Window Installation – An Evolving Challenge
Thomas K. Butt, FAIA
November 8, 2004

Introduction

Techniques for window installation have been evolving rapidly. For many years, the accepted standard involved four strips of flexible flashing integrated with a nailing fin and the weather resistive barrier (WRB) at the window perimeter. This concept was easy to understand and implement because the window fins, the flashings and the WRB were typically all in the same plane. It is amazing, however, that so many designers and builders were still able to get it wrong.

Up until several years ago, flexible flashings were made of laminated kraft paper treated with asphalt. Chronic exposure to water often resulted in disintegration and resulting structural damage. The introduction of plastic flexible flashings, mostly of the "peel and stick" (self-adhesive) variety in the decade of the 1990's improved durability vastly.

Then came the trend toward windows that are recessed from the outermost wall plane, driven either by developers and architects looking for a certain aesthetic or imposed by regulatory design review organizations. At first, self-adhering flexible flashings appeared to offer a solution to conquering the multi-plane configurations required to perimeter flash recessed windows. But few construction workers had the skill or patience required for a successful installation, and fish mouths, wrinkles and adhesion problems on dirty surfaces compromised the effectiveness. If that didn't do the job, a lather would drive dozens of nails or staples through the sill flashing.

Then in 2002 came SB 800, California's new answer to construction defects. The law gave contractors a "right to repair" prior to a homeowner initiating litigation, but it also set clear standards and warranties for performance of building components. Recent changes to the *International Residential Code* will require window manufacturers to provide installation instructions with each window. Because of the transience of contractors, the difficulties in obtaining contractors' insurance, insurance exclusions for mold, and the rising cost of water damage and mold claims, window manufacturers are increasingly being targeted by litigants as the "deep pockets" in lawsuits that often have dozens of defendants.

Where window manufacturers once avoided installation advice, they have now reluctantly embraced it, concluding that they have to provide it to protect themselves, and in the future, conform to building codes.

The following amendment (RB203) to the International residential Code (IRC) was RB203, was approved by the ICC last year in Nashville, and will become effective in 2005-2006.

> **R613.1 General**. This section prescribes performance and construction requirements for exterior window systems installed in wall systems. ~~Waterproofing, sealing and flashing systems are not included in the scope of this section.~~ Windows shall be installed and flashed in accordance with the manufacturers written installation instructions. Each window shall be provided with written installation instructions provided by the manufacturer of their product.

Even now, the leading manufacturers have gone from a dearth of installation information to a plethora. Unfortunately, most of it is complex, hard to read, difficult to understand and overly optimistic that a construction worker will implement it – particularly if it is not translated into Spanish or some other language.

Most instructions cover only a few typical installation conditions. None deal with recessed windows. Most assume that the WRB is house wrap and not building paper or felt, although building paper (asphalt saturated kraft paper) and, to a lesser degree, asphalt saturated felt, continue to predominate in the west. The procedure for flashing a window with a house wrap WRB is totally different from that using building paper or felt. There are also stacked and ganged windows that require special care, as do cladding systems such as one-coat stucco and EIFS.

In the simple old days, nailing fins were integral to the window and provided a waterproof appendage. Today, most are loosely attached and designed to fold back during shipping, making the waterproofing of that joint, as well as a corner insert, another complicating field challenge.

Then there is the architect. If the building is a custom home, the architect may know what window manufacturer will be used and can at least obtain window details and installation instructions to start from. If it is a public building or merchant built housing, the window specifications will either be generic or will anticipate more than one potential manufacturer. The architect will have to provide generic installation details and then find some way of reconciling those with the instructions of a specific manufacturer after the product is chosen. What architect or contractor would deviate from a manufacturer's instructions and risk compromising a warranty or inviting responsibility in case of a failure – even if there really is a better way of doing it?

All Windows Leak – Pan Flashings

To complicate things even more, there is a tectonic shift going on in the window industry and among the experts who design, consult and litigate about windows. The big news is that ALL WINDOWS LEAK! There are actually two kinds of windows, they say, "those that leak from the beginning and those that leak later." The one possible exception seems to be vinyl windows with heat welded corners.[1] Aluminum windows typically have sealed joints that can fail from factory defects, shipping damage, job-site damage or installation damage. Aluminum and vinyl clad wood windows still have to depend on wood joints that shrink and swell over the years through the action of heat and moisture. Vinyl windows may have strong corner joints, but a high coefficient of thermal expansion leaves the perimeter subject to excessive water intrusion that requires unique solutions. All windows suffer a decline in water resistance over the years through normal use or abuse and the deterioration of seals and weatherstripping.

