Laboratory Investigations of Weather Resistive Barriers Used with Cedar Siding

Theresa A. Weston, Ph.D.
Member ASHRAE

Tony D. Zatkulak

Jim Waggoner

Nimrit Kang

ABSTRACT

Several questions have been raised lately within the building industry about the selection and use of weather resistive barriers behind cedar siding and shingles. This paper describes how the weather resistive barrier functions in conjunction with cedar siding. In particular, experimental results on system water intrusion management (wetting and drying) are discussed. Environmental chamber testing of mock-up walls were used to understand moisture transport within the system, to compare housewrap and building felt performance, and to determine the value of incorporating an air space behind the siding. The study was limited to one set of laboratory-simulated weather conditions and shows only the relative behavior of the wall systems tested. Observations confirmed that capillary action, at the siding overlap, is a significant source of bulk water entry into the wall structure when the siding is not back-primed. Water that entered the wall at the siding overlap can move inward by vapor diffusion. Although this inward vapor diffusion was measurable, it did not appear to be large enough to cause wall damage under the conditions tested. With regard to inward vapor drive, the wall performance was not greatly affected by the type of weather barrier, but walls using a housewrap as a weather resistive barrier were observed to dry slightly faster than those using felt. Incorporating an airspace between the siding and the weather resistive barrier reduced the overall moisture level of the wall. Durability considerations in the selection of weather resistive barriers—specifically, potential for mold growth, and the effects of chemicals that may leach out of cedar—are also discussed. Based on the experimental results and analysis, the desired attributes for weather barriers in these systems and installation practices for them are proposed.

INTRODUCTION

Cedar siding is a traditional cladding used in residential and low-rise commercial construction. Cedar and other wood sidings have good traditional performance, but the installation in conjunction with other materials, proper installation techniques, and issues to do with extractive bleeding are still being discussed within the industry. More specifically, questions have been raised about the proper choice of weather resistive barrier and installation methods:

- What is the benefit of incorporating an air-space between the weather barrier and the siding?
- What is the benefit of back and end-priming siding?
- What is the effect of extractives present in cedar siding on the weather resistive barrier? And under what conditions can they interact with the weather resistive barrier?

Installation recommendations currently available to the trade generally support back- and end-priming siding and the incorporation of an air space between the siding and the weather resistive barriers. The Western Red Cedar Lumber Association (WRCLA), an industry trade organization, recommends the use of a vapor permeable building paper on the outside face of the sheathing to prevent rain and snow from penetrating the walls but allows for the escape of moisture vapor (WRCLA 1997). The WRCLA recommends the use of building paper or that equivalent building wrap be applied over foam sheathing as well as wood-based sheathings. Using furring strips to create an airspace between the siding and rigid foam sheathing is recommended for moist and severe climates. Additionally, the WRCLA recommends priming all surfaces of siding to protect the wood from water penetration, help prevent staining caused by extractives, and increase paint

Theresa A. Weston, **Tony D. Zatkulak**, **Jim Waggoner**, and **Nimrit Kang** are with DuPont NonWovens, Richmond, Va.

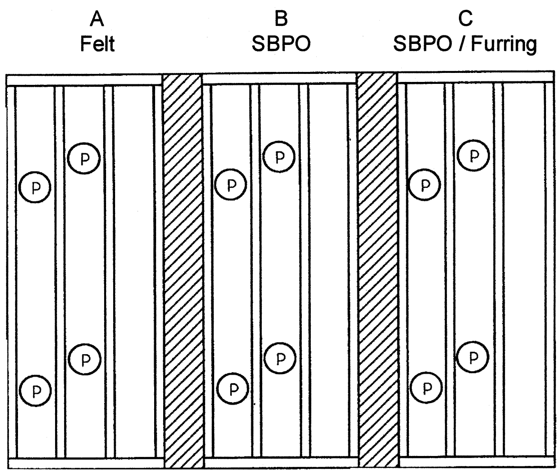
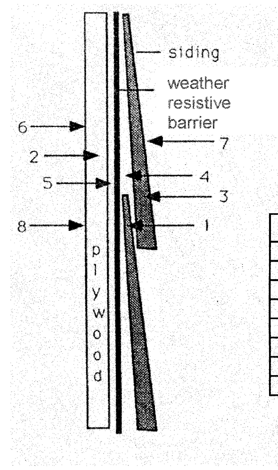


Figure 1 *Wall locations of probe sets.*



Sensor #	Type of Sensor
1	Moisture content
2	Moisture content
3	Moisture content
4	Humidity
5	Humidity
6	Humidity
7	Thermocouple
8	Thermocouple

Figure 2 *Cross-section location of the probes within a set.*

service life. In addition to the WRCLA, back- and end-priming of all siding is widely recommended by practitioners and researchers alike (Arnold and Guertin 1997; Lstiburek 1998; WWPA 1990). Researchers have described benefits of an airspace behind sheathing and the need for a weather resistive barrier (Knaebe 1995; Lstiburek and Carmody 1991; Lstiburek 1998).

