

Housewraps, Felt Paper and Weather Penetration Barriers

Siding isn't weather-proof. A second line of defense is a critical component in smart weather-protecting wall designs.

by Paul Fisette © 2001

The shell of a house serves as the first line of defense between the occupants and the outdoor environment. Walls function as a weather barrier, nail base for finish materials and an energy conserving boundary. A sensible wall system is durable. And this requires all components in a wall assembly to be compatible for the long haul. Siding, siding finishes, housewraps, insulation and wall frames must work together while achieving distinctive goals. So it is in this light that we should view a primary, but often overlooked, component in residential wall systems: weather-resisting wall wraps.

Wood, brick, masonry, vinyl, and other sidings do not function as *barriers* to driving rain. Siding is porous. There are a multitude of joints, laps, and connections making it discontinuous. Water and air are driven through these leakage points by wind, gravity and capillary forces. Also, we generally use water-sensitive materials for siding and structural elements. Leaking water rots wood, grows mold, corrodes steel and lowers insulating R-values. Another concern is that leaking air strips heat from homes and dollars from energy budgets. So air-tight construction is desirable.

Force of Nature

Most of us live in climates influenced by rain and wind. During a storm, a thin film of water clings to windward surfaces. Porous materials, like unfinished shingles, stained wood clapboards, and masonry veneers soak up water. Non-porous materials like freshly painted wood, aluminum and vinyl don't. But the film of water sticks to all siding products. As the wind's speed and direction shifts, water moves up, down and sideways under the influence of air pressure. It moves from

areas of high pressure to areas of low pressure. The area directly behind a wind-blown wall surface is at a lower pressure than its exterior face. This pressure difference works to suck the water inward through any hole it finds. I've stripped problem walls immediately after heavy rain to monitor rain intrusion and establish moisture profiles. It is perfectly clear that butt-joints, seams, holes, and siding overlaps are siphon points driven by air pressure, gravity and capillary suction. If there is no building paper, water will get wicked up into the wood sheathing where it often causes structural problems.

Many carpenters make the mistake of thinking that siding - wood, brick, vinyl, stucco - is an impenetrable barrier against the elements. The truth is, whether water is propelled by wind, capillary attraction, gravity, or some combination of these forces, sooner or later it finds its way behind, around or through the siding. Your local code may not require you to use felt or housewrap, but unless you live in an extremely arid climate -- you need to use it. Typically, building paper is installed as soon as the sheathing is installed. But to be effective, it must be integrated with the flashing that follows in later stages of the job. This means, for example, having to slit the housewrap above windows to tuck under the upper leg of a metal cap flashing, then taping the wrap to the flashing. And the wrap itself must be properly layered, overlapped and taped where necessary to provide a clear drainage path (see Watertight Walls article.)

The Problem with Caulked Joints

I think the majority of builders and siding manufacturers believe that caulking around windows, between the end-joints of siding and along corner boards constitutes the development of an impenetrable rain barrier. Building codes even prescribe caulked siding as an acceptable weather protection system. The argument goes: "If you caulk every joint, hole and seam in the siding, how can it leak?" I am not a fan of this approach, especially if caulked joints involve wood or wood-based products. The best silicone sealants boast elongation rates up to 75%. Lesser caulks, like some acrylics, move a paltry 15%! This means that

when a 1/8-inch wide caulked joint, made with the highest-grade sealant, moves 3/32-inch - it fails!

There are two things wrong with the "sealed-face" approach: First, dynamic joints, like siding joints, move dramatically as a result of moisture and thermal loading. For example, a 6-inch wooden corner board will shrink and swell 1/4-inch when exposed to normal weather conditions. By the way, vinyl moves too. Nail slots in vinyl siding are elongated for a reason: to allow for nail slippage as the vinyl siding expands and contracts (thermally). Secondly, even if a joint doesn't move enough to make the caulk itself fail, in time, repetitive movement and prolonged exposure cause failure at the bonded connection. Look closely at caulked joints that have been in service for several years and you will see hairline cracks where the caulk once bonded securely to wood, masonry and vinyl components. A hairline crack is large enough to admit pressurized water, but not large enough to encourage drying. In the short term caulking can help block water penetration. In the long run it actually traps moisture behind the siding. Can an effective sealed-face barrier system be constructed? Yes, but, it is too risky and requires vigilant and costly maintenance.