> My colleagues and I conducted a survey of over 3,500 vinyl windows that were less than two years old — factory manufactured, precision engineered. We found that 20% of them had already begun to leak. So if you build a house with 20 vinyl windows, the odds are that 4 will leak right away (others will leak later). Which 4 windows do you want leaking

[1] Vinyl windows, however, have their own problems. Because vinyl (PVC) has a relatively high coefficient of thermal expansion, compared to wood and aluminum, seasonal changes in window size and the surrounding cladding materials can open up gaps that admit more water than the WRB and drainage system can handle. A typical mitigation is to provide a gap and sealant bead for the entire window perimeter.

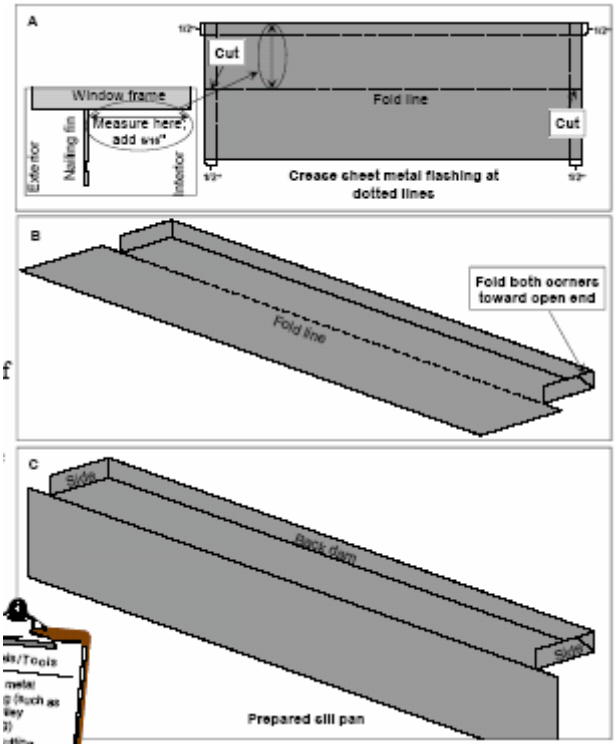
> into the wall? None of them, of course. So we have to assume that every window leaks and build accordingly. But what is the common practice?[2]

To mitigate this new revelation, experts and window manufacturers are moving toward universal advocacy of pan flashings that will, theoretically, collect any water from minor leaks and direct it away from sensitive construction components. Sill pans are being incorporated into ASTM E2112, *Installation of Exterior Windows, Doors and Skylights*. The currently prevalent design strategy keeps incidental water on the outside of the WRB, but not necessarily on the outside of the wall. Even with this type of sill pan, a significant leak could overwhelm the system and result in damage.

An example of a window manufacturer's instruction showing a pan flashing is Figure 1 from Jeld-Wen, manufacturers of Caradco, Norco, Pozzi, Summit and Wenco products. The sill pan is made of sheet metal, and the front apron fits over the sill flexible flashing and the WRB. For more information, see http://www.jeld-wen.com/resources/installation.cfm.

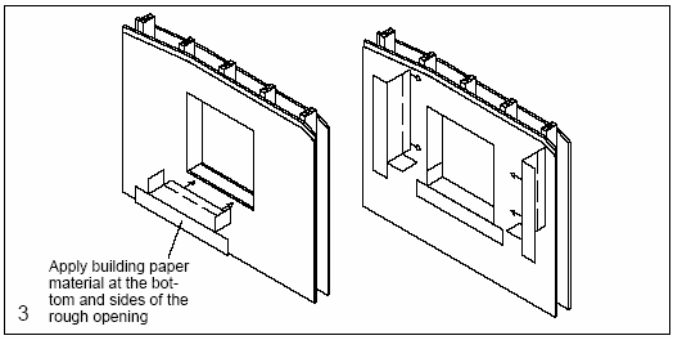
[2]Joseph Lstiburek, "Water Managed Wall Systems," *Journal of Light Construction* (March 2003)

