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The Importance of Integrating Flashing and the Water Resistive Barrier in the Exterior Wall Systems of Residential Buildings

ABSTRACT: Building science studies have recognized the importance of the proper installation of flashing and its integration with the water resistive barriers as very important to the success of a wall assembly. The roll of flashing is to direct water away from the opening to the water resistive barrier, which in turn directs the water to the exit point in the wall. The integration of these two elements and the quality of their installation is ultimately important to the success of the wall system. It is equally important to select products, which perform as intended after installation. Extensive testing has been conducted on local and regional methods that do not follow the guidelines in E 2112. When tested, many of these installation methods completely fail to perform the required function of preventing water leakage. Conclusions are that it is important to follow E 2112 in installing flashing and integrating it with the water resistive barrier (WRB). It is equally important that a WRB is used. Each element of the installation is important. If the flashing is perfect, but the WRB lets water through, then there are potential problems.

KEYWORDS: flashing, WRB (water resistive barrier), wall assembly, window installation

Introduction

The importance of a well-integrated flashing/water resistive barrier (WRB) system cannot be underestimated. The Oak Ridge National Laboratory Study done in conjunction with the City of Seattle [1] states as one of their general observations:

"Building envelopes should be designed to manage the flow of incidental moisture. It is especially important to reduce the amount of water entering the wall where adjoining building envelope components meet and where there are envelope penetrations such as windows, vents, doors, and decks.

Proper installation of weather resistive barriers and integration with flashing is one of the most important factors in the successful performance of exterior walls. Two layers of WRB (one installed behind the other) was shown to provide better drainage control than one layer."

The role of flashing is to redirect water away from the window/door opening to the outside of the wall. There are a number of different types of flexible flashings which can accomplish this. Mechanically attached flashings have been successfully used in the western United States for over 50 years. Self-adhering flashings, made with a variety of adhesive types and configurations, are a more recent addition. Self-adhering flashings offer an additional level of sealing to the window, but they are technically very demanding and need to be installed correctly.

The role of the WRB is to protect the sheathing and prevent water intrusion into the building. Water directed from the flashing to the WRB must be allowed to drain quickly out of the wall. This interface between the flashing and the WRB is critical to managing moisture in the wall. This is why flashing installation standards, such as E 2112 [2], detail not only the installation method of the flashing, but its integration with the WRB.

The AAMA Task Group on Installation Issues developed a new Standard, AAMA 504-05 [9] detailing how to test installations that deviate from ASTM E 2112. The purpose of this standard, which details a comprehensive test method, is to allow for installation variations particularly for new products and new methods.

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The AAMA Flashing Task Group has developed a performance standard (AAMA 711-05) [10] for self-adhering flashings. Part II of this standard, currently being developed, will be the installation issues surrounding self-adhering flashings. Part III will deal with the issues of mechanically attached flashings.

As the standard develops, the performance categories will become more specific and more reflective of how the products function.

WRBs were also described by a general material description, but there is now a movement starting to look at water resistive barriers by classifications based on the material structure of the product, rather than just perms and strength. This system better distinguishes the various products on the market and should provide greater ability to understand the characteristics of each product. See Table 1.

TABLE 1—*Classification of WRB by structure.*

•Type C	Asphalt impregnated cellulose fiber
•Type P	Polymeric fibrous
•Type PP	Perforated polymeric film
•Type L	Liquid applied (trowel, roll, spray)
•Type M	Microporous film

We relate laboratory testing to field experience. Problem installations are more often the result of poor workmanship than product problems. We are often asked to approve various regional installation methods. Testing these methods highlights what works and what does not.

Our testing has helped us define installation criteria and advise customers on their installation methods. The integration of flashing into the WRB creates a water management system that time and again proves to be the most successful method of managing water intrusion.

The tests below are only a representative sample of the testing we have completed, but they highlight the points above and illustrate how the information can be used:

1. To confirm installation methods.
2. To test real life field applications, particularly common current regional field practices.
3. To obtain objective results to understand the needs of future products and testing.

Tools Used in Evaluation

We used our own laboratory, third party laboratories and we participate in a number of important building science projects.

While we use standard test methods, our field experience requires that we modify and adjust tests to answer field questions and learn how our products perform under varying conditions. In all cases we are trying to duplicate the real world we see regularly. For example:

1. Hydrostatic head test: In addition to the standard test procedures, we introduce various elements to determine how various products perform under real field conditions when in contact with various substances, such as surfactants, sealants, paint and preservatives.
2. Cold box test: We had field reports from Texas that one type of butyl, flashing, installed on a cold morning ($<40°$F) would fall off as the day warmed. After duplicating this condition in our cold box multiple times, we now know that these types of adhesives are more subject to this phenomena than other adhesive types. This test criteria gives us a good performance method for evaluating new adhesive developments.
3. Compatibility testing. Materials need to be compatible and as there are no industry standards on compatibility. As a result we test our own systems and define which materials are compatible with our products. We have looked at the following and can make firm recommendations on use with our products:
   - Sealants and caulks
   - Plasticized PVC (polyvinylchloride)
   - Foams
   - EPDM (Ethylene propylene diene monomer)
   - Surfactants and wood extracts
   - Water sealants and coatings

Using third party laboratories, we test to recognized ASTM standards, such as E 1677 [3], E 283 [4], E 330 [5], E 331 [6], E 547 [7], E 96 [8], etc. We subject our products to more severe conditions than called for in the test. For example, in order to test to failure, we generally will run the test buck with only the water resistive barrier, flashing, and window. We may also test to failure in order to better understand the product and installation implications. In many cases a complete wall system (with a facing material) is difficult to analyze. Our goal is to determine if there is any product or installation defects as soon as possible.

