A Discussion on Fenestrations Testing

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Abstract

Standardized testing is a terrific way to validate the real-world performance of fenestration systems. When combined with a thorough quality assurance plan, testing an enclosure system with a standardized procedure allows design and construction teams to control for quality. With that said, testing should not be specified or performed without consideration of the needs of a project. Sometimes, an industry standard doesn’t quite match the design intent of an assembly. In these cases, testing should be adjusted accordingly. The speaker will cover the mechanics of fenestration water testing and how to critically analyze a water penetration test against a fenestration’s design intent. The presentation will include a review of common fenestration testing protocols from ASTM and AAMA, and exploration of their origins and intent. Discussion will also focus on the building science behind common fenestration systems. The dialogue will tie testing and science together to highlight areas where the two don’t align. The presentation’s conclusion will feature a discussion of what could be revised in test procedures to provide better value to design and construction teams.

Speaker

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ABSTRACT

Standardized testing is a terrific way to validate the real-world performance of fenestration systems. When combined with a thorough quality assurance plan, testing any enclosure system to a standardized procedure allows design and construction teams to control quality on their project. With that understanding, testing should not be specified or performed without consideration of the requirements of a project. Sometimes, an industry standard doesn’t quite match the design intent of an assembly. In these cases, the testing should be adjusted accordingly.

This paper aims to shine a light on the mechanics of fenestration water testing and guide the reader on how to critically analyze a water penetration test when considering the fenestration design intent. We do this by first reviewing common fenestration testing protocols from ASTM & AAMA. For the selected protocols, we explore their origin to gain a better understanding of their original intent. We then jump into the building science side of some common fenestration systems. Finally, this paper ties the testing and science together to discuss areas where the two don’t align. We conclude with a discussion on what might be revised in test procedures to help the tests provide better value to design and construction teams.

INTRODUCTION

It is not uncommon for a group of designers, owners, consultants, and contractors to all be gathered at a construction site staring anxiously at a drop of water on a window frame during a field water penetration resistance test, wondering where it all went wrong. If the stage has been properly set, the interested parties will be on the same page with a consistent interpretation of not only the test goals, but also the larger project goals. Far too often, however, there arises some conflict that usually stems from a discrepancy in expectations among the owners, designers, and fenestration manufacturers.

Owners often expect that the window will test to its specified pressure without any water intrusion to the interior. Window test reports are often included in the record documents that are submitted after the building is complete and, understandably, owners tend to be sensitive to blemishes on this record that are the result of a string of failed water leakage tests. Manufacturers, on the other hand, supported by some aspects of common industry test standards, are perhaps held to a set of expectations that are different from what the owner expects. Industry-set performance expectations generally allow some water intrusion without failing the test. Designers are often caught in the middle of this tug-of-war, having to answer to owners who do not want to see water on the interior of their window at the design-specified conditions, while also having to respond to manufacturers who say that these expectations are not consistent with standard industry terms.

Situations such as this compel the entire team—each member with his or her own unique perspective—to stand back and consider the larger picture. What is the goal of this testing, anyway? How did we get here? What are we trying to achieve by performing this test? This paper attempts to gather the different perspectives and tie them together.

SOME BACKGROUND

The building and construction industry widely subscribes to the notion that building enclosure-related failures, when they happen, tend to occur at interfaces and penetrations. Indeed, the author’s anecdotal experience supports this idea, not to mention the bulk of industry records and case studies that do the same. Perhaps the most well known types of enclosure failures relate to slow, concealed water intrusion at penetrations. The bulk of industry knowledge regarding window failures and their causes leads designers and owners of new construction projects to, rightly so, scrutinize newly installed window systems. This scrutiny is guided by a series of standardized test methods that are intended to hold all window systems to the same basic criteria such that designers and owners can compare different systems appropriately. These test standards have largely been developed by the American Society for Testing and Materials (ASTM) and further referenced by the American Architectural Manufacturers Association (AAMA) to provide the baseline for how fenestration systems should be tested throughout the progress of construction, from design and manufacturing, to installation, to post-construction.