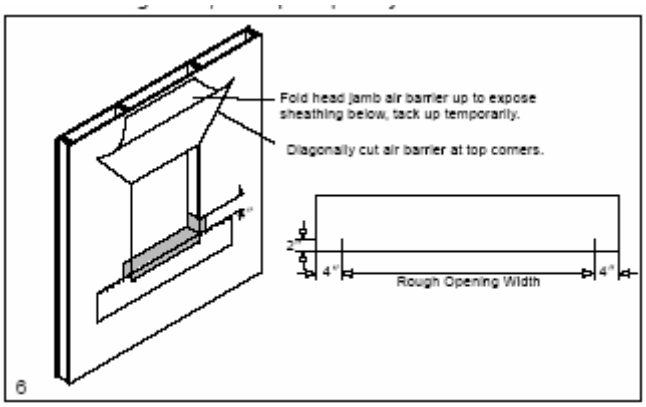
Figure 1 – *Jeld-Wen*
Installation Instructions for Primed Wood Windows with Applied Exterior Trim
J11003 (03/03)



Marvin, on the other hand, shows only sill protection made of "air barrier material or grade D building paper (Figures 2) for their single hung and double hung product (Figure 2), but for their casement product (Figure 3), the sill protection is made of "self sealing adhesive backed membrane." There is no rear leg in either example, so a true pan is not constructed. A note on the casement installtion detail advises "If metal or PVC pan flashing is to be used, install now." See http://www.marvin.com/products/installationInstructions.cfm for more information.

Figure 2 - Marvin Clad Ultimate Double Hung and Single Hung
Figure 3
Marvin Clad Casemaster/Awning



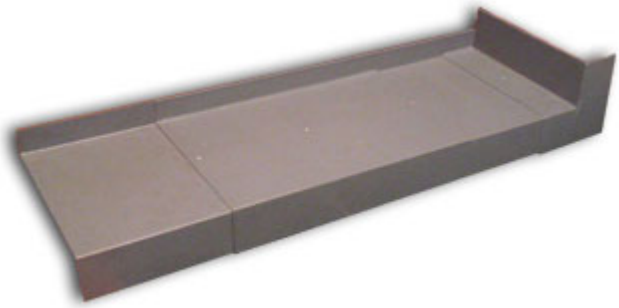


NOTE: If metal or PVC pan flashing is to be used, install now.

Although pans can be theoretically constructed solely of self adhering flexible flashing material, it is extremely difficult. Recessed windows exacerbate the challenge. One way of simplifying the process is to use a preformed sheet metal or plastic pan or use preformed corners joined by self adhering flexible flashing material. Sheet metal can be fabricated to size locally, and several plastic products are available commercially.