Test Results

The following tests are representative and illustrate some of the issues discussed above. The tests highlight some installation issues and the importance of integrating flashing into the WRB system. In the course of conducting these tests, we have also learned that water/moisture intrusion is not just a flashing, integration or installation issue, but that the WRB can play a significant part in the success of a wall assembly.

In the early development phase of our first self-adhering flashing, we did a number of ASTM E 331 tests. Installations were tested under pressure at one hour and up to eight hours, far in excess of the test requirement. We learned that self-adhering flashing should not be put over the bottom flange of the window. When water gets through the facing material, the jamb flashing directs the water down, as it should. However, covering the bottom flange created a dam effect and the water came up and over the flashing, clearly blocking the water from exiting. Simply taking a razor and cutting the corners of the flashing over the bottom flange immediately stopped the leak. Bolstered by subsequent testing of this concept, our installation instructions tell customers not to use a self-adhering flashing over the bottom flange of the window.

We conducted a battery of tests on four different flashing types, using Methods A, B, A1, and B1 using the installation standard developed by CAWM (California Association of Window Manufacturers). The CAWM Association was absorbed by AAMA. The test wall was covered with 60 min paper and a plastic house wrap. We tested these integrated systems according to ASTM E331 at 2.86 psf (33 mph) and 6.24 psf (50 mph). It became clear that all elements of the installation have to work, or the installation fails. See Table 2.

A wood window with a brick mold was tested in an installation using Method B1 with a 60 min asphalt saturated WRB and 9 in. Self-adhering flashing. Using the ASTM E331-96 test, there was no water

TABLE 2—*ASTM E331 moisture test of an installation.*

Product	Test pressure Psf	Results
60 minute paper	2.86	No leakage
Method A	6.24	No leakage
60 minute paper	2.86	No leakage
Method B	6.24	No leakage
Self-adhering Fl.-60 minute paper	2.86	No leakage
Method A	6.24	No leakage
Self-adhering Fl-60 minute paper	2.86	No leakage
Method B	6.24	No leakage
Bitumen Fl-plastic house wrap	2.86	No leakage
Modified method A1	6.24	Leakage at top diagonal WRB cut due to sealing tape pulling away at corner.
Bitumen Fl-plastic house wrap	2.86	No leakage
Modified method B1	6.24	Leakage at top diagonal WRB cut due to sealing tape pulling away at corner.
Self-adhering Fl-plastic house wrap	2.86	No leakage
Modified method A 1	6.24	Leakage at top diagonal WRB cut due to sealing tape pulling away at corner
Self-adhering Fl-plastic house wrap Modified Method B1	2.86 6.24	Leakage at top diagonal WRB cut due to sealing tape pulling away on both levels of pressure.

NOTE: Two types of flashing were tested and defined as self-adhering flashing=nonbitumen adhesive; bitumen adhesive=bitumen based adhesive system.

entry at 2.86 psf or 6.24 psf. We test various window types in order to be certain that our methods are appropriate to all parts of the country.

We had requests from builders in various parts of the country to test common installations in their area. We tested various flashing products and sizes, such as 4 in., 6 in. and 9 in.. To summarize the major results:

1. Regardless of the flashing size, products installed directly on OSB (oriented strand board) without a WRB failed at 2.86 psf. There was substantial water on the OSB, which in turn deteriorated. While most of the self-adhering flashings remained adhered and pulled fiber from the OSB after the test, the structure of the OSB deteriorated to the point where water came in behind the flashing affecting the ability of the flashing to perform its function. In the southeast, many builders consider OSB a weather barrier and do not see the need to cover it with a WRB.
2. A structural polycoated fiberboard was installed as per the instructions printed on the product. The expansion gap between sheets proved to be a channel for water. These installations failed consistently at 2.86 psf. The only way to eliminate water coming in behind the well-adhered flashing and into the window opening was to seal the gap with tape.
3. Using the above installations (OSB and polycoated fiberboard) with the addition of 2 ply 60 min WRB, the installation passed at up to 12 psf (68.5 mph), the limit of the testing equipment.
4. A competitive 4 in. bitumen flashing, using the manufacturer's instructions of no sealant, no WRB, was tested on OSB, and it failed at 2.86 psf.

In developing our new mechanically attached flashing, the next generation of mechanically attached flashing, we conducted the ASTM E331 test with 2 ply 60 min Asphaltic paper as the WRB. The Method B installation passed with wind speeds up to 25.6 psf (100 mph). Mechanically attached flashings, installed correctly, are effective at high wind speeds.