These organizations typically build standards in a consensus approach in which they invite input from the industry players, including manufacturers and designers. In general, the intent of any test standard is ultimately to set a common stage on which different manufacturers can present their product. In support of this goal, a test standard typically isolates one component of that product and tests it against some measurable and consistent metric. The test standard should respect the basic way such products work and evolve as the technology for that product does. Of course, test standards should also be understood by those performing and interpreting the test. Each test standard has limitations, sensitivities, and a fundamental goal; these should be considered during both testing and interpretation of test results.

The intent of this paper is to focus on fenestration water penetration testing, for which there are currently a handful of test standards that are widely in use today. The idea for this paper stems from field discussions surrounding field water penetration testing, but this paper will discuss water penetration testing more conceptually. Before we continue, the window test methods, standards, and voluntary specifications that we will discuss are briefly defined below:

- ASTM E331 – Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtains Walls by Uniform Static Air Pressure Difference
- ASTM E547 – Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference
SOME HISTORY
The University of Miami claims the earliest discoverable standardized window test procedure in a 1952 published paper that documents a “Study of Glass Jalousie Windows Under Hurricane Conditions.” This study has since been referenced by multiple publications as being the origin of regular standardized window testing in the industry.

The test procedure in the glass jalousie windows study consisted of a window specimen that was tested for water intrusion using an aircraft propeller to generate wind with water injected into the air stream to simulate wind-driven rain conditions that might be encountered during a hurricane event. A similar test method was ultimately included in the AAMA 501, Methods of Test for Exterior Walls specification, and was pulled out of this specification to form a stand-alone test method, AAMA 501.1, Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure,” in 2005 (Figure 1).

A few years after the early glass jalousie windows testing, a test method was developed and used in Norway that consisted of a static air pressure difference applied to one side of a window with a spray of water applied to the exterior. Due to the complicated nature of the apparatus used in the Norwegian testing, the testing method was not practical for large specimens. In the United States, early pressure chamber testing included an apparatus that consisted of a perforated pipe that poured water onto the test specimen from above, while a chamber applied a pressure gradient across the specimen. This test procedure was also deemed impractical because the water application method was driven by gravity alone; thus, water could not easily wet the window portion under any projections.

At the end of the 1950s, the water spray apparatus was modified to include spray nozzles that allowed water to cover the full specimen during pressure chamber testing. This basic test procedure, including a pressure chamber with a water spray in a grid pattern, has gone on to form the foundation for window testing across the industry.

In 1967, ASTM first published this basic procedure as a test standard, E331, Tentative Method of Test for Water Resistance of Windows by Uniform Static Air Pressure Differential. The standard was revised in 1970 to include curtainwall systems and doors. The test procedure in ASTM E331 standardized several variables in the test method, including the rate of

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<td>University of Miami glass jalousie windows standard testing.</td>
<td>Chamber testing developed in U.S. and Europe. First chamber test method drafted in U.S.</td>
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![Figure 1 – Example of AAMA 501.1 dynamic test setup.](image)

![Figure 2 – Timeline of test standards and voluntary specifications development.](image)
water spray to the exterior and the definition of water penetration. The test standard included a pressurized chamber, which applied a static pressure differential across the specimen in an effort to simulate wind conditions in a more controlled and repeatable manner than can be achieved with a propeller in AAMA’s dynamic test. In 1975, ASTM followed up with an additional test standard, E547, Test for Water Penetration of Exterior Windows, Curtain Walls, and Doors by Cyclic Static Air Pressure Differential, which basically took the method in E331 and applied pressure to the chamber in cycles instead of consistently to simulate variable wind.

ASTM E331 (static) and ASTM E547 (cyclical) were developed to test new window products in a laboratory setting but were found to be impractical by many users in a field setting. To address this, ASTM developed its E1105 test method in 1986 as a way of standardizing window tests in the field: ASTM E1105, Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Curtain Walls, and Doors by Uniform or Cyclic Air Pressure Difference. The E1105 test method carries forward definitions and procedures from both ASTM E331 and E547, and is now what is referenced in several AAMA voluntary specifications that pertain to window testing for new and existing windows in the field. See Figure 2.

