While the exterior finish should be detailed to repel and shed water, a backup system is needed for the times when the primary system fails. The backup system needs to catch any water that penetrates the cladding and to drain it safely to daylight at the bottom of the wall. This backup layer, called a water-resistive barrier by the International

CHAPTER ONE Exterior Finish

Water leakage through building exteriors has been the source of numerous callbacks and lawsuits across the United States. In nearly every case, the problems have been traced back to missing or poorly designed flashings or to weather barriers that inadvertently directed large amounts of water into building cavities or interiors. Most of these leaks occur at window and door openings or at intersections between building components. In some cases, caulks and sealants forestalled leakage at these poorly designed joints for the first few years. But eventually most caulk joints fail, allowing water to enter.

All residential cladding systems are more or less porous to water, particularly during wind-driven rain when high air pressures on the windward side of a building force water to flow toward lower-pressure areas behind the siding. Under pressure, the water exploits butt joints, lap joints, nail holes, and other openings to flow inside (Figure 1-1). Even without wind, some water will migrate through tiny gaps to the back of siding through capillary action, the way water is siphoned up a stalk of celery. This is true of brick, wood, and stucco, as well as the newest composite materials.

In older construction, water that penetrated the outer cladding had ample opportunity to dry both to the interior and to the exterior as wind washed through the wall cavities, which were kept warm by heat leaking from the building’s interior. In modern construction, however, with high levels of insulation, continuous air and vapor barriers, and low-perm sheathing panels, when water gets in, it is much slower to dry and more likely to cause damage.

While the exterior finish should be detailed to repel and shed water, a backup system is needed for the times when the primary system fails. The backup system needs to catch any water that penetrates the cladding and to drain it safely to daylight at the bottom of the wall. This backup layer, called a water-resistive barrier by the International

FIGURE 1-1 Leakage Through Siding.

All exterior claddings allow some water to penetrate. The back of this beveled wood siding, installed directly to the studs, reveals significant water staining from leakage at nail holes and from splashback and snow buildup.

SOURCE: Photo by author.
Residential Code (IRC), typically consists of properly lapped building paper or plastic housewrap integrated with all flashings to safely drain water away. It is also called the drainage layer or drainage plane. In this approach, the outer cladding functions as a decorative “rain screen,” slowing down wind and water, but it is not expected to be 100% waterproof.

RAIN-SCREEN PRINCIPLE

The optimal way to protect the structure, siding, and exterior finishes from moisture damage is to design the outer layer of the house as a decorative “rain screen” that is solid enough to shed rain, block wind, and protect the sheathing wrap, but porous enough to dry to the exterior when wet. This is accomplished by separating the outer cladding from the building’s water-resistive barrier by using an air space. This system takes advantage of the fact that no siding system is entirely waterproof and relies, instead, on the drainage layer for waterproofing (see Figure 1-2).

The rain-screen system has four components: an exterior cladding, an air space, a drainage plane, and weep holes.

1. Cladding. While the main function of the exterior finish material in a rain-screen wall is aesthetic, its durability can have a big impact on the costs of home ownership. Frequent repair, repainting, or replacement can be very costly. The cladding also protects the sheathing wrap from wind and ultraviolet (UV) radiation, and sheds most of the water that strikes the side of the building. While some exterior claddings are more porous to water than others—for example, brick, vinyl, and vertical-wood sidings are particularly leak prone—all can function well with a proper drainage plane.

2. Air space. The air space serves several functions. First, it provides a space for any water that has penetrated the cladding to drain safely away. Second, it provides a capillary break between the cladding and the building paper. Wet wood siding or stucco has been shown to degrade both building paper and plastic housewrap if it is in direct contact with the wet cladding. Cedar and redwood sidings can leach out tannins that are particularly corrosive to building papers. Third, the air space helps promote drying from the back of wood siding or from the framing and sheathing in the event of a leak. With stained or painted wood sidings, the air space will significantly extend the life of the finish.

Some siding materials, such as vinyl, aluminum, and wood shakes and shingles, are self-ventilating. For others, an air space can be created by installing vertical furring strips over the building paper. Although furring out the siding provides optimal protection for the siding and structure beneath, it also adds significant cost and complication to the job, so it is not commonly done. However, manufacturers are responding to this need with a variety of thin drainage materials that either install over the sheathing wrap or replace it (see “Draining Housewraps,” page 5).

