Improving the Performance of Painted Wood Siding:

Rain Screen, End-Grain Seal, and Back Priming

The Joint Coatings & Forest Products Committee

Back Priming Task Group

Edward Burke, *Chair*
Western Red Cedar Lumber Association

Tony Bonura
Cedar Shake and Shingle Bureau

Charles Carll*
USDA Forest Products Laboratory

Dennis Connelly
Ze-VO

Christopher Hunt
USDA Forest Products Laboratory

Doug Mall
Dow Chemical Company

Arnie Nebelsick
Edmund A. Allen Lumber Company

Norm Slavik
Norcon Forestry Ltd.

Brent Stuart
Russin Lumber

Alex Wiedenhoeft
USDA Forest Products Laboratory

R. Sam Williams
USDA Forest Products Laboratory

Moisture control is a critical means of improving the performance of solid-color stain and paint on wood siding. In this article, recommendations are given for constructing a rain screen, sealing the end grain, and back-priming siding to achieve this goal. Rain screen construction and back priming inhibit water absorption and bleed from run-down extractives if water gets behind the siding. Inhibiting water absorption improves dimensional stability of siding, thus improving finish performance. Sealing the end grain with primer decreases paint peeling and bleeding of diffuse extractives near the end of boards. These techniques should be used in combination with structure designs having adequate roof overhangs, ground clearance to bottom course of siding, roof-edge flashing, gutters, and downspouts.

WATER CONTROL

Water control begins with good design that includes adequate roof overhangs, clearance between the bottom course of siding and the ground, flashing at roof edges, gutters, and downspouts, and other practices as required by local building codes. The next most important factor is a means for improving wood drying when siding gets wet. Rain screen installation of siding is the most effective way to do this. Third in importance is sealing the end grain of siding. Back priming is the least important factor; however, when architects and contractors do not consider the other three factors, back priming can help ameliorate resulting problems with water.

Wood changes dimension as its moisture content changes. In this article, the terms for water and moisture have specific meanings *(see accompanying text box for their definitions)*. Limiting changes of moisture content improves performance of all wood products, particularly siding. When wood siding undergoes large changes in moisture content, it may split at fasteners at the ends of boards. In addition, large and abrupt changes in moisture content cause uneven distribution of moisture within siding, which may cause cupping, checking, and warping.

*Author to whom correspondence should be addressed. USDA Forest Service, Forest Products Laboratory, One Gifford Pinchot Dr., Madison, WI 53726.

Moisture

The chemical commonly called water (H_2O) has three states according to temperature and pressure conditions: gas (water vapor or steam), liquid (water), or solid (ice). When water interacts with wood, it can occur in a fourth state (bound water). Moisture is not one of the states of water; it is a term with the power to indicate uncertainty about water's state or to refer collectively to water in all its states in wood. For example, some of the moisture in a board at 50% moisture content will occur as liquid water (or ice, depending on the temperature) within cell cavities of the wood, some will occur as water vapor, and some will be bound water (bound within cell walls). Moisture thus accounts for any or all of these states in a single word. In this article, the term "water" designates water in its liquid state.

Figure 1—Demonstration of siding installation over a secondary drainage plane (rain screen) showing wall studs, sheathing, water-resistive barrier (WRB), furring strips, and interleaved WRB at the butt joint. Note that the butt joint is centered directly over the furring strip and the underlying stud and the end grain of the siding was sealed with a water-repellant preservative.

SECONDARY BARRIERS TO WATER

Water-resistive Barriers

Synthetic polymer building wraps (house wrap), asphalt-impregnated felt *(see text box on ICC-ES AC38)*, or asphalt-impregnated Kraft paper are membranes (sheet materials) installed over wall sheathing. These membranes are sometimes termed secondary barriers, sheathing membranes, drainage planes, or water-resistive barriers. Of these terms, the International Code Council (the organization that issues the International Residential Code) recognizes water-resistive barrier (WRB). A WRB protects sheathing if water penetrates past the siding. The WRB may also serve as an air barrier to limit air movement through the wall, thus decreasing energy needed to heat or cool the building.