Barrier Design

There are basically 3 types of weather-barrier systems: the *sealed-face method*, the vented *rain-screen approach*, and the *redundant-barrier system*. The sealed-face method is straight out - **non-effective**. The vented rain-screen approach is clearly the Mother of all weather-barrier systems. However, the redundant-barrier approach works well and is the most cost effective option. The vented rain-screen is a system where lengths of strapping are fastened to housewrap-protected wall sheathing. Siding is attached to the strapping leaving an air space between the back of the siding and the face of the sheathing. This design does 2 very important things: The air pressure between the air on the outside of the siding and the air space created behind the siding is similar (if the siding is leaky to air). Therefore, rainwater is not sucked through the penetrations in the siding.

No driving force! The second strength of this system is that the air space behind the siding promotes rapid drying if any water does get past the siding.

Constructing a rain screen is somewhat costly and labor intensive. Installation is unconventional, so it requires rethinking of some details. Window and door trim must be padded out. Flashing should be extended back to the sheathing beyond the air space and under the housewrap. Door hinges may need to be extended, so doors can be fully opened. Roof overhangs at gable ends must be extended to cover thicker wall sections. The bottom of the air space must be covered with screening to prevent critters from entering the vent chamber. These and other accommodations are certainly doable, but involve more labor and materials than typical construction. In my opinion, rain screens are required fare for wet, wind-blown areas like the Pacific Northwest, exposed coastal environments and hilltop exposures. But, this approach is not required or cost-effective for most climates and construction budgets.

The redundant-barrier works well for the vast majority of homes built today. And this system has the advantage of being familiar to builders. Basically, putting tar paper or approved housewrap on the exterior walls before siding is installed is the first step to build an effective redundant-barrier system. Proper installation is required to make this system work. You must design a drainage plane that keeps water out! When water penetrates the siding, it must have a clear path to follow downward. Water must remain **outside** of the protective wrap. Be sure that tops of windows, doors and penetrations are flashed properly (see Making Walls Watertight). All water must be directed outward. Also, we must choose materials that are capable of providing the protection we expect and need. The barrier should be resistant to liquid water and air infiltration, while being permeable to water vapor.

It should be noted that the redundant barrier approach works reasonably well with sidings that overlap like clapboards, lap siding and vinyl siding. These siding

applications leave small air spaces between the sheathing wrap and siding. This provides a minimal drainage plane and promotes some drying. However, panel siding, T 111, and board siding lay flat against the sheathing wrap and do not provide any drainage or drying space. Water that gets past the siding can remain trapped between the siding and wrap for longer periods of time, raising the potential for moisture problems.

Building Code Requirements

I am very respectful of building code development and the enforcement process, but I don't think building codes provide clear direction in this case. Basically, all Model codes agree on the need for a weather-resistant barrier paper (usually specified as #15 felt or Grade D Kraft paper) behind stucco, brick, stone and other porous veneers. The paper requirement is typically omitted for other types of siding when they're installed over rated structural sheathing. Alone among the codes, BOCA, in its 1998 supplement, requires a layer of #15 felt over the sheathing regardless of the siding type. BOCA has also beefed up its flashing requirements, spelling out nine areas needing flashing, and getting rid of an earlier exception for "leakproof" caulking (apparently in recognition that no caulking is leakproof for long. (See BOCA 1405.3.6 and 1405.3.10)

Though 15-pound felt is usually cited, all the codes allow for the substitution of "equivalent" materials, opening the door for plastic housewraps. To qualify as an equal, the housewrap must pass performance tests conducted by an independent lab and paid for by the manufacturer. The manufacturer submits the test data to the evaluation services of the various code bodies, which issue reports describing the material's properties and stating which code performance requirements it meets. Assuming it meets the right criteria, the housewrap can then be used instead of the felt or building paper specified in the code.