The weather resistive barrier used in cedar siding systems was traditionally #15 asphalt impregnated felt. In the last 20 years polymer-based housewraps have replaced #15 felt in many buildings because of benefits including air infiltration resistance and associated energy savings, ease of installation, and mechanical durability. One class of housewraps, flash spun bonded polyolefin (SBPO) also has higher liquid water resistance (as measured by hydrostatic head) and higher vapor permeability than #15 felt. In 1998, questions regarding the choice of weather resistive barrier in cedar siding systems were raised. In particular, some researchers expressed concern that cedar extractives may reduce the water resistance of weather resistive barriers (Fisette 1998; Lstiburek 1998).

Several experimental investigations were conducted to understand important performance issues related to the weather resistive barrier used behind cedar siding and the value of incorporation of an airspace and back- and end-priming to these systems. Investigations in three specific areas are reviewed:

- water migration through the opaque section of the wall,
- water intrusion at penetrations (around windows, etc.) in walls, and
- weather resistive barrier durability to moisture exposure.

MOISTURE MIGRATION THROUGH THE OPAQUE SECTION OF A SIDING WALL

The mechanisms of water infiltration to the field of a cedar siding wall were investigated by building mock-up walls and exposing these walls to simulated rain and drying cycles in an environmental chamber.

TABLE 1
Weather Resistive Barriers Used in Walls

Wall	Weather Resistive Barrier	Furred Air-space
A	#30 Building Felt	no
B	Spun bonded polyolefin (SBPO) housewrap	no
C	Spun bonded polyolefin (SBPO) housewrap	yes

Three test walls were constructed to fit in an environmental chamber. The three side-by-side wall sections were isolated from each other using vapor/water barriers. The walls were constructed as follows (from inside to outside surface):

1. ½ inch (13 mm) gypsum board, nailed but without taping/mudding joints (The joints were left untapped to facilitate wall disassembly at the conclusion of the exposure period.)
2. Polyethylene vapor barrier
3. 2 in. × 4 in. wood stud wall with R-11 unfaced glass fiber batt insulation
4. ½ inch (13 mm) exterior plywood with one vertical joint in each wall section
5. weather resistive barrier as shown in Table 1
6. horizontal cedar clapboard siding painted on front surface only.

Weather resistive barriers commonly used with cedar siding cover a wide range of products from #15 asphalt-impregnated felt to polymeric housewraps. This study chose to exaggerate any possible performance differences due to weather resistive barrier by choosing a #30 roofing felt and a highly vapor permeable (4406 ng/Pa·s·m^2 (77 US perms) as measured by ASTM E-96, Method A) polymeric housewrap.

Moisture content and relative humidity within the wall were measured using moisture probes and relative humidity probes. Thermocouples were also installed to measure temperature. Sets of probes were installed at the locations shown in Figure 1. A set of probes is shown in Figure 2. The environmental chamber allowed for temperature and humid-

TABLE 2
Reported Normal Climatic Conditions (Hartford, Conn.)

		April	May	June
Temperature (°F)	Daily Minimum	37.6	47.3	57
	Daily Maximum	60	71.4	80.1
Relative Humidity (%)	Hour 01	68	76	80
	Hour 07	69	73	77
	Hour 13	45	47	51
	Hour 19	52	56	60
Mean Wind Speed (mph)		10	8.8	8.1
Precipitation (inches)		4.02	3.37	3.38