3. Drainage plane. The drainage plane typically consists of asphalt-impregnated building felt or a plastic housewrap that is fully integrated with all door, window, and wall flashings. The system must provide a clear drainage path out the bottom of the building. In general, the housewrap must be cut to lap over window and door cap flashings and under window and door sill flashings. In addition, the housewrap should lap over step flashings, the upper leg of abutting roof flashings, and deck ledger flashings. Upper courses of sheathing wrap should lap lower courses by at least 6 inches and vertical seams should lap 6 to 12 inches.

4. Weep holes. Any trapped water must freely drain to daylight at the bottom of the wall either through weep holes, as in brick veneer, through a weep screed in stucco, or out the bottom of vertical furring strips installed beneath wood siding. If furring strips are used, the openings at the bottom should be screened against insects. Short sections of corrugated plastic ridge vent material placed between furring strips work well to provide solid backing for the bottom course of siding.

Rigid Foam Sheathing

Although a rain-screen wall design will improve the longevity of any siding and finish, it is particularly critical when installing wood siding over foam sheathing. Research has shown that wood sidings installed directly over foam sheathings are more prone to cupping, cracking, and paint problems than when installed over wood sheathings. Wood
sheathing acts as a reservoir for moisture that penetrates the siding. With foam, the moisture tends to build up on the back of the siding and cause problems. An air space, even a shallow space of 1/4 to 1/2 inch, between the siding and foam sheathing has been shown to reduce these problems.

**SHEATHING WRAP**

The primary goal of a sheathing wrap is to protect a building’s structural components from water. At the same time, the sheathing wrap must be permeable enough to allow drying to the building’s exterior if the framing or sheathing should get wet. While the permeance and water-resistance ratings of sheathing wraps vary significantly, how they are installed is far more important than the specific product used. The key is to always lap the sheathing wrap to shed water and to properly integrate the wrap with flashing so water is directed on top of the layer below.

All sheathing wraps fall into three basic types: asphalt felt, Grade D building paper, and synthetic housewrap. Grade D building paper is used primarily under stucco in the western United States and is essentially a lighter-weight version of asphalt felt. Comparing one material to another is difficult since there is no single standard for all products, and even where manufacturers follow the same test standard, test conditions may vary dramatically from one company to the next.

**Code Requirements**

The 2003 International Building Code calls for a “water-resistant barrier behind the exterior veneer” consisting of flashings and a “weather-resistant sheathing paper” lapped at least 2 inches horizontally and 6 inches vertically. It specifies asphalt-saturated felt that weighs at least 14 pounds per square and complies with ASTM D226, which means that most unrated No. 15 felt paper sold at lumberyards (which weigh closer to 7 pounds per square) do not comply.

Nearly all the plastic housewraps have been submitted to the model code authorities and accepted as substitutes for ASTM rated No. 15 building paper. If building in an area that follows the Model Energy Code (MEC), builders must either install a “vapor-permeable housewrap” on the exterior or seal all the penetrations in the building by using some combination of polyethylene, caulks, and gaskets on the interior.

**Performance Measures**

**Permeance.** Permeance ratings measure the rate at which water vapor passes through a material. One perm equals one grain of water vapor passing through one square foot of material per hour per inch of vapor-pressure difference. Under ASTM standard E96, manufacturers can use either test A (dry cup) or test B (wet cup), which yield somewhat different results. Grade D building paper uses yet another standard for measuring permeance, which is roughly equivalent to a permeance rating of about 5, similar to asphalt felt materials. Plastic housewraps range in permeance from around 5 to over 50.

In general, a sheathing wrap should have a permeance of at least 5 to enable wall assemblies to dry out should they get wet. Since common sheathing products like plywood and oriented-strand board (OSB) have permeance ratings of less than one, the sheathing is more likely to interfere with drying than the sheathing wrap.

**Water Resistance.** Several different tests are used to measure the ability of building papers to stop liquid water. Grade D building papers must have a 10-minute rating under ASTM D779, commonly called the “boat test,” in which a piece of building paper is folded in the shape of a boat and floated in a dish of water until it soaks through and wets a powder on top. Some Grade D papers are rated as high as 60 minutes.