Be careful: As in most code matters, it's up to your local inspector to approve an equivalent material. Chances are, given the wide use and acceptance of

housewrap, you won't have a problem. But if it's an unfamiliar brand, the inspector may ask you to provide the evaluation service report for the product.

So far, we've just been talking about the structural codes, all of which reference the Model Energy Code. Under the MEC you either have to use caulk, tape, and gaskets to seal up seams and penetrations in the building shell against air infiltration, or the easier route, you can install a "vapor-permeable housewrap." If you live in a state or locale that has adopted and enforces MEC, this may be the reason you use a housewrap. Felt will also meet the criteria, since its perm rating is typically around 5 in the dry state.

Making Sense of Housewrap Specifications - Testing

ASTM (the American Society of Testing & Materials) has recently convened a task force on weather-resistive barriers -- asphalt-treated kraft paper, asphalt-saturated organic felt, and housewrap -- in an effort to bring some consistency to the performance criteria by which these products are measured. A recent memo from the chairman of the group states that the three materials, any of which may meet the code criteria for "building paper" or "weather-resistive barrier," are "described by different...standards" and that "there is no way to compare materials by a common set of criteria." The memo goes on to list no less than 24 test standards that manufacturers may pick and choose from to gain code approval for their products.

Apples to Oranges

A basic problem is that even if two manufacturers use the same test, the results can't be compared because the tests are often set up differently. For example, ASTM E 283, commonly used to test resistance to air infiltration, requires that the weather barrier be stretched over an 8x8-foot wall frame. However, the manufacturer can instruct the testing lab to put the wrap over anything from an open-stud wall to a fully-sheathed, sided, insulated, and drywalled frame. Plywood can be oriented horizontally, so the seams fall between studs, or

vertically, so the seams fall over the studs. To make a comparison, you would have to buy a copy of the code report for each product. Unless the test assemblies were exactly the same, a comparison of the specs would be meaningless.

There are many test procedures that can be used to qualify wall wraps as water resistant, but ASTM D 779, commonly called the "boat test," is recognized as the industry standard. In this test, a small sample of wall wrap is folded like a piece of origami and floated on water in a petri dish. A powdered substance, called an "indicator," is sprinkled on top of the wrap in a fine-layered, 1-inch circle. As water soaks up through the wrap, the indicator begins to change color. When an observer determines that the indicator is changing color at the fastest rate -- a sign that water is passing through the wrap at the most rapid rate -- the test is over and the elapsed time is noted. To qualify as a Grade D wrap, it must take at least 10 minutes for the color to change at its fastest rate. If a wall wrap claims a rating of 60, that means it took 60 minutes.

A problem with the boat test is that water vapor can also trigger the indicator's change of color -- meaning that a highly vapor-permeable wrap like Tyvek fails. As an alternative, DuPont put Tyvek through AATCC 127, the "hydro-head" test, to prove its water resistance. In this test, the material is subjected to a 22-inch column of water -- the same force exerted by a 200-mph -- and must not leak a drop for 5 hours. This is a far more demanding test for water resistance than the boat test, yet as far as I know, among the plastic wraps, only Tyvek and R-Wrap have passed. Some researchers claim that felt has also passed, though inconsistently.

How Much Is Enough?

Here again, product literature can be misleading. Some manufacturers may list hydro-head test values like "186 cm." This is the height that the water column reached before the material began to leak.

One tested value that actually can be compared between brands of housewrap is vapor permeance, which is usually tested according to ASTM E 96, with the results expressed in perms. The higher the value, the more permeable the material. (A material with a perm rating of 1 or less is considered a vapor barrier.) Unfortunately, the wide spread in perm ratings among brands -- from 5 perms to over 200 perms -- makes it a little difficult to assess the importance of this number. The codes require wall wraps to match or exceed Grade D building paper, which has a minimum perm value of 5.

