PROOF POSITIVE:

MEASURING AIR BARRIER PERFORMANCE WITH THE ASTM E 2357 STANDARD

BY MARK KENNEDY AND CRAIG BOUCHER

Today, no commercial building design is complete without a continuous air barrier. Preventing air leakage is a critical factor in creating energy-efficient and healthy structures. Indeed, preventing air leakage can generate energy savings of up to 39%, according to a recent study by the National Institute of Standards and Technology.[1] In addition, a robust, continuous air barrier helps control moisture in wall structures. Moisture can degrade energy efficiency, cause structural damage, and is a major cause of mold and other health hazards that can contribute to "sick building syndrome."

For architects and specifying engineers, this simple reality begs a complex question: How can one know that a particular air-barrier assembly will effectively prevent air leakage? While manufacturers of air barrier materials and products claim a variety of advantages, how can one validate the performance of products in the context of a typical application, under real-world conditions?

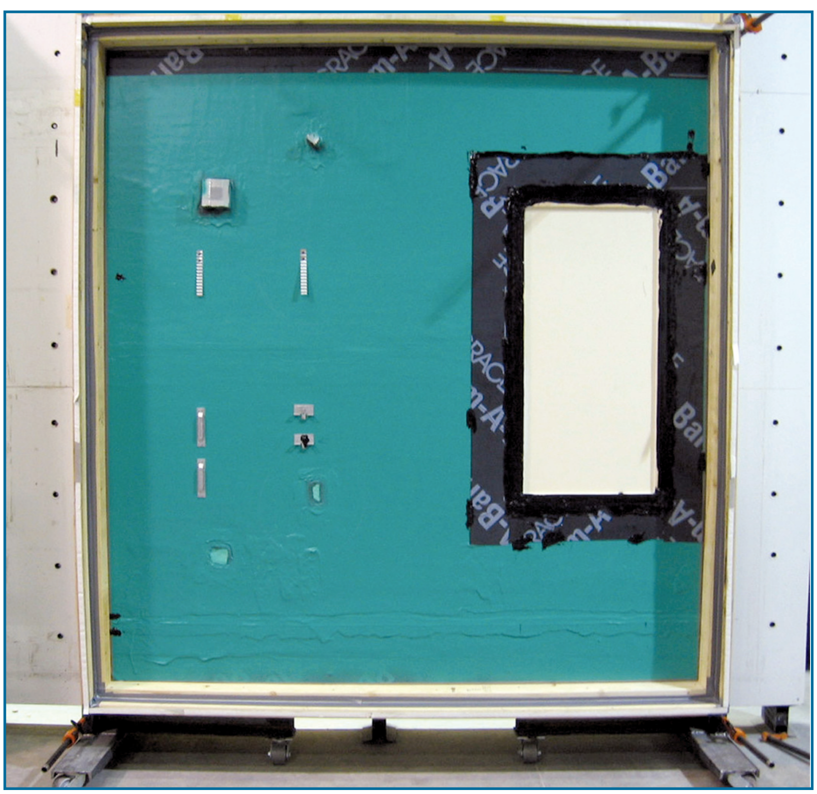


Figure 1 – Photo of an 8 ft x 8 ft mock-up wall with penetrations and a window opening to be tested per ASTM E 2357.

A Uniform Test

The answer lies in a standard recently adopted by the American Society for Testing and Materials (ASTM): ASTM E 2357 *Standard Test Method for Determining Air Leakage of Air Barrier Assemblies*. Developed in collaboration with leading architects and structural engineers, ASTM E 2357 provides a uniform methodology for testing and measuring the leakage rate of air-barrier assemblies as they are typically used in building enclosures, under realistic wind -load cycles.