There are many numbers and test codes, which can get confusing, but the method of test, in general, is similar across the board. Pressure chamber test methods basically consist of the following components (Figures 3, 4, and 5):

- **Specimen:** A window specimen installed plumb into a rough opening to a chamber.
- **Water Spray:** Applied to the specimen at a rate of five gallons per minute through a series of spray nozzles set up in a grid pattern. The magnitude of flow—five gallons per minute—was based on what the test method authors thought was reasonable to achieve full coverage of the window specimen; ultimately, the goal is full coverage to uncover any water leaks.

- **Pressure Chamber:** The test chamber described in ASTM E331, a lab-based procedure, was designed to apply a positive pressure to the exterior of the window as may be expected in a wind event. Since applying a chamber to the exterior of a building in the field is impractical, ASTM E1105, the field version of the test, instructs that the test chamber is to be applied to the interior of the
specimen with an applied vacuum.

- **Time:** Water is then applied using either static pressure for 15 minutes or cyclic pressure with five-minute intervals. The authors of ASTM E331 proposed that 15 minutes was a sufficient time period to exhibit weaknesses in the fenestration system.

Although the ASTM E331 standard has been updated four times since its creation, the basic components of the test method have not changed. Indeed, the procedure in ASTM E331 is now so standard that it is used widely in test methods and voluntary specifications throughout the industry.

The ASTM E1105 standard has also been updated several times over the years, but much like the E331 standard, the basics of E1105 have remained the same. For the purpose of this paper, the author intends to discuss ASTM E1105 specifically, as it is the standard usually followed during field fenestration tests and the document that is often scrutinized when a field failure occurs.

**DISCUSSION ON ASTM E1105 TEST STANDARD**

This field test standard has some specific wording, as well as some notable ambiguities. For example, being strictly a test procedure, ASTM E1105 does not specify a minimum test pressure (though both ASTM E331 and E547, the lab equivalents, do). The test pressure, which one can argue is a design requirement rather than a procedural item, is left up to the industry in the field and could be the subject of a paper on its own. Instead, the standard specifies how to achieve a pressure differential. Given the origin of the test, it is safe to assume that the intent of the test is, and has always been, to provide a standardized method of testing that can be performed at various levels of intensity. Specifically, the intensity of the pressure chamber test is determined by the pressure differential applied to the chamber. The pressure differential is the key variable; all else being equal, different windows will test to different pressure differentials. This approach is consistent with standard scientific method, in which a limited number of variables are monitored and controlled in a repeatable test.

On the other hand, the test procedure is clear on the rate of water spray to be applied to the test specimen—a rate of five gallons per hour per square foot. Since this is very clearly called out in the ASTM test, it is sometimes scrutinized during testing as having a more significant impact on the performance of the specimen than the ASTM E1105 authors intended. Some observers have attempted to convert the spray rate in this standard to inches per hours of rainfall. ASTM, in their non-mandatory information note “X1., Spray Rack Rate,” indicate that the purpose of the water-spray system is to wet the specimen uniformly for the purpose of evaluating water resistance. There is no evidence that the developers of Test Methods E1105, E331, and E547 intended to reproduce or simulate any given rain event. Indeed, the author’s anecdotal experience with field fenestration testing suggests that the rate of water application to a vertical window surface alone does not usually govern, since water is shed quickly from the surface and does not typically accumulate sufficient volume to generate enough hydrostatic pressure on the exterior of the fenestration to make a significant impact. The number, 5 gal/hour/sq. ft., is merely a target.

Time is also defined in the test standard: 15 minutes continuous in Procedure A (static), and at least 15 minutes of pressure difference total in Procedure B (cyclic). The 15-minute duration of spray was included in the initial ASTM E331-70 definition of “water leakage” and has since carried forward to some degree in the ASTM E1105 standard. The duration of spray—much like the rate of water application—is intended to provide enough time to allow a discontinuity or leak to present itself and is not necessarily intended to be representative of real-world rain conditions.