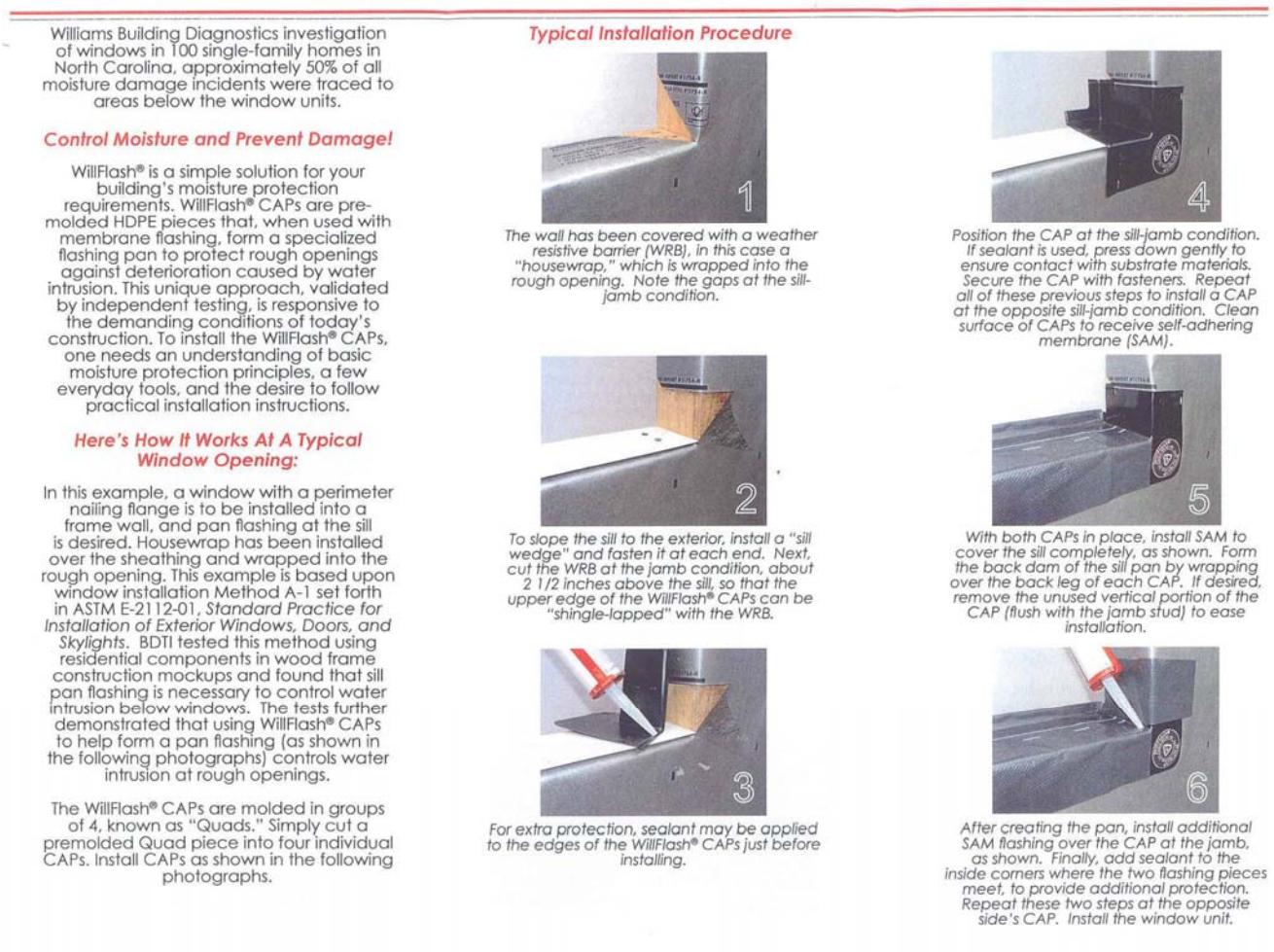
One such product, *Jambsill Guard*, has been around for a decade and is intended primarily for doors (Figure 4).

Figure 4 - *Jambsill Guard*
(for more information, see http://www.jambsill.com/products.asp?what=jg)



A more recent addition is WillFlash, made of flexible plastic. Two corners are intended to be joined by self-adhering flexible flashing, and the rear leg is made by self-adhering flexible flashing over a sill wedge and semi-rigid form, such as a piece of vinyl siding. For recessed windows, two end pieces can be overlapped to form a two-level pan.

Figure 5 - *WillFlash*
(Building Diagnostic Technologies, Inc., P.O. Box 859, Springhouse, PA 19477, 215/628-3750, fax 215/628-3128, email info@willflash.net)



Williams Building Diagnostics investigation of windows in 100 single-family homes in North Carolina, approximately 50% of all moisture damage incidents were traced to areas below the window units.

Control Moisture and Prevent Damage!

WillFlash® is a simple solution for your building's moisture protection requirements. WillFlash® CAPs are pre-molded HDPE pieces that, when used with membrane flashing, form a specialized flashing pan to protect rough openings against deterioration caused by water intrusion. This unique approach, validated by independent testing, is responsive to the demanding conditions of today's construction. To install the WillFlash® CAPs, one needs an understanding of basic moisture protection principles, a few everyday tools, and the desire to follow practical installation instructions.

Here's How It Works At A Typical Window Opening:

In this example, a window with a perimeter nailing flange is to be installed into a frame wall, and pan flashing at the sill is desired. Housewrap has been installed over the sheathing and wrapped into the rough opening. This example is based upon window installation Method A-1 set forth in ASTM E-2112-01, *Standard Practice for Installation of Exterior Windows, Doors, and Skylights*. BDTI tested this method using residential components in wood frame construction mockups and found that sill pan flashing is necessary to control water intrusion below windows. The tests further demonstrated that using WillFlash® CAPs to help form a pan flashing (as shown in the following photographs) controls water intrusion at rough openings.