TABLE 3
Exterior Conditions

Days	Temperature Cycle	Target Relative Humidity	Water Spray	UV/IR Exposure
1 to 9	3ºC to 16ºC (38ºF to 60ºF)	45% to 70%	2 hours/day	2 hours/day
10 to 16	8ºC to 22ºC (47ºF to 71ºF)	47% to 77%	2 hours/day	5 hours/day
17 to 25	14ºC to 27ºC (57ºF to 80ºF)	51% to 80%	2 hours/day	5 hours/day

ity to be controlled on both sides of the panel. Indoor conditions were maintained at 63ºF to 69ºF and 40% to 55% relative humidity. The daily exterior temperature and humidity cycles were based on the normal conditions for April, May, and June in Hartford, Connecticut. Table 2 shows 20-year (1960-1989) normal weather conditions in Hartford, Connecticut, reported by the National Oceanic and Atmospheric Administration (NOAA 1989). It was desired to challenge the walls with a simulation of rain, along with wind and solar radiation, either of which could increase the amount of inward moisture movement. "Rain" was provided by using a spray rack. "Sunlight" periods, which immediately followed the "rain" periods, were simulated using a combination of ultraviolet and infrared bulbs. The "rain" and "sunlight" exposures were superimposed on the temperature and humidity profiles developed from the weather data. A pressure differential of 5 Pa was applied across the wall to simulate a 10 kph (6 mph) wind blowing into the face of the wall. Although it was recognized that it is unreasonable to expect a wind to blow in a constant direction and at a constant level, this experiment was limited by the experimental facilities. The level of "wind" chosen was two-thirds of the average normal wind speed reported for Hartford (NOAA 1989). Exterior conditions are shown in Table 3.

Chamber controllers successfully controlled the temperature despite the turning on and off of the UV and IR bulbs, but the humidity tended to vary from the target conditions. Measured exterior and interior ambient conditions are shown in Figures 3 through 5 for each of the test phases. The start of the period of radiant heating is marked. Experimental responses are noted for each test period.

1. Starting from a "dry" condition, during the spray period, the following was noted to occur in all three wall sections shown in Figure 1, except as noted below:

- Moisture content of the siding increased at the siding lap. The outer clapboard (probe #3) increases from ≈10% to 12% to 14%. The inner clapboard (probe #1) increases from ≈ 10% to 20% to 40%.
- Relative humidity in the gap behind the siding (probe #4) increases from ≈ 40% to ≈80% RH.
- Relative humidity between the plywood and weather resistive barrier (probe #5) increases from ≈60% to 80% RH on Walls A and B**.** A smaller increase in relative humidity occurs on Wall C.
- The moisture content in plywood increased from 10% to 12%.

The felt and SBPO walls appeared to perform the same. The wall with the airspace incorporated into it showed smaller increases in moisture content throughout the wall.

2. During the "sunlight" period (radiant heating period following water spray), the following was noted to occur:

- Siding temperature increases 30ºF to 40ºF and is not uniformly distributed across the panels.
- Moisture content of the siding decreases at the siding lap. The outer clapboard (probe #3) decreases from 12% to 10%. The inner clapboard (probe #1) decreases quickly from 40% to 20%.
- Relative humidity in the siding airspace (probe #4) drops from 80% to 70% RH in Walls A and B. Relative humidity in the siding airspace drops rapidly from 80% to 40% in Wall C.