Along with defining the test procedure, including specifics on water spray and method of achieving pressure differential, the test method defines a series of terms and definitions. One notable definition that is included is for the term “water penetration,” which the standard defines as:

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

Based on this definition, at any given specified test pressure, water can enter the test chamber and remain on the window specimen. If that water does not overflow the “innermost vertical plane” of the specimen, the water intrusion is not considered “water penetration” (Figure 6). Though the test is very specific on the definition of water penetration, it is ambiguous on allowable quantity.
Additionally, the standard defines a failure criterion as:

...water penetration in accordance with 3.2.3 [definition of water penetration]. Failure also occurs whenever water penetrates through the perimeter frame of the test specimen. Water contained within a drained flashing, gutters, and sills is not considered failure.\(^9\)

The challenge with these definitions is that, depending on their interpretation, they may not always align with the expectations of designers, specifiers, and the end users of the windows, and may conflict with building science-based design objectives, discussed further in this paper (Figure 7).

Following research on the origins of the test standards and their wording, the origin of the definition for water penetration was not clear to the author. One may be able to surmise that it might have something to do with the very early standardized testing of glass jalousie windows at the University of Miami, which intrinsically don’t have a water or air control layer (more on these later). If a definition for water penetration must be global enough to work for both a jalousie window on the one hand, and a unitized curtainwall on the other, then this might be the right definition.

Or, perhaps a different reasoning for this definition might be how the authors thought the test should be applied. For example, the authors may have intended this to be a “limit states” test—a test to bring the specimen to near ultimate loads under which some leakage, if contained, would be considered reasonable performance. Perhaps, when the test standard was developed following early testing in Florida that simulated hurricane conditions, the mindset of the authors may have been that the window, under such conditions, should be allowed to leak and capture water to some degree—thinking that the window would seldom be exposed to such intense weather events and would not leak under normal conditions. Surely, it is reasonable to say that the window should have some design pressure under which no water intrusion should occur, and some limited state during which a finite amount of controlled water leakage may be reasonable to anticipate.

Whatever the origin of the wording, ASTM E1105 (as well as E331 and E547) ultimately allows the designer and specifier some room for modification, if needed, to align with their project goals, indicating that the failure criteria is as defined “unless otherwise specified.”\(^9,13,16\)

The AAMA501.1 test method (the propeller test) has a similar, though slightly more specific, definition of water penetration (called “water leakage” in the test method), defining it as:

...any uncontrolled water that appears on any normally exposed interior surfaces, that is not contained or drained back to the exterior, or that can cause damage to adjacent materials or finishes. Water contained within drained flashings, gutters, and sills is not considered water leakage. The collection of up to 15 ml (½ oz) of water in a 15-minute test period on top of an interior stop or stool integral with the system shall not be considered water leakage.\(^15\)

This definition is mostly adopted by the AAMA 503 voluntary specification (which is intended for curtainwalls),\(^18\) while the AAMA 502 voluntary specification maintains a definition similar to that in ASTM E1105 and E331.\(^17\)

The different interpretations and definitions of water penetration, water leakage, and fail criteria in the standards compel the industry to take another look at these standards and consider whether a global change may be in order. The definition of water intrusion is simply perceived by some in the design community as being “too lax,” and as a result, designers and specifiers are frequently applying more stringent definitions in their project specifications,\(^9\) which in turn often leads to contention when manufacturers don’t fully understand the idiosyncrasies of a project specification and bid their product based on standard AAMA or ASTM definitions.

**THE BUILDING SCIENCE**

In 1967, when ASTM E331 was first being developed and published, the field of building science was still very much in its infancy. The National Institute of Building Sciences (NIBS) was founded in 1974, with a mission to connect the U.S. government with the private sector in an effort to “improve the built world.”\(^10\) In Canada, the Canada Housing and Mortgage Corporation (CHMC), founded in the 1940s to house war veterans returning home from World
War II, didn’t start to focus on the performance of building enclosures until the late 1970s. Indeed, the CMHC credits the 1990s as being the “new era of building science,” in which the building enclosure became a big part of the conversation as it pertains to building performance. The Roof Consultant’s Institute (RCI) joined the picture in 1983, focusing first on roofing, and growing into the international group we know today, whose mission now incorporates the full building enclosure.

The standards, not having changed significantly, have remained largely idle through substantial changes and leaps of knowledge in the building industry. This is not to say that the standard must change for the sake of change itself. What the author suggests is that the building enclosure discipline has experienced a paradigm shift since the 1990s, and the route of normal science is to revisit practices as paradigms change. The gains in knowledge of fenestration design and manufacturing that have largely developed alongside the gains in the building science discipline compel the standards to adjust such that they fit into the larger picture and remain relevant.