In general, products with very high vapor permeability, such as DuPont’s Tyvek®, do poorly in the boat test since water vapor can pass through and wet the indicator powder. However, Tyvek® and other nonperforated plastic housewraps perform well in the alternate “hydro-head” test in which the material is placed under a 22-inch column of water and must not leak for five hours. More importantly, nonperforated plastic housewraps generally do a very good job of shedding liquid water in the field.

**Air Infiltration.** Many sheathing wrap suppliers tout their products’ ability to block air infiltration, often citing proprietary test results. Some follow ASTM E283, in which an 8-foot-square wall section is tested before and after installation of the sheathing wrap. However, since the manufacturer is free to specify the type of wall assembly, one test is not comparable to another, and none simulates real job-site conditions with seams and holes in the sheathing wrap.

If a house already has a reasonably tight wall assembly, there is little evidence that a layer of housewrap will significantly tighten the building. In general, air-sealing efforts are better spent on the building’s interior, using caulks and gaskets or a continuous polyethylene air/vapor barrier.

**Sheathing-Wrap Materials**

Installed carefully, any of the sheathing wraps can perform well and keep water out of walls. The three main choices are traditional asphalt felt, Grade D building paper, and the newer plastic housewraps. The optimal product will depend upon the siding choice, building details, and climate. With any sheathing wrap material, however, the key to good performance is to carefully lap the material to shed water. This job has been made easier by the introduction of a number of peel-and-stick membranes for use around windows, doors, and other trouble spots. General performance characteristics of sheathing wraps are summarized in Table 1-1.
Asphalt Felt. The old standby, asphalt felt, has a perm rating of around 5 and moderately good water resistance, making it suitable for use as a sheathing wrap. However, unlike plastic housewraps, asphalt felt will absorb water when wet. Once wet, its permeability jumps from around 5 to as high as 60. In the event of water leaking into the wall, asphalt felt may help store some of the water, and its high permeability when wet will promote drying to the exterior. Housewrap, in contrast, tends to trap any liquid water that gets behind it.

Some contractors find felt easier to install and weave into flashings because of its rigidity and narrow roll width. Felt, however, tends to get brittle and deteriorate under long-term exposure to UV radiation and is more prone to tear during installation than plastic housewraps. For situations where prolonged exposure is expected, plastic housewraps are better suited. Otherwise, asphalt building felt remains a valid choice for modern homes.

Although traditional 15-pound rag felt weighed 15 pounds per 100 square feet, the material sold today as No. 15 felt is made of recycled cardboard and sawdust and actually weighs only 7 to 8 pounds per square. Most of the lightweight building paper sold has no ASTM rating. ASTM-rated No. 15 felt is either a minimum of 7.6 pounds per square (ASTM D4689) or 11.5 pounds per square (ASTM D226). Similarly, the unrated variety of No. 30 felt typically weighs only 15 to 20 pounds per square versus 26 to 27 pounds for rated Type 2 felt (ASTM D226).

Grade D Building Paper. Grade D building paper is an asphalt-impregnated kraft-type paper, similar to the backing on fiberglass insulation. Unlike asphalt felt, it is made from new wood pulp, rather than recycled material. Its most common use is under stucco in the western United States. The vapor permeance of Grade D paper is similar to asphalt felt. Its liquid water resistance ratings range from 20 to 60 minutes, as measured by using the boat test (see “Water Resistance,” previous page).

Because Grade D paper tends to deteriorate under prolonged wetting, the trend in three-coat stucco is to use two layers of 30-minute paper. Because the paper tends to wrinkle, the two layers tend to form a small air space, creating a rain-screen effect.