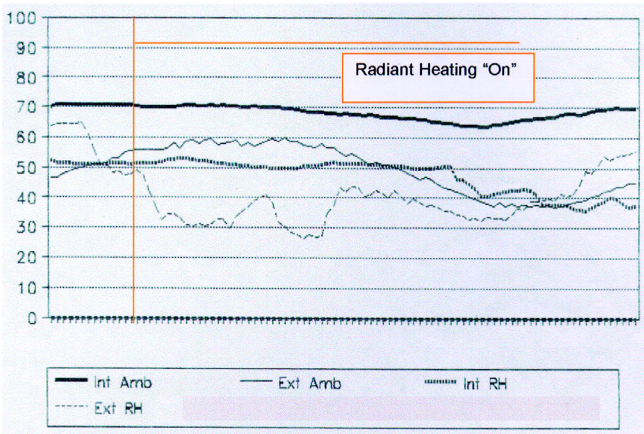


Figure 3 *Typical daily ambient conditions (Days 1 to 9).*

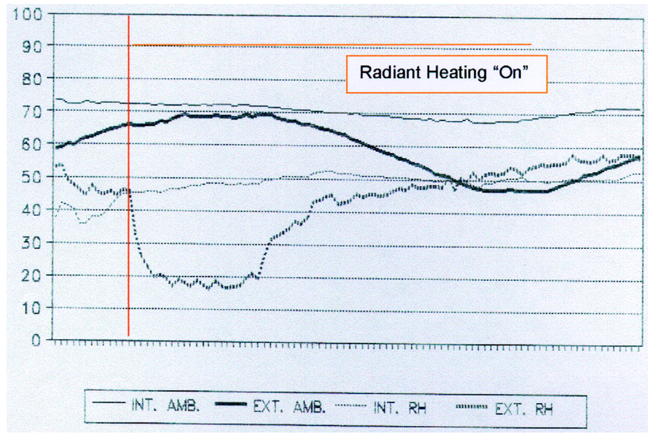


Figure 4 *Typical daily ambient conditions (Days 10 to 16).*

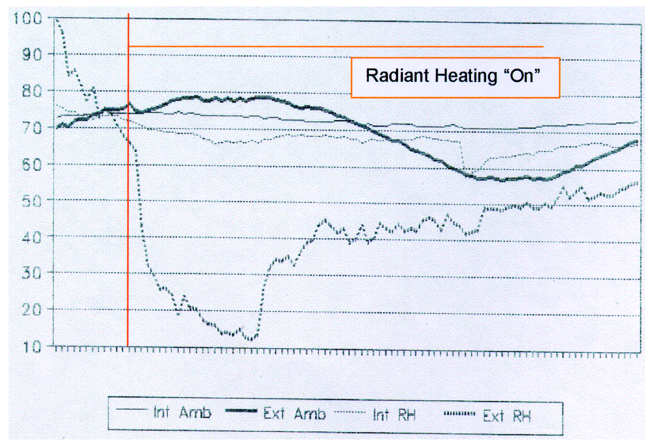


Figure 5 *Typical daily ambient conditions (Days 17 to 25).*

- Relative humidity between the plywood and the weather resistive barrier (probe #5) increases from 80% to 90% RH in Walls A and B as the temperature differential drives the moisture toward the "inside" of the wall structure. In Wall C, relative humidity between the plywood and the weather resistive barrier decreases. The decrease in relative humidity is slower and less than that in the siding airspace.
- Moisture content of the plywood (probe #2) increases from 12% to 14% on Walls A and B.

The felt and SBPO walls appeared to perform the same. The wall with the airspace incorporated into it showed significantly less inward moisture transfer.

3. After the lights are turned off (until next spray cycle), the following was noted to occur:

- Siding temperature rapidly returns to ambient conditions.
- Moisture content of the siding gradually returns to 12%.
- Relative humidity between the plywood and the weather resistive barrier (probe #5) slowly decreases to ~ 60%. The walls exhibited differences in relative humidities, which may be indicative of drying rates. During one typical exposure period, the relative humidities at the end of the drying stage were 76%, 56%, and 44% for walls A, B, and C, respectively.

Moisture content of the plywood returns to ~10%. The felt and SBPO walls performed similarly, although the SBPO showed indications of faster drying. The wall with the airspace dried significantly faster than the other walls.

At the conclusion of the monitored test, sections of the test walls were dismantled (starting at the interior) to obtain visual and tactile confirmation of the moisture probe data. In some instances moisture content was determined by weight. The first observation of each wall was made immediately following the last two-hour period of water spray. Table 4 summarizes the conditions found in each wall. When available the weighed moisture content is included.

The visual observations in combination with the probe data confirm that water is drawn into the wall by wicking (capillary action) and absorption into the siding at the clapboard laps. This transfer would probably be reduced if the siding were back-primed. Back-priming would provide a barrier for moisture absorption into the back of the wood and could also reduce wicking by changing the surface properties of the siding. The felt wall appeared to have transferred slightly more water into the wall and plywood. The incorporation of an airspace appears to cause only a slight reduction in the water entry into the wall.

An additional section of each wall was dismantled after ultraviolet and infrared lighting. Table 5 summarizes the conditions found in each wall.

The visual observations in combination with the probe data previously discussed indicate that moisture is transferred inward when the wet siding is exposed to radiant heat. Once the radiant heat is removed, the moisture flow reverses and drying proceeds to the exterior. Sheathing never reached a moisture content level of greater than 20%, which would not be expected to result in damage to the wall. These results should only be used understand the wall system performance

TABLE 4
Visual Observations After Spray Cycle

	Wall A	Wall B	Wall C
Interior Gypsum Board	Dry	Dry	Dry
Insulation	Slightly Wet	Dry	Dry
Plywood	Slightly Wet (12%)	Dry (10%)	Dry (9.5%)
Weather Barrier	Slightly Wet (11%)	Dry	Dry
Siding	Very wet at overlaps	Very wet at overlaps	Wet at overlaps

(Dry = no observable moisture, Slightly Wet = damp to the touch but no liquid water observed, Very Wet = liquid water present. The numbers in parentheses reflect weighed moisture content.)

