/17-4/23 (4/19) | 0.42” | 2 | | | 1 | | | | | | 57-100% | 50/70° (9/21°) |
| 12 | 4/24-4/30 (4/27) | 0.02” | 2 | | | 1 | | | | | | 25-100% | 45/58° (7/14°) |
| 13 | 5/1-5/7 (5/4) | 0 | 2 | | | 1 | | | | | | 32-94% | 43/59° (6/15°) |
| 14 | 5/8-5/14 (5/13) | 0 | 1 | | | | | | | | | 25-93% | 48/73° (9/22°) |
| 15 | 5/15-5/21 (5/19) | 0.56” | 3 | | | | | | | | | 31-97% | 49/67° (6/19°) |
| 16 | 5/22-5/28 (5/23) | 0.14” | 4 | 1 | | | | | | | | 31-93% | 51/66° (10/18°) |
| 17 | 5/29-6/4 (6/3) | 0.67” | 1 | | | | | | | | | 36-100% | 54/72° (12/22°) |
| 18 | 6/5-6/11 (6/10) | 0.69” | 2 | 2 | | | | | | | | 35-96% | 68/87° (20/30°) |
| 19 | 6/12-6/18 (6/17) | 0 | 1 | | | | | | | | | 37-93% | 67/82° (19/27°) |
| 20 | 6/19-6/25 (6/23) | 0.01” | 1 | 1 | | | | | | | | 30-93% | 59/76° (14/24°) |
| 21 | 6/26-7/2 (6/28) | 1.01” | 2 | 2 | | | | | | | | 38-100% | 71/84° (21/28°) |
| 22 | 7/3-7/9 (7/6) | 1.10” | 1 | 2 | | | | | | | | 41-97% | 68/78° (20/25°) |
| 23 | 7/10-7/16 (7/15) | 1.66” | 1 | 1 | | | | | | | | 30-96% | 70/86° (21/29°) |
| 24 | 7/17-7/23 (7/22) | 1.11” | 1 | 1 | | | | | | | | 31-100% | 73/88° (22/30°) |
| 25 | 7/24-7/30 (7/29) | 0.15” | | | 2 | | 1 | | | | | 33-100% | 69/86° (20/29°) |
| 26 | 7/31-8/6 (8/2) | 0 | | | | | | | | | | 35-100% | 71/88° (21/30°) |
| 27 | 8/7-8/13 (8/12) | 0.02” | 3 | 1 | | | | | | | | 45-100% | 72/86° (22/29°) |
| 28 | 8/14-8/20 (8/19) | 0.08” | 3 | 1 | | | | | | | | 39-96% | 68/82° (19/27°) |
| 29 | 8/21-8/27(8/26) | 0 | 1 | | | | | | | | | 31-94% | 63/82° (17/27°) |
| 30 | 8/28-9/3 (8/31) | 0.35” | 3 | | | 1 | | | | | | 51-100% | 68/83° (19/28°) |
| 31 | 9/4-9/10 (9/8) | 0 | | | | | | | | | | 24-94% | 60/80° (15/26°) |
| 32 | 9/11-9/17 (9/16) | 0.03” | 3 | | | | 1 | | | | | 29-100% | 66/84° (18/28°) |
| 33 | 9/18-9/24 (9/22) | 0 | | | | | | | | | | 24-90% | 63/82° (17/27°) |
| 34 | 9/25-10/1 (9/28) | 0.16” | 2 | | | | | | | | | 28-94% | 54/74° (11/23°) |
| 35 | 10/2-10/8 (10/6) | 0.28” | 2 | | | | | | | | | 48-100% | 62/71° (16/21°) |
| 36 | 10/9-10/15 (10/10) | 0.20” | 4 | | | | | | | | | 44-100% | 56/62° (13/16°) |
| 37 | 10/16-10/22 (10/17) | 0.17” | 1 | | | | | | | | | 37-90% | 51/61° (10/16°) |
| 38 | 10/23-10/29 (10/26) | 0.31” | 1 | | | | | | | | | 41-96% | 40/49° (4/9°) |
| 39 | 10/30-11/5 (11/2) | 0 | | | | | | | | | | 21-86% | 47/64° (7/17°) |
| 40 | 11/6-11/12 (11/10) | 0.01” | 2 | 1 | | | | | | | | 36-100% | 46/60° (8/15°) |
| 41 | 11/13-11/19 (11/18) | 0.30” | 1 | | | | | | | | | 26-93% | 41/54° (5/12°) |




Sensor # 12 did not record data due to a malfunction. Accordingly, it is not included here.