The WillFlash® CAPs are molded in groups of 4, known as "Quads." Simply cut a premolded Quad piece into four individual CAPs. Install CAPs as shown in the following photographs.

Typical Installation Procedure

1

The wall has been covered with a weather resistive barrier (WRB), in this case a "housewrap," which is wrapped into the rough opening. Note the gaps at the sill-jamb condition.

2

To slope the sill to the exterior, install a "sill wedge" and fasten it at each end. Next, cut the WRB at the jamb condition, about 2 1/2 inches above the sill, so that the upper edge of the WillFlash® CAPs can be "shingle-lapped" with the WRB.

3

For extra protection, sealant may be applied to the edges of the WillFlash® CAPs just before installing.

4

Position the CAP at the sill-jamb condition. If sealant is used, press down gently to ensure contact with substrate materials. Secure the CAP with fasteners. Repeat all of these previous steps to install a CAP at the opposite sill-jamb condition. Clean surface of CAPs to receive self-adhering membrane (SAM).

5

With both CAPs in place, install SAM to cover the sill completely, as shown. Form the back dam of the sill pan by wrapping over the back leg of each CAP. If desired, remove the unused vertical portion of the CAP (flush with the jamb stud) to ease installation.

6

After creating the pan, install additional SAM flashing over the CAP at the jamb, as shown. Finally, add sealant to the inside corners where the two flashing pieces meet, to provide additional protection. Repeat these two steps at the opposite side's CAP. Install the window unit.

Flashing Recessed Windows

Recessed windows in frame construction are a special challenge. Not only do they require a pan flashing under the window unit, but they also require a pan covering the exterior sill area. This means that four multiplane corner transitions are needed – two for the window pan and two for the sill pan. The window pan needs to lap over and be sealed to the sill pan. It is possible to leave the exterior sill pan on a recssed window exposed, but typically, it is overed with a finish such as stucco.

Stucco on horizontal surfaces is vulnerable to water penetration at cracks and joints, so the sill pan and the WRB below it needs to be robust. Avoid penetration of the sill pan by fasteners. Stucco lath can be formed over the sill pan using expanded metal lath fasted only at vertical surfaces instead of wire lath.

Figure 6
Decay in framing below a recessed window sill due to inadequate protection of the framing by flashing

Figure 7
Exterior sill flashing of a recessed window using self-adhered flexible flashing. Multiple layers are required to fashion corners, resulting in wrinkles and fishmouths. Voids behind inside corners are vulnerable to puncture

The soffit also needs special attention, particularly when the clading is stucco. Although the building codes have required weep screeds at the base of stucco-clad walls for years (see *California Building Code* 2506.A.5 and *International Building Code* 2512.1.2), there is no explicit code requirement for exactly the same condition that a wall-soffit interface. Without a weeping function at a wall-soffit, any water penetrating the stucco above a soffit will be trapped above the soffit where it can penetrate vulnerable joints and laps in the WRB.

The solution is a combination drip and weep screed commonly available from manufacturers of stucco trim and accessories. Failure to use a drip-weep at soffits, even the small soffit formed by a recessed window can result in massive damage. Sme type of weep-dripfunction is recommended where materials other than stucco are used for cladding.

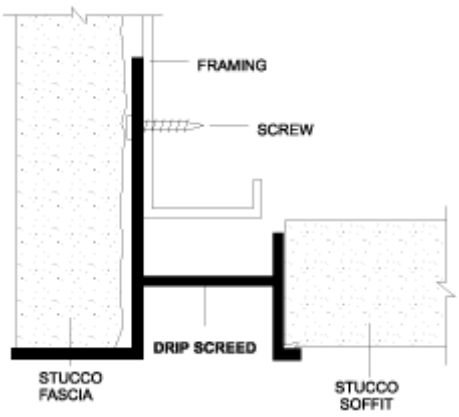


Figure 8
Typical soffit weep-drip screed of extruded aluminum

Figure 9
Damage at recessed window head resulting from lack of a soffit weep-drip screed