To complicate things, the permeance of felt paper is a moving target. Felt paper absorbs water and ranges from a low of around 5 perms when it's dry to over 60 perms when it's exposed to relative humidity above 95%. The perm values of engineered wall wraps, however, are moisture-stable. Although high permeance is generally desirable in a wrap, excessively high ratings are not as important as resistance to air and water.

The Products

There is no shortage of housewrap products. The last time I counted there were at least 14 brands. The knee-jerk reaction is to think that all products work the same: wrap the house; apply the siding; and you're warm and dry. Plastic housewraps are engineered materials. They are designed to prevent air infiltration and keep out liquid water, while allowing water vapor to escape from inside of the home. That's a tall order. Felt paper and all of the plastic housewraps display these properties to one degree or another. The difficulty comes in distinguishing between them. The question is: how well do these materials work? And if you choose to use a housewrap, does it matter which brand?

With all of the code test data available, you'd think it would be easy to evaluate performance and compare one product to another. Unfortunately, there is not consistency in the testing procedure or in how the results are reported, so

comparisons are difficult or meaningless. As an alternative, my students and I recently decided to do some testing of our own in the lab at UMass.

Lab Bench

My current work at the University of Massachusetts includes laboratory study and field investigation of construction problems. I receive hundreds of questions regarding the performance of building materials each year. Many questions are related to siding performance and moisture intrusion. Most water intrusion problems I see are clearly related to the improper installation of materials. Usually, flashing details around doors, windows and penetrations are to blame. But I was roused by my fieldwork to test some of the more popular housewrap brands and see how they performed when exposed to a few basic laboratory conditions.

Test Products

BRAND	MATERIAL	MANUFACTURER
Amowrap	woven polypropylene with a perforated coating	Tenneco Building Products
Barricade	woven polyethylene with a perforated coating	Simplex Products Division
Pinkwrap	woven polypropylene with a perforated coating	Owens Corning
R-Wrap	porous polyethylene film laminated to scrim	Simplex Products Division
Typar	spun-bonded polypropylene with a perforated coating	Reemay, Inc.
Tyvek	spun-bonded polyethylene	E.I. DuPont de Nemours

HomeWrap		& Co.
15 Pound Felt	asphalt impregnated	

Our goal was not to establish quantifiable data that predicted real-world performance. But we did want to explore the character or tendencies of these wraps when exposed to clean water, soapy water, and cedar-extractive-rich water. We subjected each wrap to a 3-1/2 inch hydro head instead of the 22-inch head used in the AATCC 127 test. A 3-1/2 inch head delivers a force to the wrap that is roughly equivalent to a 70 mph wind. We recorded the loss of water over a 2-hour period for each test we performed. Wind pressure and hydro-head conditions are certainly 2 different things, but we felt this was a reasonable level of stress to apply since wind commonly exerts a similar force on rain-covered walls.

Our test results showed that after a series of 2-hour test runs, clean water never leaked through Tyvek or R-Wrap; 15-pound felt lost 30% of its water on average; and all other products drained completely. It was especially noteworthy that the perforated wraps (Amowrap, Pinkwrap and Barricade) lost more than 80% of the water in the first 15 minutes. The performance of Felt and Typar was highly variable. Typar and Felt often held water for 30 minutes or more before leaking.

There was speculation that surfactants (soaps) could make housewraps more water permeable. And we found this to be true. Surfactants, which break down the surface tension of water, making it flow more easily, are present in soaps and oils that can be found on the surface of construction materials and hands of installers. This may be significant since people regularly powerwash their homes, perhaps making them more likely to leak. Also, cedar and other wood sidings contain water-soluble extractives that are thought to act as surfactants. Paints and stucco have surfactants as part of their formulation too. So surfactants seemed like an interesting thing to investigate.