Testing in-house and with outside laboratories, it became clear that there were certain non-flashing issues that lead to moisture/water during the test. See Table 3 for what was discovered in a first test.

TABLE 3—*Water penetration test—ASTM C547-93.*

Material	Test pressure range PSF (mph)	Water permeability gallons/day/ft2
60 minute paper #1	36.3–34.7 (119–116)	0.023
60 minute paper #2	36.5–35.4 (119–118)	0.028
Plastic house wrap	36.5–32.5 (119–113)	0.096

Additional field and laboratory observations, led us to another step in the testing. There were reports in certain geographic regions where stucco contractors were using detergent as a slip agent to apply the stucco. They reported problems with water in the wall assembly. Previous tests showed that water was getting into the wall even though there were no visible leaks in the flashing. It was clear that issues such as taped seams, the tape itself could affect tests results. We decided to modify the test so that only product performance would be tested, not only installation differences between products. The test wall assembly was modified to 4 ft × 4 ft in order to fit the size of all the products tested without seams. A trough was built into the bottom of the test wall and the water captured was weighed. We tested a number of products under these conditions, using ASTM E283 Air Infiltration and ASTM E331 water resistance tests. We tested an extra wide version of 60 min paper. The products were sprayed with a diluted detergent/water spray, allowed to rest and then retested. The tests show that paper performs better under moisture/surfactant conditions than plastics and virtually the same on air penetration. The results are summarized in Table 4.

The ASTM E1677-95 test was conducted on various product configurations. ASTM E1677 is a combination of ASTM E331, E547, and E330. In this test, our concept of using the very severe conditions of no facer and no sheathing, made it difficult to get a good detailed reading of the products. However, we learned a number of things: perforated wraps leak very quickly under pressure; with taped seams, 60 min paper passes the air tests equal to the plastic house wraps. Observing the tests we saw that every element used in the installation is important to its success. For example, sealants were often used badly, seam tapes need to stand up to moisture/water, and under these very severe conditions workmanship was key. See Table 5.

TABLE 4—*Competitive product test before/after surfactant ASTM E283/E331.*

Test	Plastic #1	Plastic #2	Plastic #3	60 min paper	60 min paper 2 ply
Air infiltration per E283					
1.56 PSF/25 mph	0.0 cfm	0.0 cfm	0.0 cfm	0.2 cfm	0.0 cfm
6.24 PSF/50 mph	0.1 cfm	0.4 cfm	0.8 cfm	0.7 cfm	0.3 cfm
Water resistance per E331					
2.86 PSF/33 mph	No leakage	No leakage	No leakage	No leakage	No leakage
6.24 PSF/50 mph	No leakage	No leakage	No leakage	No leakage	No leakage
Spray samples with 10% concentration of detergent/rest 15 min					
Water resistance per E331, weight of water in the trough					
2.86 PSF/33 mph	0.585 lbs	0.4765 lbs	0.433 lbs	0.167 lbs	No leakage
Air infiltration per 283					
1.56 PSF/25 mph	0.0 cfm	0.0 cfm	0.0 cfm	0.2 cfm	0.0 cfm
6.24 PSF/50 mph	0.1 cfm	0.1 cfm	0.2 cfm	1.6 cfm	1.2 cfm

TABLE 5—*ASTM E1677 test of seven products.*

Product tested	E331	E547	E330+	E330−	E283
Plastic WRB, taped seam	pass	pass	pass	tape[a]	pass
Plastic II WRB, no seam	pass	pass	pass	pass	pass
Plastic III, taped seam	pass	pass	pass	pass	pass
Plastic perforated, no seam	pass	water	pass	pass	pass
Extra wide 60 min	pass	pass	pass	pass	pass

[a]Tape kept coming off after repeated exposure to water.

Summary

It is clear from this testing that certain things are very important:

1. Quality installation is of basic importance in determining how a wall assembly will perform. Field short cuts and poor supervision often are the source of problems. Flashing is not the first line of defense, but only one part of the defense system to manage water.
2. Proper integration of the flashing with the WRB is extremely important. Time and again tests show that flashing without a WRB or where not well integrated will limit and direct the water, but often will not offer full protection.
3. Using approved installation methods, such as E2112, where the flashing is integrated into the WRB works. Eliminating the WRB is a source of future problems.
4. A WRB is very important element in the performance of the wall assembly. It becomes the key element in carrying diverted water down to the exit point in the wall.
5. The installation methods as well as each part of the installation: the flashing, the WRB, any tape used, the sealant, and fasteners, all contribute to the success or failure of the wall assembly. We know that many products work when tested, but observation show that their integration is very important.
6. Not all WRB products are equal and they do not perform equally under all conditions, so WRB selection is as important as the flashing in predicting the long term success of a wall assembly.

A great deal of research has been done with results that help us improve, not only our products, but give the industry information which will help minimize future problems. Good installation practices are everyone's concern.

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