Fundamentally, the intent of a building enclosure system is to separate environments. The exterior environment is uncontrolled, and has conditions that can be widely variable. Interior conditions, on the other hand, are often intended to be more stable, controlled, and less variable. In order to separate these environments and enclose a space, we need to control the variables. These variables, which are addressed by the enclosure, include air and its component parts: water, heat, harm (people and impact), fire, and sound. Sometimes, the enclosure even acts as structure while simultaneously controlling these variables. For the purpose of this discussion, we will focus on the separation of environments necessary to control weather—specifically air, water, thermal, and vapor variables.

In this regard, when designing a building enclosure, the building science professional focuses on what are known as “control layers.” Basically, these are defined boundaries in the building enclosure that work together to separate the exterior environment from the interior environment. These control layers are continuous around the full enclosure and can be traced from the walls, to the roofs, to the floors. They are also closely related to each other, as you will read below. When considering one of the control layers, we must always remember to step back and consider how it relates to the others, and how it relates to the larger building system.

The primary control layers that a building science professional reviews are air, water, thermal, and vapor.

**Water**

Control of bulk water is important for longevity of the building structure. Because of the nature of most building materials, water is responsible for much of the damage associated with a building enclosure failure. Uncontrolled water intrusion is also often responsible for deterioration of interior air quality. Because of the fluid nature of water, the water barrier must be continuous, though it does not need to be continuously sealed. Redundancy and containment are important for water control, as well as lapping and shedding. Liquid water is often carried within moving air, in the form of wind-driven rain, so even though a water barrier does not necessarily need to be air tight to be waterproof, one must consider the location and detailing of both the water and air barriers together when designing for water control.

**Thermal**

The energy we feel as temperature is held largely in the bulk gasses of air. So, a well-designed and constructed air barrier is usually the first step for thermal control across the building enclosure. The building enclosure is intended to keep occupants at a comfortable temperature despite the cold or heat outside. To do this, a thermal insulation system, used to control heat exchange across the enclosure, is necessary in addition to an air barrier. Heat is transferred primarily in three ways: convection (movement of fluids—addressed by the air barrier and thermal insulation), conduction (through solids—addressed by thermal breaks and through thermal insulation), and radiation (through space itself—addressed by reflective coatings). In order for the thermal enclosure to be effective, it needs to be continuous.

**Vapor**

Water vapor (gaseous water) is a special trace gas within the mix of gasses that make up air. Water vapor is unique in that it ties the water, air, and thermal control layers of the enclosure together. Consider that water gas molecules are much smaller than the rest of the molecules in bulk air; as a result, water vapor can diffuse through some materials that would otherwise be impermeable to bulk air. The ability of air to hold water vapor is a function of the air’s temperature; more heat means more energy and thus more water vapor. We experi-

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Figure 8 – Building science control layers overlain onto a typical curtainwall assembly.
ence the water vapor in the air as humidity. While water vapor can diffuse through materials that the rest of bulk air cannot, it usually does so quite slowly. Bulk air movement, on the other hand, can carry water vapor across an enclosure much more effectively than diffusion alone. So, a continuous air barrier remains important in control of water vapor—but a well-placed vapor retarder is also important.

In general, these four primary control layers need to translate at all interfaces, including at fenestrations, to make an effective enclosure system. Figure 8 applies these control layers to a typical fenestration system.

Different types of fenestration systems treat the various control layers differently, but in general, there are three ways to construct a fenestration system. For the purpose of this paper, we have assumed that all the fenestration systems discussed are designed with an air barrier in mind, as required for conformance with most commercial energy and building codes.

- **Face Sealed** – Face-sealed systems have no plan for water within the outermost surface of the system. All seals and gaskets in a face-sealed system are assumed to be perfectly tight. In a face-sealed system, no water should enter the system, as there is usually no means to drain the water back to the exterior.

- **Concealed Barrier** – In a concealed barrier system, the primary water and air control layers are concealed by some cladding component. The cladding component is not necessarily intended to drain and manage water; it simply covers the underlying layers and conceals them.