TABLE 5
Visual Observations After Lighting Cycle

	Wall A	Wall B	Wall C
Interior Gypsum Board	Dry	Dry	Dry
Insulation	Slightly Wet	Slightly Wet	Dry
Plywood	Slightly Wet	Slightly Wet	Dry
Weather Barrier	Slightly Wet (10%)	Slightly Wet	Dry
Siding	Slightly Wet (17%)	Slightly Wet	Dry

(Dry = no observable moisture, Slightly Wet = damp to the touch but no liquid water observed, Very Wet = liquid water present. The numbers in parentheses reflect weighed moisture content.)

qualitatively. The conditions used in the study were limited and not intended to predict real world behavior quantitatively.

MOISTURE INTRUSION AT WALL PENETRATIONS

Although the wall testing in the opaque section of the wall provides the baseline moisture performance of the cedar siding system, much more water can be delivered into the wall system at the intersections with windows and other penetrations than through the siding system itself (Tsongas 1998). The level of water infiltration at penetrations is dependent on the detailing of specific building walls and therefore difficult to characterize quantitatively in the laboratory.

Visualization experiments using an acrylic clapboard siding test rig (Figure 6) were used to characterize the movement of water from a penetration and the potential effect of the weather resistive barrier and its installation on the movement of the water. Water introduced at the top of the test rig tended to spread along each of the individual clapboard contact points. Lateral movement across the back of wood siding laps has been previously reported (Tsongas 1998). Tsongas also reported that horizontal wrinkling of the building paper weather resistive barrier exacerbated the water's lateral movement. Because they absorb water, asphalt-impregnated building papers and felts wrinkle when exposed to wetting and drying cycles. This wrinkling has been shown to reduce drainage in wall systems (Weston et al. 2001).

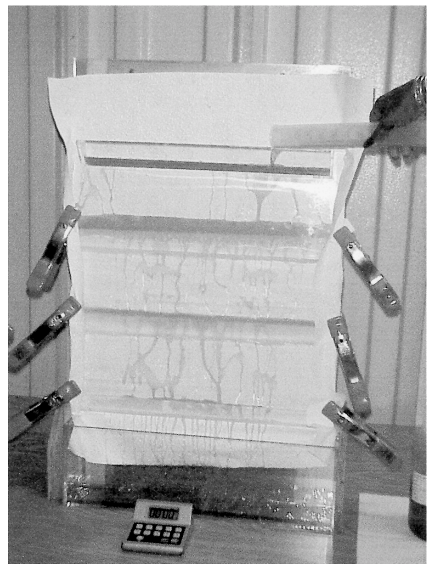


Figure 6 *Acrylic clapboard siding test rig.*

The amount of spreading outward at siding laps versus movement down and out of the wall was dependent on the spacing between the siding and the sheathing. Adding a furred airspace (commonly 3/8 inch) behind the siding would allow a clear drainage path. The use of smaller drainage spaces was investigated using the acrylic clapboard test rig and by texturing the underlying weather resistive barrier. Because the acrylic simulation clapboard material was non-absorbing, water that built up at the clapboard laps tended to run out the front face of the siding. Testing was conducted in which the water that ran out at the laps was collected separately from that which drained at the bottom of the unit (Figure 7). The results shown in Figure 8 indicate that even a space as small as 400 microns effectively allows drainage out of the wall. In a cedar siding system, the swelling of siding and sheathing would have to be considered when sizing a drainage space. Horizontal wrinkling, which has been observed to occur when either building papers or felts are exposed to wetting and drying, may reduce drainage (Tsongas 1998; Weston et al. 2001).

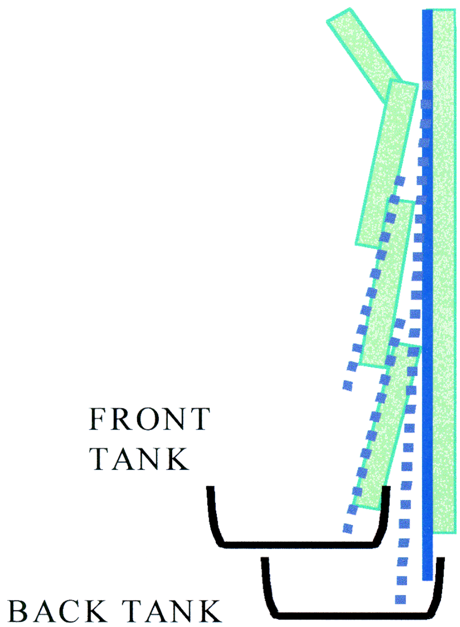


Figure 7 *Drainage test apparatus.*

If large amounts of water collect at siding laps it may have detrimental effects on the siding. Much of the water that collected at siding laps could be absorbed into the back of the siding, causing deterioration if it is not primed. This is another reason for back-priming siding.