Plastic Housewrap. There are a wide range of plastic housewraps on the market. Most are nonwoven fabrics made from either polyethylene or polypropylene. Some have perforations to let water vapor pass through and the others are designed to let water vapor diffuse through the fabric itself. Because there is no single testing standard for plastic housewrap performance, it is difficult to make apples-to-apples comparisons. However, published performance data and limited field studies suggest the following:

- **Permeance to water vapor.** The leading nonperforated products (Tyvek®, R-Wrap®, and Amowrap®) are significantly more permeable to water vapor, ranging from 48 to 59 perms, than nearly all the perforated materials.
- **Water resistance.** All sheathing wraps adequately shed water on vertical surfaces. Pooled water, however, will leak through most perforated plastic housewraps over time, while the nonperforated materials will contain liquid water indefinitely. No. 15 asphalt felt retains water moderately well, but it allows some penetration over time.

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### Table 1-1 Sheathing Wrap Performance

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Uses</th>
<th>Pros</th>
<th>Cons</th>
<th>Perms</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt felt</td>
<td>Sheathing wrap under siding, roofing</td>
<td>Moderate resistance to liquid water. Absorbs and stores water. High permeability when wet.</td>
<td>Deteriorates under prolonged exposure to UV radiation. Prone to tear.</td>
<td>Approx. 5</td>
<td>Use min. 14 lb. material. Good option for all types of siding. Use with rain screen. Do not rely on for air infiltration barrier.</td>
</tr>
<tr>
<td>Grade D paper</td>
<td>Sheathing wrap under stucco</td>
<td>Resists water from 20 to 60 min. as per rating.</td>
<td>Deteriorates if saturated.</td>
<td>Approx. 5</td>
<td>Use two layers of rated material under stucco.</td>
</tr>
<tr>
<td>Plastic housewrap (perforated)</td>
<td>Sheathing wrap under siding</td>
<td>Good permeability.</td>
<td>Low resistance to liquid water</td>
<td>9 to 48</td>
<td>Use in relatively dry areas.</td>
</tr>
<tr>
<td>Plastic housewrap (nonperforated)</td>
<td>Sheathing wrap under siding</td>
<td>Most have high permeability and high resistance to liquid water. Creates air barrier if taped.</td>
<td>Could trap liquid water from leak.</td>
<td>6 to 59</td>
<td>Good option for all types of siding. Use with rain screen. Can also serve as air-infiltration barrier if taped at all seams and edges.</td>
</tr>
<tr>
<td>Draining housewraps</td>
<td>Sheathing wrap under siding, Drainage plane.</td>
<td>Provides drainage plane and air space for rain screen.</td>
<td>Relatively new and untested in field.</td>
<td>varies</td>
<td>Good option for all types of siding in areas subject to windblown rain.</td>
</tr>
</tbody>
</table>
• **Damage from extractives.** Some researchers have noted that extractives leaching out of redwood and cedar siding can cause plastic housewrap to lose its water repellency and to deteriorate. Back-priming the wood siding or leaving an air space behind the siding will help prevent this. Stucco will also degrade plastic housewrap and is rarely installed over it.

• **Recommendations.** Given their high permeance ratings and excellent resistance to liquid water, the nonperforated housewraps are a good choice for most building applications. Traditional asphalt felt is also a good option. Many contractors find plastic sheathing wraps more convenient than asphalt felt in that they weigh only 1 to 2 pounds per square, and they are more flexible in the cold and more tear-resistant. Also they are available in 9- to 10-foot-wide rolls versus 3-foot rolls for asphalt felt.

**Draining Housewraps.** In the last few years, manufacturers have responded to the need for an air space and drainage plane with a variety of housewrap products that are either wrinkled or corrugated to provide an integrated air space. These include products intended primarily for stucco, such as DuPont’s StuccoWrap®, and others developed for siding, such as Raindrop Housewrap, which is a plastic drainage mat from Pactiv, Inc. (see “Resources,” page 47). The air space created by these products is minimal, ranging from 0.02 inch thick for StuccoWrap to 0.008 inch thick for RainDrop®. Although these materials may allow for some drainage, it is unlikely that they will provide any measurable airflow to promote drying.

A more promising approach is a 1/16-inch nylon matrix, called HomeSlicker®, which has vertical drainage channels and installs between the sheathing wrap and siding. The material is rigid and thick enough to resist compression by the siding but thin enough that windows, doors, and trim can be installed without furring.