Figure 10 (Left)
Damage at recessed window head resulting from lack of a soffit weep-drip screed

Design Recommendations

So, how does an owner, contractor or developer and his architect cope with all this? Here are my suggestions:

1. Details have to be drawn. If you don't know which brand of window will be used, take your best guess. Obtain that manufacturer's installation details, usually available on the Internet.
2. Determine the key differences, if any, between the standard installation instructions and the specific project. This may include recesssed windows, different WRBs, or custom stacking and mulling configurations. Contact the manufacturer's technical representative for assistance or advice.
3. Prepare full scale head, jamb and sill details for all typical opening conditions. Anything less than full scale will not be comprehesible because of the interfacing and lapping of multiple layers of WRBs and flexible flashings. Use diagrams, if necessary to show installation sequences.

4. The manufacturer's instructions will refer to primers, sealants, drain screens, flexible flashings, foams and other accessories only generically. Find out from the window manufacturer what specific brands and products are compatible and acceptable. Typically, a manufacturer will have tested the installation sucesssully with specific accessory products. If that information is unanvailable, a one-part urethane sealant conforming to ASTM C920 is probably the best bet where sealant is called for. Because of dust and dampness on surfaces, a primer recommeneded by the flexible flashing manufacturer is always good insurance.
5. If a different window than that detailed is used, it may be necessary to revise all the installation details for consistency.
6. Whether or not the manufacturer recommends a sill pan, it should be included in the design. The sill fin should not be sealed to the flexible flashing and WRB so that any leaks into the assembly can eventually drain out on the outside of the WRB.
7. When the first window is ready for installation, convene a pre-installation meeting and field demonstration of a prototype attended by at least the architect, the window installer and the job superintendent to work out any bugs and agree on the final procedure. If at all possible, a technical representative from the window manufacturer should be present. Some one should take photos and make notes for distribution and review, perhaps with sketches if necessary.

Self-Adhering Flexible Flashing Materials

Self adhering waterproofing membranes, such as W.R. Grace *Bituthen/Vycor* and *Polyguard* have enjoyed a limited use as penetration flashings, sub-flashings for copings, and similar applications for years. They are flexible, elastomeric (which makes them self-healing), adhesive and unaffected by water. They typically have a foil or plastic backing to protect the adhesive and come rolled with a release paper that is removed just prior to application.

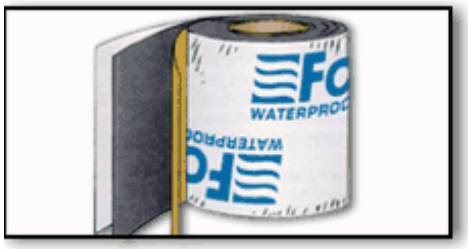


Figure 11
Example of a self-adhering flexible flashing product, Fortifiber "Fortiflash"

Today, there are dozens of products generically known as self-adhering flexible flashings, or self-adhering flashings (SAF). A comprehensive survey appeared in the June, 2001, edition of *Journal of Light Construction*.[3] These products appear to be a quantum leap above the old paper-based products widely used until only recently, but they are not a panacea, and they have their own challenges. Also, not every flexible flashing is created equal.

Unless some fatal flaw turns up with self-adhered materials, the non-adhesive flashings appear to have become obsolete. The only remaining application appears to be something like *Moistop* used under a sill flashing to keep it from adhering to the sheathing (so the WRB can be tucked up

[3] Martin Holladay. Choosing Flexible Flashings" *Journal of Light Construction* (Williston, VT: Journal of Light Construction, June 2001)

behind it). In addition, there may be cold weather applications where adhesives will not stick and non-adhesive flashings may be the only alternative.

There are no industry standards for self adhering flashings, although the ICC Evaluation Service has an Acceptance Criteria (AC148) for Flashing Materials that is used as criteria for accepting a number of proprietary products (http://www.icc-es.org/Criteria/pdf/ac148.pdf). Evaluation Reports on specific products can be searched at http://www.icc-es.org/Evaluation_Reports/index.shtml.

Polymers

There appear to be differences among SAF products based on the waterproofing and adhesive polymer used. The two prevailing polymers are rubberized asphalt and butyl. There is some indication that rubberized asphalt tends to creep or run more in hot environments or when left exposed for more than a limited time, which may adversely affect long term adhesion.