Rain Screen

Spacing siding 3/8–3/4 in. (9–19 mm) away from the WRB to form an air space gives a rain screen. Rain-screen construction is particularly beneficial for modern structures, which tend to have many wall penetrations and sometimes have minimal or no roof overhangs. Rain-screen construction incorporates a WRB and the space between the back of the siding and the WRB serves as a capillary break (*Figure* 1). The capillary break enhances drainage down the back of the siding or down the surface of the WRB. The airspace also tends to increase the drying rate of siding if it gets wet. Rain-screen installation of siding minimizes unequal moisture content distribution through the thickness of siding, thus minimizing warping and decreasing extractives bleed. To install siding with a rain screen, place the WRB over the sheathing, fasten furring strips through the sheathing to the underlying wall studs, and fasten siding through the furring strips to the underlying sheathing and wall studs. Structures where siding is installed directly over a WRB typically results in relatively inconsistent in-service moisture content distribution from front to back of siding, compared with installations where the siding is installed using a rain screen.

ICC-ES AC38

The International Code Council Evaluation Service (ICC-ES) has issued AC38, Acceptance Criteria for Water-Resistive Barriers (WRB). The criteria on which acceptability is determined are strength, resistance to passage of (permeation by) liquid water, and resistance to transmission of water vapor. AC38 addresses all three types of WRBs (synthetic polymer, asphalt-impregnated felt, and asphalt-impregnated paper). The document recognizes that test methods used to measure properties can vary by barrier type. AC38 recognizes four grades of WRB (A through D) with Grade A having the highest resistance to liquid water permeation and Grade D the lowest.

SIDING INSTALLATION AND FINISHING

Wood Grades

Wood siding comes in various grades and grain angles (e.g., vertical grain all heartwood western redcedar, flat grain western redcedar, mixed grain eastern white pine). The width of flat-grain grades of siding change almost twice as much as vertical-grain grades for the same change in moisture content. Flat-grain grades of siding typically show less cupping when installed using a rain screen.

Back Priming

The back side of siding may get wet several ways. If siding is exposed to wind-driven rain or splash wetting, water can enter behind the siding at wall penetrations (e.g., windows, doors, and vents). Proper flashing greatly minimizes wetting; however, some capillary rise at the laps of siding boards may occur. The back side of siding may also get wet during cold weather as air flows from the inside to the outside through walls; water vapor may condense in the wall cavity and on the back side of siding as air cools. Incorporation of interior vapor retarders in buildings in cold climates (which has been the norm since the 1960s) has limited the prevalence of within-wall condensation, but has not eliminated it.

When siding becomes wet on its back side, objectionable streaked bleeding of water-soluble extractives may occur, particularly with highly colored wood species such as redwood and western redcedar (*Figure* 2). Back priming can limit water absorption on the back side of siding during times when rain penetrates the siding and when condensation occurs. Back priming helps decrease moisture-induced dimensional change, prolongs coating service life on the face side, and is particularly beneficial for limiting extractive bleed.

Back-priming wood siding is labor intensive when done during construction; therefore, siding is usually factory pre-primed on all surfaces or back-primed as part of factory finishing of the face side. Factory-finish plant operators control application rate, temperature, and moisture conditions during finish application; thus, their customers benefit by getting a consistent product (usually with a warranty) that contractors can install in the winter, when exterior painting is not possible.

Coating End Cuts

Siding performs poorly if end-grain cuts are not sealed. The end grain of siding absorbs liquid water much more rapidly than lateral grain (flat grain or vertical grain). Water absorption by end-grain surfaces gives uneven moisture distribution, which causes cracks at fasteners and end-grain checks in siding. Paint is prone to peel at the end of boards if the end grain is not sealed (*Figure* 3). As part of the installation instructions for pre-finished siding, manufacturers require siding to be touched up on the end grain if it is cut during construction; the siding usually comes with paint for this purpose.