**Sheathing Wrap Installation**

The primary function of the sheathing wrap, whether building felt or plastic housewrap, is to protect against water leakage. It is critical, therefore, to cover the entire shell from roof to foundation, including gable ends and band joists, and always to lap upper layers over lower layers to shed water. It is also critical to integrate the sheathing wrap with all window, door, and other wall flashings if the weather barrier is to be successful.

The IRC requires asphalt felt to be minimum 14 pounds per square (ASTM D226), overlapped a minimum of 6 inches at vertical joints and 2 inches at horizontal laps. Plastic-housewrap manufacturers recommend 6 to 12 inches of overlap at vertical seams and 4 inches at horizontal laps, with all joints tapered.

It is good practice to wrap corners at least 6 inches each way. If the walls are sheathed and wrapped before being raised, leave a 6- to 12-inch overlap at one side of each corner, and leave a 12-inch, unstapled flap at the bottom to cover the band joist area after the sheathing is nailed off. Wide staples with a minimum 1-inch crown are recommended every 12 to 18 inches for plastic housewraps.

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**FLAShING MEMBRANES**

Peel-and-stick eaves membranes have been used for nearly 20 years to prevent roof leaks from ice dams and other roofing trouble spots. These are typically available in 36-inch widths and are used to protect eaves, shallow-pitch roofs, and other problem roof areas. Over the past few years, a new family of related products has been introduced to help seal walls against water intrusion.

**Flashing Tapes**

Typically ranging in width from 4 to 12 inches, these peel-and-stick membranes greatly simplify the task of creating a continuous barrier to water entry around doors, windows, decks, and other problem areas. Flashing tapes are faced with reinforced polyethylene or foil on the outer surface and a peel-away paper on the adhesive surface. The foil-faced products may be left exposed to the weather permanently, whereas the plastic-faced tapes should not be exposed to sunlight and weather for more than 30 days (longer for some brands) since UV radiation will degrade the facing.

**Modified Bitumen vs. Butyl.** Most flashing membranes are made from modified bitumen, the same rubberized asphalt used in eaves flashing. Some use a more expensive butyl rubber core, which stays more flexible in cold weather and is more stable at high temperatures. Butyl products also bond better to difficult substrates than modified bitumen and can be peeled off and adjusted during installation.

**Moldable Flashing.** A unique butyl-based flashing tape from DuPont, called Tyvek FlexWrap®, has a wrinkled facing that allows it to be molded easily to irregular shapes such as the head flashing of round-top windows. It can also be bent to create a pan flashing at window sills without any cutting and folding at the corners. Despite the higher material costs, labor savings make this product appealing for tricky applications.

**Applications.** These products offer several distinct advantages over metal flashings: They are easily bent or molded for an accurate fit, can accommodate settlement and shrinkage movement, are self-sealing around nail holes, and bond well to a variety of materials, including metal, wood, plywood, and vinyl window flanges. They provide long-lasting waterproof protection if installed
correctly. Oriented-strand board (OSB), concrete, and other masonry materials, however, can be problematic for some of the rubberized-asphalt flashings and may require priming for a good bond. Consult with the product’s specifications for compatible surfaces and priming requirements.

Installation of Flashing Membranes

To obtain the best results with these products and be protected by the manufacturer’s warranty, it is advisable to follow the manufacturer’s recommendations. These vary from product to product, but generally they address the same issues: application temperature, priming, installation techniques, and compatibility with surrounding materials.

Temperature. In general, the rubberized asphalt (modified-bitumen) products start to lose stickiness at around 50°F and will not bond much below 40°F. Unless you are working with a rubberized-asphalt product specifically formulated for low-temperature applications, a butyl-based product is a better choice in cold weather.

Very high temperatures can also be problematic for rubberized-asphalt membranes. When subjected to high temperatures and pressure, for example, when squeezed under a dark-colored metal flashing exposed to direct sun, the material will soften and begin to flow. Unless formulated for high temperatures and labeled “hi-temp,” most modified bitumen will begin to soften between 185°F and 210°F. High-temperature formulations can tolerate up to around 240°F, but are generally not as sticky.

Substrates. Each manufacturer specifies which products are safe to bond to and which require priming. Solid wood, plywood, vinyl window flanges, and metal are usually fine as long as they are free of oil and dust. Some manufacturers of rubberized-asphalt tapes recommend that all materials be primed for best performance, particularly in cold weather. Most require that concrete and masonry be primed, and some require the priming of OSB and gypsum sheathing as well.