- **Rainscreen** – A rainscreen system employs a two-stage approach to managing water. There is an exterior water-shedding surface that is mostly continuous with intermittent weeps; a concealed, protected, and vented drainage cavity; and a backup water-control boundary beyond which no water is intended to pass to the interior.

In each case, there is a defined plane for all the discussed control layers. We will highlight the defined water-control boundary, beyond which the design intent is for no water to be permitted. Refer to graphics in Figures 9, 10, and 11 for examples of how the water control boundary looks in each type of fenestration.

**BRINGING IT ALL TOGETHER**

When considering the building science side of the equation, one finds a clear disconnect between the industry-adopted definitions of water penetration in the standards and the design intent as described in building science fundamentals, which include a water control boundary that is often not planar.

The scientific method
requires repeatable tests with controlled and limited variables that test a specific item to prove or disprove a hypothesis. Each fenestration design and assembly can ultimately be seen as a hypothesis of performance. It’s important to understand what the intent of the test is, or consider what it should be: What, specifically, is the test standard trying to prove or disprove? Ultimately, the test standards referenced in this paper are a validation of the water control boundary for the fenestration system. Consider again the definition of water penetration in the referenced test standards. When looking at the various boundaries of the water control for different fenestration systems, as is done in Figures 9-10, it is evident that the water control boundary as defined by the building science doesn’t align with the boundary used to trigger the term “water penetration” as defined by the fenestration system test standard (Figures 12 and 13).

The author notes that control layers are not necessarily absolute. The air control layer, for example, does not stop all air from passing in an uncontrolled manner; rather, it limits the rate of air penetration to a manageable level. This is similarly the case for the building enclosure thermal and the vapor control layers; these do not necessarily completely stop the passage of energy or vapor, respectively. Rather, they reduce the uncontrolled passage to a manageable level. One may argue that the water control layer is no different and that some water intrusion onto the window, provided that it is controlled and manageable, is sufficient for performance. While this is a fair conclusion, the author suggests that liquid water control in the building enclosure is special. It is fair to say that some water passage inboard of the outer face of the fenestration system is usually inevitable. Indeed, building enclosure design allows for water to be controlled and managed through the rainscreen principle, which is increasingly the method of design for enclosure components. Fundamentally, the water control layer actually consists of multiple layers: a water-shedding layer, a drainage space, and a boundary of watertightness beyond which water is not permitted to pass at the specified design pressure difference.

Consider Figure 13, which shows a typical operable casement window. This figure illustrates one example of a fenestration system allowing water to bypass the outermost plane in such a way that it is contained within drained gutters that are intended to take and discharge water. Building science fundamentals acknowledge that it is nearly impossible for water to not bypass the outermost plane of any system. This is why internal drains and gutters are fairly standard practice in many fenestration systems. Allowing water to bypass the secondary water control boundary—even if that water is contained on the frame of the window inboard of the water penetration boundary defined by ASTM—would defeat the design intent of the system. Water inboard of that secondary water control boundary is simply not planned for, and thus, not intended to drain or be discharged in any way. Allowing water to bypass that line without constituting a failure simply because the water is inboard of the innermost vertical plane of the specimen, does not acknowledge the design intent of such a system.

Looking at the adjacent building enclosure components, such a definition that allows water to bypass the boundary of watertightness at the specified pressure difference would simply not suffice. The fenestration, being an extension of the building enclosure, is often subject to the same rigor and performance expectation. It is with this perspective that the building enclosure designer comes to the table.

Consider the face-sealed fenestration system in Figure 9 and the concealed barrier fenestration system in Figure 10, which I’ve shown again in Figure 14 with the “water penetration” boundary as defined by the test standard. While these two fenestration design approaches do not employ a rainscreen principle, they, by design, also do not allow for the passage of liquid water inboard of their water-control boundary. In these designs, water intrusion into the window beyond that boundary would constitute a failure of the design intent, even though

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**Figure 12 – Water control boundary as defined by building science compared with “water penetration” boundary as defined by ASTM E1105.**

**Figure 13 – Water control boundary as defined by building science compared with “water penetration” boundary as defined by ASTM E1105.**
it may not constitute a failure by letter of the standard. This approaches the heart of the misalignment in expectations and the origin of much contention during interpretation of field test results. The standard has a set criterion of failure that is based on a definition of water penetration that does not match the design-side definition of water penetration. The boundaries defined by the building science design community simply do not match the boundaries established by ASTM in the late 1960s. Until these boundaries agree, there will remain a potential for misunderstanding, unmet expectations, and contention in our industry.