Prior to ASTM E 2357, one could only evaluate performance for individual air barrier assembly components—the air barrier, the flashing, or the sealing materials by themselves. This "piece-by-piece" approach does not provide a holistic evaluation of real-world performance, where the interaction among components—and the interaction of components and wall elements such as

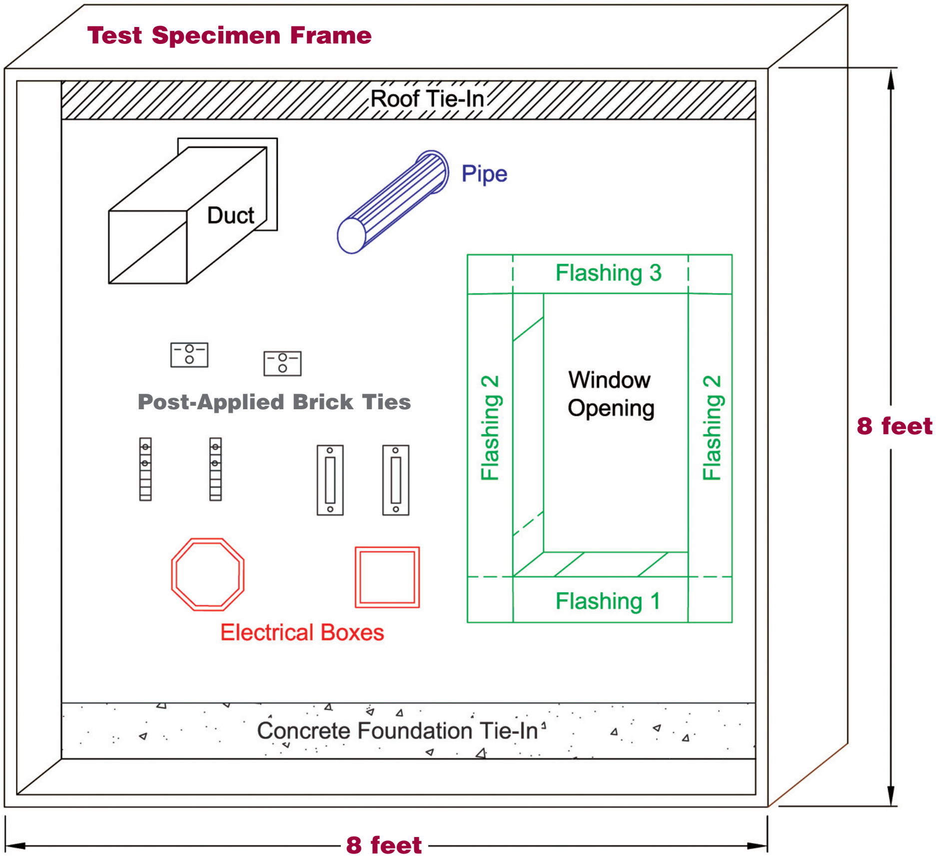


Figure 2 – Diagram of specimen wall for testing air-barrier assembly performance, as specified in ASTM E 2357.

windows and other penetrations—is key to the assembly's ability to maintain a continuous barrier. ASTM E 2357 overcomes these limitations by enabling a uniform method of evaluating and comparing entire air-barrier assemblies.

The first such objective, uniform method available, ASTM E 2357 has been adopted by the Air Barrier Association of America (ABAA) as a key element of its acceptance criteria.

"ASTM E 2357 is the only test method that gives the user any information on the performance of an installed air barrier assembly. Every building contains multiple air barrier materials. Only when a material is selected and combined into an assembly does it actually perform the function of an air barrier," said Laverne Dalgleish, executive director of the ABAA. "ASTM E 2357 determines the air leakage rate after being conditioned under real-world loads, which provides the user with a precise air leakage rate and confidence that it will provide this performance when installed. Data from ASTM E 2357 is critical to every design professional."

Realistic Wall Specimen

ASTM E 2357 defines a specimen wall assembly and test protocols for evaluating air-barrier performance. The specimen is a realistic, 8 ft x 8 ft wall mock-up, complete with typical wall penetrations—window, galvanized duct, PVC pipe, post-applied brick tie-ins, and hexagonal and rectangular electrical junction boxes, all of specified dimensions—as well as roof and concrete foundation interfaces (see *Figure 2*). The air barrier assembly to be tested is applied to the wall, complete with flashing and sealing materials applied around all penetrations and at air-barrier joints in specified locations on the wall. The wall specimen is then mounted in a well-sealed test chamber with an air supply that allows application and measurement of both positive and negative air-pressure differentials across the wall structure.