Many published details show asphalt-rubber flashing tapes bonded to asphalt felt and plastic Housewraps. While these are rarely listed as suitable substrates in product literature, manufacturers of flashing tapes claim that their products will bond satisfactorily to both these materials as long as they are clean. Do not expect a good bond to dirty housewrap that has been exposed to the weather for a month or to any dirty job-site material. For that reason, it is always best to detail flashings and to layer materials so that they shed water even if the adhesive bond fails.

Compatibility. Rubberized-asphalt flashings should not be in direct contact with flexible vinyl flashings. The asphalt compound will draw the plasticizers out of the vinyl, causing the asphalt to soften and flow and the vinyl to become brittle. The rigid polyvinyl chloride (PVC) used in window flanges, however, is generally not a problem.

Rubberized-asphalt flashings should also not come into contact with any caulks or sealants unless specifically formulated for that use. Like soft vinyl, sealants may react with the asphalt, causing it to flow and stain the adjacent materials, such as window flanges.

Butyl-based flashings are compatible with most construction caulks and sealants, but they should never be installed in contact with any asphalt-based products such as roofing cement or bituminous flashing membranes. These may degrade the butyl and undermine its ability to seal. In these applications, rubberized-asphalt is a much better choice.

Applying Pressure. Flashing tapes must be pressed firmly into place to ensure full contact and a good bond. Some manufacturers recommend using a hard rubber roller for best results.

Splashback Protection and Other Uses. While most flashing tapes are used around doors and windows, they can be put to good use wherever water penetration is an issue. Other applications include band joists, deck ledgers, inside and outside corners, and any areas subject to frequent wetting. On wall areas adjacent to a deck or abutting a roof, for example, where splashback or snow buildup is likely to wet the siding, sections of membrane up to 36 inches wide can protect wall assemblies. Make sure to lap all layers of flashing, sheathing wrap, and adhesive membrane so that water is directed to the outside of the building, even if the adhesive bond fails.

Caution: Cold-Side Vapor Barrier. In cold climates, covering an entire wall section with waterproof membrane will create a cold-side vapor barrier, potentially leading to serious moisture problems and wood decay within the wall cavity. A section of membrane up to 3 feet wide, however, is unlikely to cause problems.

WALL FLASHING

Wall flashings are required at openings, corners, intersections, and wherever a roof terminates into a wall. While peel-and-stick tapes have replaced these flashings at many details, metal flashings are still preferred for many standard details and applications where the flashing is visible or needs to hold a shape or serve as a drip edge.

Flashing Materials

Choose metal flashings that are compatible with the adjoining building materials and are at least as durable as the siding and roofing materials where they are to be placed. (See “Galvanic Corrosion,” page 83, for information on metal compatibility.)
Aluminum. Most residential wall flashing today is made from light-gauge aluminum coil stock. Aluminum is inexpensive, easy to bend, and holds paint well. However, it tends to oxidize and pit in salty or polluted air and, if unpainted, will corrode from contact with masonry due to the lime and acids. Aluminum cannot be soldered. If using aluminum, use at least .029-inch coil stock, preferably anodized or prefinished, which is much more resistant to corrosion.

Copper. When the budget allows, copper is a good choice. Copper flashings come in two types: soft and harder cold-rolled. Soft copper is very malleable and useful for molding into irregular shapes. The harder cold-rolled material is a better choice for most applications, because it is stronger and more durable.

Copper flashings solder easily and offer good corrosion resistance, even in polluted air and in contact with masonry. Over time, all unpainted copper will oxidize and develop a green patina that protects the underlying copper. While most people find the patina attractive, the runoff of the green oxidation can stain siding or trim.

Some experts also caution against using copper or lead-coated copper in contact with redwood or red cedar or its runoff. Over time, the copper surface will be etched by the acidic wood runoff. Although actual failures of copper flashings are rare, they have been reported in areas of the Northeast after 10 to 20 years of service. Acid rain, combined with exposure to runoff from red cedar or other corrosive materials, is suspected as the cause. (See also “Copper,” page 83.)