# APPENDIX E: MANUFACTURER/PRODUCT SURVEY MATRIX

| Product Name/ Manufacturer | Type | Description | End Dams? | Integral Rear Dam? | Slope To Exterior? | Drainage Provision? | Apron Extension Below Sill? | Extension Along Jamb? | Seam(s) in Pan? | Depths Covered /SKUs | Manufacturer Reported Installation Time | Delay Required Before Window Installation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aqua Flash | Liquid system. | Liquid acrylic system and reinforcing mesh. Trowel, roll or brush on. | Application to Jambs<br><br>Variable | No | No | No | 0 | Variable | 0 | All Sizes | < 15 Minutes | Sealant to Dry |
| Astro Pan | Sill pan with ends and back. | PE sill covering between molded PE end units. | Yes<br>1 ¼" | Yes *<br>1 1/8" | No | No | 1 1/8" | 1 ¼" | 2 | 4 9/16" &<br>6 9/16" | < 10 Minutes | Adhesive to Dry. |
| Contour Stretchable Flashing | Sill and corner covering. | Self-adhered conformable membrane. One-piece application includes "curved" ends with continuous sill covering. | Yes<br>Variable | No | No | No | Variable | Variable | 0 | All Sizes | < 10 Minutes | 0 |
| Damsill | Sill covering with back. | ABS channeled board. | No | Coming | Yes * | Yes | 3/4" | 0 | 2 | 4 9/16 " | < 10 Minutes | Caulking to Dry. |
| Dupont Flashing System | Sill and corner covering. | Self-adhered conformable membrane. One-piece application includes "curved" ends with continuous covering. | Yes<br>Variable | No | No | No | Variable | Variable | 0 | All Sizes | < 10 Minutes | 0 |
| EZ Pan | Sill covering with ends and partial back. | Self-adhered membrane sill covering between HDPE interchangeable corners with integral rear dam. | Yes *<br>3" | Yes * | Yes * | Yes | Variable | 21/4" * | 2 | 4 9/16"<br>2¼", 1 ¾"<br>& 1 ¼"<br>Can Adapt to All Sizes | < 10 Minutes | 0 |

* Indicates compliance with ASTM E2112 Recommendations

| Product Name/ Manufacturer | Type | Description | End Dams? | Integral Rear Dam? | Slope To Exterior? | Drainage Provision? | Apron Extension Below Sill? | Extension Along Jamb? | Seam(s) in Pan? | Depths Covered /SKUs | Manufacturer Reported Installation Time | Delay Required Before Window Installation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jamsill Guard | Sill pan with ends and back. | PVC molded sill covering between molded end units. | Yes 1 3/8" | Yes * 5/8" | Sloped* Weep Area | Yes | 1 ¼" | 1 3/8" | 2 | 7 Depths 6 9/16" to 1 1/8" | < 5 Minutes | Adhesive to Dry. |
| MFM Window Wrap | Sill and corner covering. | Self-adhered conformable membrane. One-piece application includes "curved" ends with continuous covering. | Yes Variable | No | No | No | Variable | Variable | 0 | All Sizes | < 10 Minutes | 0 |
| Moistop Flashing & Moistop Corner Shield | Sill covering with ends. | Self adhered membrane sill covering between molded flexible plastic corners. | Yes * 3" | No | No | No | Variable | Variable | 2 | One Size Fits All | < 10 Minutes | Adhesive to Dry |
| Protecto Sill Drainage System | Sill pan with corners and back. | Self-adhered membrane sill covering and wicking membrane between molded PE corners. | Yes * 3" | Yes * | Yes * | Wicking Membrane | Variable | 3" * | 2 | 3", 5", 1 3/4" | < 10 Minutes | Caulking to Dry |
| Sill Flashing | Sill pan with ends and back. | PE left and right overlapping sections. | Yes 2 " | Yes * ¼" | No | No | 3" * | 3 ¾" * | 1 | One Size Fits All 3 ½" & Less | < 5 Minutes | 0 |
| SillSaver | Sill pan with ends and back. | PVC molded sill covering between molded end units. | Yes 1 15/16" | Yes * ½" | Yes * | Yes | 2" * | 1 13/16 | 2 | 1 5/8, .2", 2 3/8" | < 10 Minutes | Adhesive to Dry. |
| Sure Flash | Sill covering with flexible flashing corners. | Self-adhered membrane between flexible flashing corners. | Yes Variable | Yes * 3/8" | Yes | Yes | Variable | Variable | 2 | All Sizes | < 10 Minutes | 0 |
| SureSill | Sill pan with ends and back. | PVC molded sill covering between PVC molded end units. | Yes 1 7/16" | Yes * 1 1/8" & 3/8" intervals | Yes * | Yes | 2" * | 2 3/8 " * | 2 | 2", 4 1/8", 4 9/16" and 6 7/16" | < 10 Minutes | Adhesive to Dry. |