**THE PATH FORWARD**

ASTM does not purport to be a steady-state organization, where, once a standard is published it is held indefinitely. Indeed, ASTM invites the industry to comment on its standards and provide feedback and criticism as may be appropriate with the changing times. To this point, ASTM has already been considering draft edits to the definition of water penetration as is described in ASTM WK27894, which was initiated in 2010, is still in draft form, and states that “The current definition of water penetration in E1105—as well as E331 and E547—does not align with end user expectations when associated with service wind loads. This work item will provide a more accurate definition of water penetration with end user expectations.” Being a consensus organization, changes often take time while the committee considers the perspectives of various players and considers potential unforeseen impacts from any changes.

In the interim, designers, specifiers, and owners may consider a few steps that can be taken to mitigate the potential for misunderstanding and contention as they relate to window water penetration performance testing in the lab and field. Some possible steps are included below:

1. **Request and read the test reports** from the fenestration manufacturer, and inquire what water penetration test was performed in the lab, what the specific results were, and how the test was performed. Even though the ASTM lab test procedure defines water penetration the way it does, many manufacturers test their windows such that no water intrusion occurs inboard of the water control boundary. Understanding how the specific fenestration was tested in the lab will provide a more realistic performance expectation that the manufacturer will be more likely to honor in the field.

2. **Define the expected performance** clearly in your project specification, including a reasonable and appropriate pressure difference that the fenestration system must (and can) meet in the lab and in the field, a specific definition of water penetration that respects the fenestration design intent and the boundary of watertightness, and criteria for a failure that also respects the design intent for the specific fenestration.

3. **Consult with your fenestration manufacturer, window installer, and owner** early in design and construction to relay the project performance expectations. The project performance expectations should be set amongst the owner, design team, and window manufacturer prior to any testing. It may be the case that under test conditions, a limited amount of water in the test definitions is acceptable to an owner if there are trade-offs with cost and the expectation is set. Keep in mind that while a current owner may accept the performance of a fenestration for a cost savings, a future owner (if the building gets sold) may not accept such performance criteria.

On the larger industry scale, a revision to the ASTM standard is due, in the author's opinion. The definition of water penetration in the referenced standard and subsequent
standards is too prescriptive and does not respect the design intent of many modern fenestration systems or the current practices of building science. In order to adjust for this mismatch, many designers provide project-specific performance criteria, sometimes including a more stringent definition of water leakage, but this often leads to contention in the field, especially when there is a water leak and the manufacturer contends that their product is held to a different standard. Fundamentally, the point of a standard is to standardize wording so that such contention is avoided. An update to the standard can be as simple as revising the definition of water penetration to “any water that passes the defined boundary of watertightness for the fenestration system at the specified pressure.” This definition would allow manufacturers to define their own boundary of watertightness clearly, such that owners and designers would better understand what to expect and could rely on their windows not exhibiting water leakage of any kind inboard of the boundary of watertightness under specified conditions.

Ultimately, when there are misunderstandings or contention in the field, it is usually the result of poorly set expectations. In such cases, it is best for all players to step back, consider the perspective of those around them, and find a common middle ground that is practical, appropriate, and respects the project goals. In this regard, a common understanding of fenestration systems, building science principles, along with the design team and end-user expectations, may help bridge the misunderstandings and move the industry as a whole one step further.

REFERENCES

4. AAMA 501-15, Methods of Test for Exterior Walls.
16. ASTM E547-00 (Reapproved 2009), Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference.
17. AAMA502-08, Voluntary Specification for Field Testing of Newly Installed Fenestration Products.
18. AAMA 503-08, Voluntary Specification for Field Testing of Newly Installed Storefronts, Curtain Walls and Sloped Glazing Systems.