Figure 12
Adhesive polymer from a self-adhering flexible flashing flowing out of a joint between wood trim and stucco

Will butyl adhesives stick to weather resistive barriers? This has not been resolved “The jury is still out on whether butyl tapes should be allowed contact with asphalt felt. “If you are talking about 15-pound felt, there is not a lot of asphalt, because felts are relatively dry,” says Winzeler. “You’ll probably have fewer issues with compatibility than with roofing cement. But until you test, you can’t be sure.” Theresa Weston, a chemical engineer at DuPont, recently opined that DuPont’s butyl tape, FlexWrap, is compatible with asphalt felt.

Rubberized asphalt is incompatible with some types of flexible vinyl, especially vinyl flashings that come in a roll. It doesn’t appear to have any compatibility problems with hard vinyl, like the vinyl used for window fins. Watch out for staining. Rubberized asphalt, like other asphalt products, can stain some materials, especially vinyl. According to Bob Sims, customer service manager at Bakor, such staining, called plasticizer migration, occurs when oils in the asphalt dissolve plasticizers in the vinyl. Since rubberized-asphalt flashings shouldn’t be left exposed,

staining is generally not a problem. The siding or other material used to cover the flashing usually hides any stains."[4]

Exposed Surface

If the material is not going to be covered with cladding soon after installation, a foil surface SAF seems to be a good idea.

Thickness

Some SAF and window manufacturers believe that thinner flexible flashings result in better workmanship and that lesser build-up of thickness can result in fewer problems integrating flashings with windows and door frames as well as claddings.

Self-Adhering Flexible Flashing Installation and Workmanship

Workmanship - General

Workmanship may be the most important factor of all, particularly for recessed openings. Wrinkles, fishmouths and lack of sufficient pressure to achieve good adhesion are serious problems.

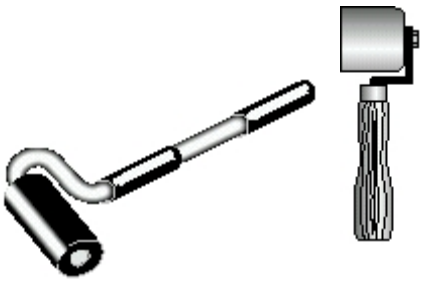


Figure 13
Roller tools made for plastic laminate and wallpaper can be used to apply pressure to flexible flashings to avoid wrinkles ad achieve good adhesion. These are available from:
Beno J. Gundlach Company
211 North 21st Street • PO Box 544 •
Belleville, IL • 62222 • USA

The illustration above shows two of several types of rollers available that can be used to install self-adhering flexible flashings. Some product manufacturers require the use of rollers for installation. Hand pressure, alone, is generally not sufficient to provide maximum adhesion and avoid wrinkles. Workers assigned to installation of flexible flashings should have good manual dexterity and be trained to do proper, high quality installations.

> Hand pressure or roller? Many, but not all, manufacturers recommend that their flexible flashing should be installed with a steel or hard-rubber J-roller — the same type of roller used for gluing plastic laminate countertops. Many manufacturers' reps admit that this recommendation is widely ignored, but doing so carries some risk: When it comes to priming and using a roller, the bottom line is that builders who deviate from a manufacturer's recommendations can't expect any support from the manufacturer if something goes wrong.[5]

There may eventually be standards for bonding, adhesion, allowable fishmouths, wrinkles and air voids, but these are still in the developmental stage. For adhesion, ASTM D D3330 *Test Method*

[4] Martin Holladay. Choosing Flexible Flashings" *Journal of Light Construction* (Williston, VT: Journal of Light Construction, June 2001)
[5] Martin Holladay. Choosing Flexible Flashings" *Journal of Light Construction* (Williston, VT: Journal of Light Construction, June 2001)

for Peel Adhesion of Pressure-Sensitive Tapes, or ASTM D903 *Test Method for Peel or Stripping Strength of Adhesive Bonds*, can be used in a laboratory setting, but field use may be difficult. Flashing manufacturers often publish adhesion information. For example, Fortifiber provides lap adhesion properties of its 25 mil and 40 mil "Fortiflash, as 9.3 lbf/in and 10 lbf/in, respectively. There are no known qualitative industry standards for installation workmanship.