* See Page 26

| Product Name/ Manufacturer | Type | Description | End Dams? | Integral Rear Dam? | Slope To Exterior? | Drainage Provision? | Apron Extension Below Sill? | Extension Along Jamb? | Seam(s) in Pan? | Depths Covered /SKUs | Manufacturer Reported Installation Time | Delay Required Before Window Installation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRX Window Wrap | Liquid system. | Liquid water-based polyurethane and paper. Trowel, brush, or roll on. | Application to Jambs<br><br>Variable | No | No | No | 0 | Variable | 0 | All Sizes | < 15 Minutes | Sealant to Dry |
| Vapro Shield & Vapro Shield Sill Saver | Sill covering with corners and / or sill pan with ends and back. | Spun bond polypropylene with sonic welded corners of like material – can incorporate with Sill Saver system. | Yes<br>5"or<br>1 13/16" | No | Yes * | Yes | Variable | 5" * or<br>15/16 " | 2 | One Size Fits All | < 15 Minutes | Adhesive to Dry |
| Vycor & Vycorners | Sill covering with ends. | Self-adhered membrane sill covering between molded plastic corners. | Yes<br>2 ½" | No | No | No | Variable | 21/2" * | 2 | One Size Fits All | < 10 Minutes | 0 |
| Water Block Flashing & Water Block Corners | Sill covering with ends. | Self-adhered membrane sill covering between molded plastic corners. | Yes *<br>2 ¼" | No | No | No | Variable | 2 1/2 " | 2 | One Size Fits All | < 10 Minutes | 0 |
| Water Out Flashing | Sill pan with ends and back. | Polypropylene sill covering between interchangeable molded end unit. | Yes *<br>5 7/8" | Yes *<br>½" | Yes * | Yes | 2" * | 2 ¾" * | 2 | 4 9/16" | < 10 Minutes | Adhesive to Dry |
| Wet Flash PM7000 | Liquid system. | Liquid system with paper. Trowel, brush or roll on. | Application to Jambs<br><br>Variable | No | No | No | 9" Flashing Incorporate | Variable | 0 | All Sizes | < 15 Minutes | Sealant to Dry |
| Will Flash Custom Pan | Sill pan with ends and back. | Copper, stainless, or material of choice made as specified for each window. | Yes *<br>3" or Greater | Yes *<br><br>As required | Yes * | Yes | 2" or * Greater | 2" or * Greater | ? | All Sizes | < 5 Minutes | 0 |

* See Page 26

| Product Name/ Manufacturer | Type | Description | End Dams? | Integral Rear Dam? | Slope To Exterior? | Drainage Provision? | Apron Extension Below Sill? | Extension Along Jamb? | Seam(s) in Pan? | Depths Covered /SKUs | Manufacturer Reported Installation Time | Delay Required Before Window Installation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WillFlash Liquid Pan | Liquid system. | Silicone based system with mesh and preformed silicone corners | Application to Jambs. | No | No | No | Variable | Variable | 0 | One Size Fits All | < 20 Minutes | Sealant to Dry. |
| WillFlash® Quickpan | Preformed sill pan with ends and back. | Cross-laminated PE sheet; one piece application includes folded ends with continuous sill covering. | Yes * 3” | Yes * 7/8” and Less | Yes * | Yes | 3 ½” * | 2” * | 0 | One Size Fits All (6 9/16” – 1”) (4 9/16”– 1”) | < 5 Minutes | 0 |

* See Page 26

# MANUFACTURERS' CONTACT INFORMATION

| Product Name | Manufacturer | Contact | Phone | Fax | E-mail and Website |
|---|---|---|---|---|---|
| Aqua Flash | Dryvit Systems Inc.<br>One Energy Way<br>West Warwick, RI 02893 | I. J. Valainis | 401-822-4100 | 401-823-8820 | Ijv @dryvit.com<br><br>www.dryvit.com |
| Astro Pan | Astro Plastics<br>14101 Industrial Park Blvd. N.E.<br>PO Box 2299<br>Covington, GA 30014 | Andy Whitley | 800-334-4474 | 770-786-2737 | awhitley@astroplastics.com<br><br>www.astroplastics.com |
| Contour Stretchable Flashing | Ludlow Products<br>400 Texas St.<br>Shreveport, LA 71101 | Kirk Mathews | 877-832-0333 | 601-693-8181 | kmathews @ludlowcp.com<br><br>www.ludlowcp.com |
| DamSill | Moisture Warranty Corp.<br>20306 N. Main St.<br>Cornelius, NC 28031 | Dana Osborn | 800-400-8679, Ext. 152 | N/a | danao @moisturefreewarranty.com<br><br>www.moisturewarranty.com |
| DuPont Flashing Systems | DuPont Weatherization Systems<br>Chestnut Run Plaza<br>Wilmington, DE 19805 | Xuaco Pascoal | 804-383-2407 | 302-999-4399 | N/a |
| EZ Pan | Carlisle Coating & Waterproofing Inc.<br>900 Hensley Lane<br>Wylie, TX 75098 | Brian Carey | 800-527-7092 | 972-442-0076 | careyb @ccw.carlisle.com<br><br>www. carlisle-ccw.com |
| Jamsill Guard | Jamsill Inc.<br>PO Box 485<br>Talent, OR 97540 | Greg Moffitt | 800-526-7455 | 541-488-7472 | greg @jamsill.com<br><br>www. jamsill.com |