We ran a series of hydro tests using soapy water and then another series using a cedar-extractive solution. We limited our tests to Tyvek, R-Wrap and Felt, since these were the winners of the first round of clean-water tests. Tyvek and R-Wrap lost about 10% of the soapy water column in 2 hours. Felt seemed unaffected by soap, still losing 30% of its water. Tyvek and R-Wrap lost about 3% of the cedar-extractive mix in 2-hours, while Felt again lost 30%. It does appear that soaps and extractives do have at least some affect on the water resistance of housewraps.

NOTE: Typar introduced a new non-perforated housewrap in 2003. We tested this new version in our lab during the spring semester of 2003 using the same tests described above. We found that the new Typar performed as well as Tyvek and Rwrap in the hydro-head testing. In fact it demonstrated superior resistance to surfactants when compared with the performance of Tyvek.

Housewrap or Felt?

Based on our testing, if I were buying a housewrap today, I would choose either Tyvek or R-Wrap, because they display the best water resistance. But so far, I've avoided the million dollar question - housewrap or felt? The truth is, there's not million dollar answer. In general, I don't think it matters a whole lot. If you get the flashing details right, and are careful installing the building paper, you will prevent 99% of the moisture problems caused by wind-driven rain and snow. Either product, housewrap or felt, will provide an adequate secondary drainage plane. And either product is permeable enough to allow interior moisture to escape.

As it happens, I have felt paper on my own home, and if I could choose between felt and housewrap and do it over again, I'd still choose felt. That's because I believe that under certain circumstances, felt outperforms housewrap. For example, an ice dam or roof leak may allow liquid water to get behind the felt or housewrap. It's also possible for the sun's heat to drive water vapor through the housewrap from the outside, where it can condense on the sheathing. In either of

these cases, you now have liquid water on the wrong side of the wrap. Under these conditions, the liquid water would be trapped by the housewrap, which is permeable only to water vapor. Felt, on the other hand, will absorb the water, and more quickly dry to the outside.

End Notes

Despite your best efforts, some water will make it through the siding, so you ought to plan for it. If you choose the right housewrap and install it correctly, you should have dry wall cavities. One associated issue that deserves special mention is the installation of wood siding over housewraps.

Wood is an absorbent material. It stores water. Since rain is sucked through butt-joints, seams and even upward past overlapping edges, it has access to the back surface. We usually paint the face of siding to reduce water absorption. But many builders leave the backside raw. You don't want to store water in a place that has direct contact with vapor permeable housewraps. The sun's heat can turn the stored liquid water into vapor. The vapor moves inward when the temperature of the siding face is warmer than the air behind the siding. And since housewraps are vapor permeable, they can allow vapor to pass into the building envelope from the outside. As the sunsets or moves to another side of the house, the temperature of the wall may drop below the dewpoint temperature, changing the vapor back to liquid. And guess what? The reconstituted liquid is on the wrong side of a water-resistant barrier! This set of conditions is suspected to have caused wet sheathing in several unusual cases.

In short: Backprime wood siding so it doesn't absorb water and bleed extractive juice onto potentially sensitive housewraps! The best advice is to pre-treat all sides of the wood with a coating of clear water repellent preservative. Water repellents block liquid water much better than paint. And it allows vapor to pass out of the wood if any water happens to get sucked into the siding through splits and cracks. Very forgiving! After the water repellent has dried, install the siding,

prime and apply 2 top coats of 100% acrylic latex paint. Don't forget to treat the ends, edges and backs of wood siding.

Recommendations

- always use housewrap (even with a vented rain screen)
- determine if climate requires a vented rain screen or redundant barrier system.
- for redundant barriers I would choose Tyvek, R-Wrap or 15-pound felt
- tape all seams in barrier
- protect all flashings with overlapping wrap
- avoid use of caulking, concentrate on developing an effective drainage plane.
- protect all penetrations with appropriate detailing
- prime all surfaces of wood siding (back-priming) before applying top coats

For results of our follow-up study involving capillary suction through housewraps see "Leaky Housewraps".

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