It may not be reasonable to expect a level of workmanship in the field that can successfully flash recessed windows and doors. I have yet to see a level of workmanship that, in my opinion, is fully acceptable. Without a history of performance, however, it is impossible to tell how critical this will be.

Products Without Flashing Fins

Some products without waterproof installation fins require flexible flashings to be adhered to frames, which involves careful workmanship to result in an effective and permanent seal. Most conventional aluminum windows are still shipped with continuous perimeter fins intended for both installation and waterproof connections to flashing. Some manufacturers of vinyl clad wood and vinyl windows incorporate fins that are intended predominantly for installation and are not attached to the window frame with a waterproof joint. Pella is an example. Self-adhered flexible flashings have to be rolled onto the fins at a 90 degeree angle to achieve a waterproof connection. Workmanship and adhesion are challenges.

Minimum width of flexible flashings at opening perimeters

Traditionally, 9 inches has been the industry standard recommended minimum, and this is incorporated into ASTM E2112. There is no reliable data from which to draw conclusions about the optimum or minimum width of flashings. Sometimes, lesser width flashings are extended in effective width by adding additional strips. Some professionals have voiced concerns that excessively wide flashings create an area with a vapor retarder and could have an adverse impact on a wall's ability to pass water vapor, resulting in condensation problems.

Primers

Based on tests described in an unpublished paper, primers recommended by flashing manufacturers can significantly increase adhesion.6

Sealant

Setting door and windows fins be set in sealant over flexible flashings may be a good idea because of the difficulty in achieving a complete and permanent seal with the flashing adhesive, this makes the continuity of the fin-to-flashing joint virtually certain, and this is a critical area of exposure because of the relatively high possibility of some water intrusion occurring through the joint between the window frame and the cladding/trim. For installations without a double application of flexible flashings, this would be even more critical.

Integration with Weather Resistive Barriers

Traditionally, non-adhesive flexible flashings have not been sealed to WRB's. There is no body of evidence that suggests this has been a contributing factor in typical failures. After all, WRB roll products are required by code to be lapped only 6 inches at ends and 2 inches top and bottom.

---

[6] Zima, A. D., Weston, T. A., and Haygood, R., "Comp[arision of Butyl Versus Modified Asphalt Window Flashing Adhesives," Durability of Building and Construction Sealants and Adhesives, ASTM STP 1453, A. T. Wolf, Ed., ASTM International, West Conshocken, PA 2004

However, flashings around openings may be expected to have more exposure to water than WRB's under the field of cladding. Some window manufacturers (Pella) require a sealed connection between the flexible flashing and the WRB.

Sill Weeping

Traditionally, finned aluminum windows have been sealed all around. It was presumed that no water would pass through the plane of the WRB, fins and flashings. With clad wood windows, particularly, there seems to be a movement toward creating a sill pan that can weep. This is separate from the integral weeps in the window product that are intended to weep to the outside of the cladding. Pella, for example, provides instructions on how to create a partial sill pan from flexible flashing material and instructs that it not be sealed to the sill fin so that any water intruding past the plane of the WRB would, theoretically, drop down to the sill pan and weep out under the sill fin and into the plane of the WRB.

Application to Sheathing

Is there any reason that flexible flashings should adhere to sheathing other than temporarily until the cladding is applied? In other words, does the flexible flashing/sheathing bond play any role in the water resistance of the system? Other than providing temporary positioning and serving to keep the flashing system in place, a bond between a flexible flashing and sheathing appears to have no other role – certainly not a waterproofing role.

Typically and traditionally, for installation in conjunction with organic felt and paper-based WRB products, flexible flashings are applied to sheathing prior to the installation of the WRB. For non paper-based (polymer products), such as housewraps, are installed first, and flexible flashings installed on top, with a slit made in the WRB above the head that the flashing can be inserted shingle-style. No data is available to substantiate the advantage of one method over the other.

Layering

Are two layers of flexible flashings better than one? If so, should they "sandwich" the WRB, go under it, or over it? Or does it make any difference? We are aware of no test data that can provide a conclusion. Because of potential adhesion failures, two layers would appear to provide a higher factor of safety than one layer.