| Product Name | Manufacturer | Contact | Phone | Fax | E-mail and Website |
|---|---|---|---|---|---|
| MFM Window Wrap | MFM Building Products Corp.<br>525 Orange St.<br>Coshocton, OH 43812 | Tod Windsor | 740-622-6161 | 740-622-6161 | mail @mfmbp.com<br><br>www.mfmbp.com |
| Moistop Flashing & Corner Shield | Fortifiber Building Systems Group<br>419 West Plumb Lane<br>Reno, NV 89509 | David Olson | 800-773-4777 | 775-333-6411 | dolson @fortifiber.com<br><br>www. fortifiber.com |
| Protecto Sill Drainage System | Protecto Wrap Co.<br>1955 S. Cherokee St.<br>Denver, CO 80223 | Robert Shaw | 800-759-9727 | 303-777-9273 | bob @protectowrap.com<br><br>www. protectowrap.com |
| Sill Flashing | Pulte Homes<br>100 Bloomfield Hills Pike<br>Bloomfield Hills, MI 48304 | Jim Petersen | 248-433-4653 | 248-988-5018 | jimpetersen @pulte.com<br><br>www.pulte.com |
| SillSaver | SillSaver Industries Ltd.<br>42899 Adams Rd.<br>Chilliwack, B.C. Canada V2P 4K9 | Scott Wark | 604-999-1576 | 604-823-7434 | sillsaver @shaw.ca<br><br>www. sillsaver.com |
| Sure Flash | Flashing Products Inc.<br>2319 Federal Ave. East<br>Seattle, WA 98102 | Dale Ackerman | 206-568-6633 | N/a | daleackerman @sureflash.com<br><br>www. sureflash.com |
| SureSill | SureSill Ltd.<br>PO Box 202673<br>Austin, TX 78720-2673 | Mishko Teodorovich | 866-440-7873 | 512-502-0007 | mishko @suresill.com<br><br>www.suresill.com |
| TRX Window Wrap | Vinyl Doctor<br>8235 N.E. Beech<br>Portland, OR 97213-1168 | David Fenske | 503-249-0737 | 503-262-8000 | David @vinyldoc.com<br><br>www. vinyldoc.com |

| Product Name | Manufacturer | Contact | Phone | Fax | E-mail and Website |
|---|---|---|---|---|---|
| Vapro Shield & Vapro Shield Sill Saver | VaproShield 915 26th Avenue Gig Harbor, WA 98335 | Dave Hales | 866-731-7663 | 235-858-3297 | dave.hales @proctorgroup.com<br><br>www.vaproshield.com |
| Vycor Flashing & Vycorners | W.R. Grace & Co. 16 Horseshoe Rd. Chelmsford, MA 01824 | John Carrier | 866-333-7726 | N/a | j.m.f.carrier @grace.com<br><br>www. graceconstruction.com |
| WaterBlock | International Building Components 21428 Woods Creek Rd. Monroe, WA 98272 | Mark Gilstrap | 888-610-2151 | 360-863-8434 | ibcinc @verizon.net<br><br>www. waterblocksystems.com |
| Water Out Flashing | Water Out Flashing 8206-1200 Providence Road Charlotte, NC 28277 | Ross Allen | 866-568-0050 | 704-364-8829 | rallen @wateroutflashing.com<br><br>www.wateroutflashing.com |
| Wet Flash PM 7000 | Building Envelope Innovations LLC 1115 N. 97 St. Seattle, WA 98103 | Carl Havenstein | 206-985-3788 | 206-985-3689 | chavenstein @tatleygrund.com<br><br>www.wet-flash.com |
| WillFlash Custom Pan, Liquid Pan, QuickPan | Building Diagnostic Technologies Inc. ** PO Box 859 Springhouse, PA 19477 | Russel Graham | 215-628-3750 | 215-628-3128 | info@willflash.net<br>www.willflash.com<br><br>** Associated with Williams Building Diagnostics and Mark Williams, Author of this report. |