WEATHER BARRIER DURABILITY AND SELECTION CONCERNS

There are many aspects related to durability that should be considered when choosing a weather resistive barrier for any cladding system, including

- resistance to the mechanical damage that may occur prior to covering,
- weathering (UV radiation, precipitation, thermal, and humidity cycling) during the construction phase,
- long-term thermal and moisture cycling within the wall, and
- chemical resistance and compatibility with adjacent materials.

Two durability aspects of moisture exposure within a wall were investigated: the potential for mold growth on weather resistive barriers and the reduction in water resistance due to surfactant exposure.

Weather Resistive Barrier Mold Resistance

Water intrusion can lead to structural deterioration caused by the growth of mold and mildew on several construction materials in a wall. Several weather resistive barriers were evaluated for mold growth resistance according to a modified version of ASTM D3273-94. This method calls for exposing samples in an incubation chamber to mold spores. The chamber was maintained at constant temperature of 32ºC and 93% to 99% relative humidity. The test was modified as follows: instead of soil, mold cultures on potato dextrose agar (PDA) plates were used in the incubation chest as a source of mold spores. This avoided dirt speck on the samples. Three molds, Aspergillus niger (ATCC 6275), Aureobasidium pullulans (ATTCC 9348), and Penicillium sp. (ATTC 12667), were purchased and grown on 1.3% PDA plates until sporeulation. The mold plates were added to the chest. At each inspection new mold cultures were added to the chests and the old cultures removed. The three replicate test sheets for each sample were individually suspended in the incubation chest in random order. During the course of the experiment, each sheet was systematically relocated so that all sheets were exposed to the same areas of the environmental chamber.

Mold resistance is defined as the ability of a sample to resist fungal growth that can cause discoloration and ultimate decomposition of sample medium. The degree of growth is estimated visually by comparing the mold growth on the sample to photographic standards using the ASTM guideline (D3274). During the course of the exposure, each sample was evaluated and rated at different time points. Samples are rated from 0 to 10 resistance. Resistance of 0 is having the heaviest infestation of mold. A 10 means there was essentially no visual evidence of mold growth. The presence of mold was confirmed by microscopy at 12, 20, and 50X magnification. Results are shown in Table 6.

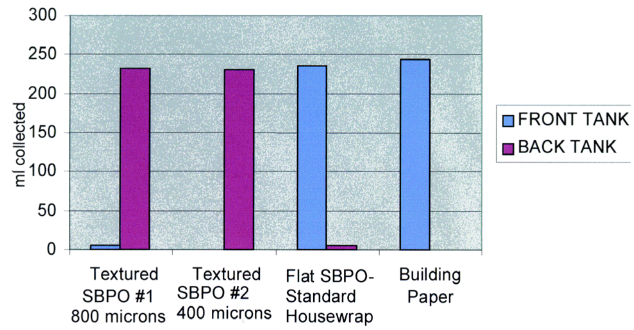


Figure 8 *Drainage test results.*

TABLE 6
Mold Resistance per ASTM D3273-94

Weather Resistive Barrier	Mold Resistance Rating
SBPO Housewrap #1	10
SBPO Housewrap #1	10
SBPO Housewrap #3	10
10 min Grade D Building Paper	9
60 min Grade D Building Paper	8
#15 Felt	5

TABLE 7
Strength of Surfactant Solutions

	Surface Tension (dynes/cm)
Distilled water	72
Cedar solution #1 (soaked in water 24 hrs)	50
Cedar solution #2 (soaked in water 72 hrs)	59.5
Detergent solutions	25.1 to 39

The results demonstrate that housewraps offer superior resistance to mold and mildew growth compared to building paper and felt products. Building papers and felts are more susceptible to mold growth because the cellulose in them absorbs water and is a good food source for mold. The cause of the difference in mold potential observed between felt and building papers is not known. Performance of felt and paper may be dependent on the fiber source used to make the paper or other differences in composition.