Whether siding comes pre-finished, pre-primed, or will be finished following installation, siding installers need to seal the end grain as they cut and fit each piece of siding. A variety of finishes including oil-based stains, water-repellent preservatives, and oil–alkyd stain-blocking primers can seal the end grain, but oil–alkyd stain-blocking primers are most effective. Oil–alkyd stain-blocking primers have a wide window of temperature conditions for successful application. In cold weather, latex finishes may not seal the end grain as effectively, as they do not coalesce properly at low temperatures. If exposed, end cuts may weather along with the finish on the lateral surface. If possible, refinish end cuts when the structure is refinished.

Bevel Cuts

We recommend bevel cuts at the end of boards (as opposed to 90° cuts) where siding pieces are butted end-to-end (*Figure* 4). To avoid splitting siding,

Figure 2—Extractive bleed of siding caused by wetting the back side of unprimed siding.

Figure 3—Water absorption into the end grain of siding caused the finish to peel. Note also that fasteners are too close to the end of the siding.

Figure 4—Pre-drill siding prior to nailing at the end of a piece of siding.

Figure 5—A 45° bevel joint on rain screen construction showing a primer applied to the end grain and interleaved water-resistive barrier.

Figure 6—Completed joint. Note that fasteners are approximately one inch (25 mm) from the bottom edge of the siding and spaced well away from the end of each board. Nails were angled slightly to penetrate the furring strip and the underlying sheathing and wall stud.

pre-drill holes for nails at the end of siding. Drill a hole slightly larger than the diameter of the nail and ensure that the nail embeds into the wall stud. Nails inserted into the sheathing only will not hold. Pre-drill for nails as far from the end of the siding while still nailing into the wall stud. This can minimize the splitting and paint failure at the end of the siding (*Figure* 3). Prolonged exposure to sunlight may damage many modern WRB materials; consequently, a bevel cut rather than a 90° cut also prevents photodegradation of the WRB at the joint. We recommend flashing the end joints by interleaving thin-sheet metal or asphalted felt behind the gap and over the top of the siding below the gap (*Figures* 5 and 6). The flashing moves water that penetrates the gap in the siding to the outer surface of the siding course below the gap. End cuts of factory back-primed siding are likely to be 90° cuts; thus, if bevel joints are used, they are end-grain field cut. Siding installers need to seal them as they cut and fit siding.

SUMMARY

Moisture control is essential to obtain decades of service from painted wood siding. Roof design and installation, including adequate overhang, flashing at roof edges, gutters, and downspouts, are critical for controlling water. Use rain-screen installation in conjunction with water-resistive barriers to shed water that penetrates past the siding, seal the end grain, and back-prime siding. Back priming of siding is particularly helpful on structures with minimal roof overhang and siding that is not installed as a rain screen. Back priming decreases water absorption into the back side of siding and thus decreases extractives bleed and improves dimensional stability. CT

Joint Coatings/Forest Products Committee

The Joint Coatings/Forest Products Committee (JCFPC) was established in the 1980s as a group of scientists and professionals from within the coatings industry and the forest products industry, committed to the following: seeking fundamental information which will increase basic knowledge of both the coatings and forest products industries, improving protection and performance of their products and construction practices, sharing non-proprietary information regarding the changing nature/emerging technologies of coatings and forest products, establishing the challenges and best practices for protecting forest products, seeking channels though which to publicly distribute and update information on best practices, publicly disclosing this information in a comprehensive and easily understood manner, and providing a source of industry support and guidance for the Forest Products Laboratory. The committee functions through task groups organized to write articles on wood/paint interaction.

For more information, or to join the JCFPC, contact Christopher Hunt (cghunt@fs.fed.us), Tony Bonura (tony@cedarbureau.com), or Doug Mall (Mallddd@dow.com).