Lead-Coated Copper. This is a sheet of copper with a lead coating on each side. Where staining of building components from runoff is a potential problem, lead-coated copper may be used, which has a less noticeable gray runoff. Also, without the lead coating, copper flashing will react with galvanized steel.

Lead. For special flashing applications where a high degree of malleability is required, lead is an option. In addition to being easily bent and molded, lead is very resistant to corrosion. Lead is relatively soft, however; so it should not be used where it will be bumped or walked on. Also, it is best if left unattached on one side; if rigidly fastened on all sides, it can tear from fatigue due to thermal movement.

Sidewall Flashing Details

Windows and Doors. Window and door flashings are discussed extensively in a later section (see page 119).

Termite Shields. Metal termite shields are widely used atop foundations in the southern United States and in tropical climates as a physical barrier to termites. They sit directly on top of foundation walls, piers, and other supports before the first piece of wood is installed (see Figure 1-3).

At one time termite shields were thought to block the entry of subterranean termites, the most widespread and destructive wood-boring insect in the United States. However, subterranean termites, which nest in the soil, will exploit the tiniest gaps in termite shields or other barriers to reach the wooden portions of a house and will build tunnels along exposed foundation walls and around termite shields if necessary. Although the shields do not stop termites, they slow down their progress and force them to build their tunnels in the open where they can be easily seen during inspections.

To work at all, the termite shield must have tightly sealed joints and be sealed around foundation bolts and other penetrations. Joints can be either soldered or mechanically interlocking. If the barrier is unsealed, termites will find any small gaps and render the effort worthless.

In general, termite shields should be a minimum of 6 inches above grade and extend out 2 inches on either side of the foundation at a 45 degree angle. In addition to making termite infestations visible, they also form a capillary break between the foundation and sill. Areas where a termite shield cannot be used, for example, where a concrete stairway abuts a foundation wall, are at high risk for termite entry.

In termite-prone regions, the only reliable way to prevent termite damage is to use treated wood in critical locations and treat the surrounding soil with termiticide.

Water Table. On many traditional homes, a wide board called the “water table” is installed along the foundation...
and supports the first piece of siding. The water table should extend about an inch over the foundation and be protected by a metal drip cap installed under the sheathing wrap. Cut a slit in the sheathing wrap along the entire length of the water table and slip the upper leg of the flashing under the wrap (see Figure 1-4).

Decks and Porches. It is critical to protect against leaks and water buildup at deck ledgers, since decay in this part of a building can lead to structural failure of the deck. At a minimum, install a cap flashing that tucks under the sheathing wrap and goes over the ledger (see Figure 4-8, page 145). Adding a second flashing, either peel-and-stick membrane or aluminum-coil stock, between the sheathing and ledger, as shown, is a worthwhile backup should any water get over, around, or through punctures in the cap flashing. Since pressure-treated wood can be corrosive to unfinished aluminum, use coated-aluminum or galvanized-steel flashing.

Corners. Corner boards are prone to leakage due to shrinkage of materials and wind exposure. For simple, effective backup protection, add a spline of asphalt felt paper at outside corners so that it extends 6 inches beyond the corner boards. Inside corners also benefit from a spline (Figure 1-5).

With this type of backup protection and with the end grain of the siding well sealed, it is unnecessary to caulk the siding joints at inside and outside corners. Leaving a small gap and not caulking these joints allows any water that penetrates to dry to the exterior. Eventually caulking joints will fail anyway, allowing water to leak in but inhibiting drying.

Step Flashing. Integrate all step flashings with the sidewall-sheathing wrap by slipping the upper legs of the step flashing under the sheathing wrap (Figure 1-6). Where snow buildup is anticipated, add a band of peel-and-stick membrane lapped over the step flashing but under the sheathing wrap.
**Splashback.** In wall areas subjected to splashback, snow buildup, or high moisture from other sources, rubberized asphalt membranes in widths up to 36 inches can be used to protect the wall sheathing and structure. Water damage from splashback is common in wall sections located under the eaves of a roof with no gutters. Walls above decks or flat roofs are also prone to moisture damage from splashback or snow buildup.

In all cases, make sure to detail the flashing membrane so that it tucks under the sheathing wrap above and over the step flashing or cap flashing below. If installed along the foundation, the membrane should cover the joint where the sill meets the foundation.