Reduced Water Resistance of Weather Resistive Barriers due to Surfactant (Cedar Extractive) Contamination

One durability issue specific to cedar systems is the effect of wood extractives on the water resistance properties of weather resistive barriers. Although porous, weather resistive barriers repel water because they are made of materials (polyethylene, asphalt) that water does not wet. "Surfactants" (short for surface active agent) are a class of chemicals that are widely used in industrial processes to increase the wetting of surfaces and disperse incompatible chemicals. It has been suggested that chemicals naturally present in cedar can be extracted by water and behave as surfactants. The strength of a surfactant, which is dissolved in water, is indicated by the surface tension of the solution. To determine the surfactant strength of cedar extractives, solutions of cedar soaked in water were compared to distilled water and to detergent solutions using the "ring" method. Results, shown in Table 7, show that indeed cedar wood extractives do have surfactant behavior, but not at the level of detergent solutions. The data show an unexplained increase in surface tension with soak time for cedar solutions. This is believed to be due to cedar material variation.

The water resistance of a weather barrier can be described by known phenomena, the water repellency of fabrics. The interaction of a liquid (whether wetting or nonwetting) with a fabric surface is described by

$$\Delta P = 2\,\gamma_{LV}\frac{\cos\theta}{r}$$

where

ΔP = pressure difference across the curved surface,

γ_{LV} = liquid-vapor surface energy,

θ = contact angle, and

r = equivalent pore radius.

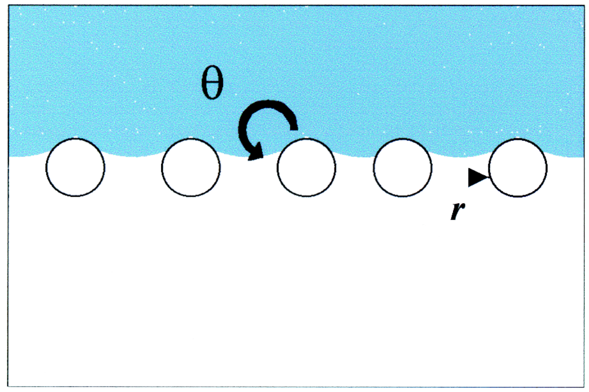


Figure 9 *Effect of contact angle in the water repellency of fabrics.*

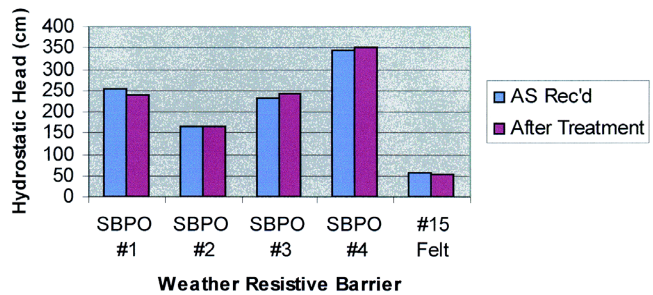


Figure 10 *Effect of cedar soaking on water resistance.*

If ΔP is negative (θ is greater than 90°) the liquid will tend not to penetrate the fabric. (See Figure 9.)

In general $\gamma_{LV}\cos\theta = \gamma_{SV} - \gamma_{SL}$, so the equation can also be written as

$$\Delta P = 2(\gamma_{SV} - \gamma_{SL})/r$$

where

ΔP = pressure difference across the curved surface,

γ_{SV} = solid-vapor surface energy,

γ_{SL} = solid-liquid surface energy,

r = equivalent pore radius.

For repellency, the surface tension of the liquid is not directly involved, but (γ_{SV} - γ_{SL}) must be negative. When a surfactant coats the surface of a weather resistive barrier, it increases γ_{SV}. For water repellency it is estimated that γ_{SV} should be less that 40 dynes/cm (Adamson 1976).

The reduction in water resistance of weather resistive barriers due to extractives from cedar siding was directly investigated by measuring water resistance by hydrostatic head (AATCC Method 127) before and after exposure to an aqueous solution of cedar extractives obtained by soaking chipped cedar siding in distilled water for 24 hours.

In a first test, weather resistive barriers were exposed by 24-hour immersion in the aqueous cedar solution, followed by removal and air drying. The results, shown in Figure 10, indicate no loss of water resistance resulting from the cedar extractive exposure.