Test Procedure

Once the specimen is secured in the test apparatus, the wall specimen is subjected to a specified wind-load schedule with both positive and negative loads during three distinct loading stages (see *Figure 3*):

- **Sustained Load –** 600 Pa (12.5 psf – equivalent to 70 mph) for one hour.[2]
- **2000 Cyclic Loads (Positive and Negative) –** 800 Pa (16.7 psf – equivalent to 81 mph) pulses for three seconds, after which pressure is released until it returns to 0 Pa; this is performed 2000 times with positive loads, followed by 2000 negative load cycles.
- **Wind Gusts –** 1200 Pa (25 psf – equivalent to 99 mph) for three seconds.

After each stage, the air barrier assembly is inspected for signs of damage, loosening, or other failure that could compromise performance. Following the wind loading, the air-leakage rate or air permeance is measured at a reference pressure of 75 Pa (air permeance is also measured at 25, 50, 100, 150, 250, and 300 Pa). Upon completion of the air permeance measurements, air-barrier deflection is measured.

The result of this calculation is a measurement of air permeance expressed in terms of cubic feet per minute per square foot (cfm/ft^2) or liters per second per meter squared (L/s*m^2). As a yardstick, the ABAA-specified requirement for an air-barrier assembly tested according to ASTM E 2357 is 0.04 cfm/ft^2 (0.2 L/s*m^2)or less.

Testing the Standard

In April of 2007, Grace Construction Products contracted independent laboratory Intertek to conduct testing on several barrier materials per ASTM E 2357. Testing was conducted at Intertek's Madison, Wisconsin, facility. Six wall specimens were constructed according to the ASTM E 2357 specifications, with a different air barrier material applied to each set of two walls: a fully-adhered sheet membrane; a synthetic, spray-applied membrane; and a spray-applied, vapor-permeable, "breathable" membrane. Flashing membranes were used to flash the window openings on all wall specimens, and a liquid membrane was used in appropriate areas, such as water-bucking laps of flashing membrane and annular space around the duct, pipe, and electrical box penetrations.

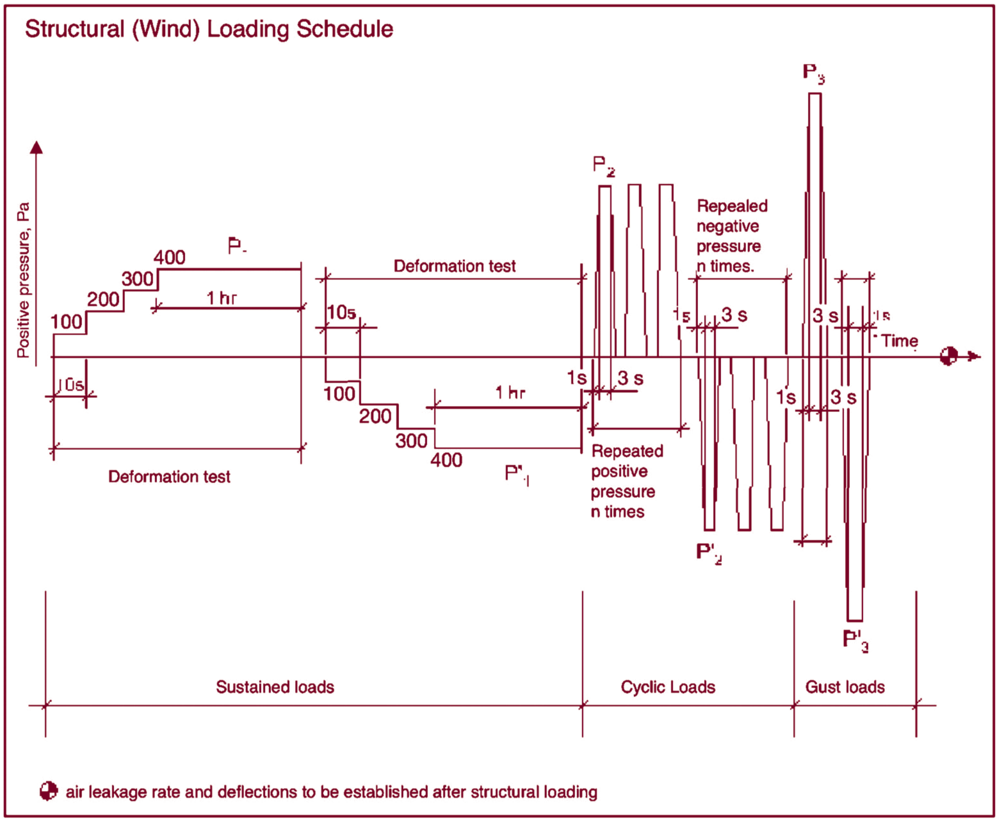
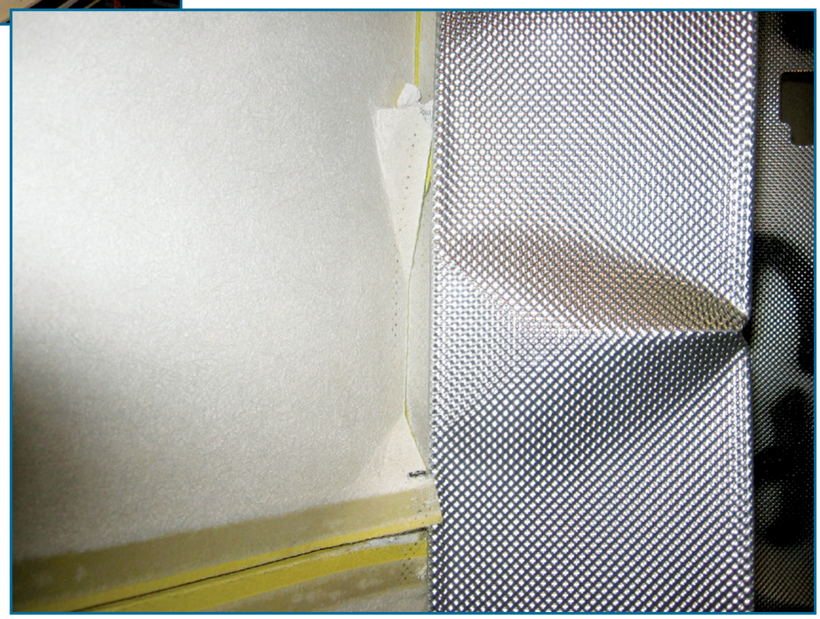