Figure 11 *Typical weather resistive barrier in plastic hoop.*

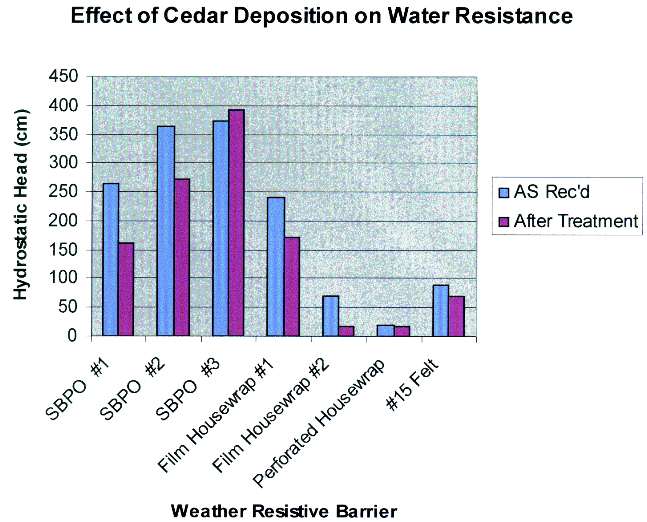


Figure 12 *Effect of cedar deposition on water resistance.*

In a second test, weather resistive barriers were exposed by creating a small trough out of the weather resistive barrier by placing it between two plastic hoops (See Figure 11). Then 100 mL of cedar solution was poured into the trough. The weather resistive barrier and solution were then heated at 60ºC (140ºF) to evaporate the water and deposit the cedar extractives on the weather resistive barrier. Water resistance results are shown in Figure 12. All weather resistive barriers, with the exception of one of the SBPO housewrap samples, showed a decrease in water resistance after cedar deposition. SBPO housewraps showed between 39% and no reduction with an average reduction of 20%. In all cases the water resistance of the SBPO housewrap, even after cedar treatment, was greater than that of #15 felt before treatment. The #15 felt had a water resistance loss of 23% after exposure. Film-based and perforated housewraps were also included in this test series. The film base included both a microporous film-based housewrap (#1) and a vapor permeable monolithic film-based housewrap (#2), which had water resistance reductions of 29% and 76%, respectively. Some of the water resistance loss of these materials may have been caused by mechanical damage during the testing due to their mechanical fragility. The perforated housewrap tested had a very low water resistance prior to treatment and showed a small loss due to cedar exposure.

CONCLUSIONS AND RECOMMENDATIONS

The results of the investigations support the use of an airspace and back- and end-priming siding.

- Opaque siding walls with an airspace incorporated exhibited a lower moisture content when exposed to simulated rain and radiant heating.
- An airspace also allowed for drainage of water, such as that which could enter the wall at penetrations, therefore reducing “puddling” at the siding laps. Drainage, however, can be achieved by a much smaller space than provided by the furring strips currently used to maintain an airspace. Textured weather resistive barriers have potential for providing this smaller space.
- Back- and end-priming were not directly addressed in this work, but this practice, because it “seals” the siding, is recommended because it should both limit the extraction of cedar surfactants and reduce the amount of water absorbed into the siding backside.

The most significant differences between weather resistive barriers were related to their behavior when exposed to moisture. When the various factors studied in this work are combined, flash spun bonded polyolefiin (SBPO) housewraps were seen to have the best overall performance.

- Testing of simulated rain and radiant heating of opaque siding walls indicates that the type of weather resistive barrier had little influence on the entry of moisture into these walls. Texturing the surface of a weather resistive barrier increases the drainage of water entering at penetrations and therefore reduces the amount of water that collects at siding laps.
- SBPO housewraps were tested to be mold-resistant, while asphalt/cellulose weather resistive barriers exhibited the potential for mold growth.
- All weather resistive barriers lost water resistance when cedar extractives were deposited on the samples. SBPO housewraps exhibited the highest water resistance either before or after cedar extractive treatment.
- If water containing cedar extractives was not allowed to dry on the weather resistive barrier, the water resistance of the barrier was not reduced. Provisions for drainage behind siding should increase the durability of weather resistive barriers to cedar extractives.

Study of the selection and use of weather resistive siding and other exterior cladding systems should be continued. The work described in this paper was conducted on a specific cladding system (clapboard wood siding) with a limited selection of weather resistive barriers (flash spun bonded polyolefin housewraps and building felt). The study of other cladding systems and weather resistive barriers, including other types of housewrap and use of multiple layers of weather resistive barriers, should be conducted.

The primary concern of this work was moisture and its effects. There are several other environmental factors, including UV and thermal exposure and in-service mechanical stresses, which could be important to the durability of weather resistive barriers. Additional studies should be conducted to determine the effects of these factors and their interactions.

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