Figure 3 – Chart of Wind Loading Schedule specified by ASTM E 2357, illustrating positive and negative sustained, cyclic, and gust loads, to which the air barrier assembly is subjected during testing.

After being subjected to the ASTM E 2357 standard wind-load schedule, air permeance for all three of the wall specimens was measured to be less than <0.0008 cfm/ft^2 (0.004 L/s*m^2). This represents air leakage rates below the detectable limit of the laboratory test equipment for all three air-barrier assemblies tested.

Intertek then took testing a step further, going beyond the wind loads specified by ASTM E 2357 to test the air-barrier assemblies under extreme conditions. They were subjected to the equivalent of 168-mph wind gusts (for comparison, the highest

Figures 4A, 4B, and 4C – Photographs of some of the six wall specimens tested by Intertek. Each wall specimen was constructed according to ASTM E 2357 specifications, with one of the three air-barrier materials tested.



Figures 5A and 5B – The air barrier systems tested by Intertek withstood wind gusts equivalent to 168 mph, remaining fully adhered and intact while the substructure was brought to failure.

wind gusts recorded during Hurricane Katrina were approximately 150 mph), at which point the wall structure itself buckled under crushing air pressures of up to 72 psf (3445 Pa). The air barriers remained intact and fully adhered to the wall, even as the underlying wall structure failed.

A key contributor to the ASTM E 2357 standard, Lance E. Robson, Jr., AIA, of Building Envelope Technologies, Inc., reviewed the test results and was pleased to see that the standard delivered the insight intended.

"Air barrier products have abounded on the marketplace in recent years, as the industry has embraced a new understanding in building construction, which itself is a rare occurrence," Robson said. "By providing test results utilizing ASTM E 2357, product manufacturers can demonstrate the sufficiency of their materials when combined into an assembly that will work with the whole building system. This enables all interested parties to make informed decisions with assurance for the buildings' design and sustainability."

References

1. Steven J. Emmerich, Timothy P. McDowell, Wagdy Anis, "Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use," (NISTIR 7238), June 2005.
2. The Pascal (Pa) is the scientific unit of pressure. 1 Pascal = 0.01 millibar of air pressure.

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