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**WOOD SIDINGS**

Solid wood sidings remain popular in many sections of the United States despite their need for regular refinishing. In the Northeast, the most popular profile remains a simple bevel siding, or “clapboard.” In the western states, heavier profiles such as channel rustic are more common.

**Species**

Red cedar remains the wood siding material of choice due to the natural decay resistance of the heartwood and its attractive appearance when stained or finished clear. Other decay-resistant woods are popular in the regions where they are produced: for example, redwood on the West Coast and cypress in the Southeast and Gulf Coast. On projects where premium wood species are not affordable, builders also use a wide variety of softwoods, including pine and spruce, which are not naturally resistant to decay. While most suppliers of wood siding now recommend back-priming and priming of cut ends, these details are even more critical with the less decay-resistant species.

**Grading**

Since wood siding is a nonstructural application, grading is generally for appearance only and is not governed by building codes. Most western species used for siding are graded according to one of the established grading agencies such as the Western Wood Products Association (WWPA). Still, manufacturers are free to name the grades as they choose for marketing purposes. So one company’s “Select” grade may be quite different from another’s. For this reason, it is best to examine the material before specifying or purchasing.

**Premium Grades.** Western woods are generally labeled either premium or knotty grades. Premium grades have more heartwood and fewer defects and are typically kiln-dried. The highest grades of cedar are typically Clear VG (vertical grain) Heart and Clear Heart. Premium grades for other western woods include C Select, D Select, Superior, and Prime.

**Knotty Grades.** In general, “sound tight knots” or “select tight knots” (STK) indicates that there are no knots that will come loose or affect the performance of the siding. Other common designations are Select Knotty, Quality Knotty, 2 & Better Common, 3 & Better Common, and NPS (no prior selection). Since there are no uniform standards for these designations, an inspection of the material is important.

**Moisture Content.** Ideally, the siding should be installed close to its equilibrium moisture content for the local climate (see Table 1-2). In general, unseasoned or green wood is shipped with a moisture content of greater than 19%. Air-dried or kiln-dried siding is shipped with a moisture content of 15 to 19%. In western woods, dry has a different meaning for premium and knotty grades. In premium grades, dry means the siding has no more than 15% moisture content. In knotty grades, dry means that the moisture content does not exceed 19%.

Dry siding stored on the site (stickered if possible) will usually acclimate to local conditions in a week to 10 days. Unseasoned wood may need 30 days or longer to acclimate.

**Siding Profiles.** Because horizontal profiles naturally shed water, they resist water leakage better than vertical profiles. Also vertical wood siding is prone to wick up moisture from the bottoms of the boards, particularly where there is snow buildup or splashback. Diagonal siding is the most prone to leakage since water is conducted down the joints to window headers and other possible entry points. The most common profiles with typical installation details are shown in Figure 1-7.

---

<table>
<thead>
<tr>
<th>TABLE 1-2</th>
<th>Wood Moisture Content for Siding, Sheathing, and Exterior Trim</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended Moisture Content at Time of Installation</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Most of Continental U.S.</strong></td>
<td><strong>Dry Southwestern States</strong></td>
</tr>
<tr>
<td>Average</td>
<td>Individual Pieces</td>
</tr>
<tr>
<td>12%</td>
<td>9%–14%</td>
</tr>
</tbody>
</table>

**Source:** Adapted from the *Wood Handbook*, 1999, USDA Forest Products Laboratory.
Installation Details

While the premium grades of siding are more forgiving of installation and finishing problems than budget materials, all wood siding requires attention to detail to provide a durable and attractive exterior. Critical details are back-priming, air space, nailing, and finishing.

Drainage. An air space behind the siding, in addition to protecting the building shell (see “Rain-Screen Principle,” page 2), also improves the performance of wood sidings. The siding material is less prone to moisture movement and paint is less likely to fail, even if the space is only $\frac{1}{4}$ inch wide. While the vast majority of wood siding is installed directly on the sheathing wrap, builders who have had problems with paint and siding have found that adding an air space is worth the additional cost. New products—such as wrinkled and corrugated sheathing wraps with an integral air space, and behind-the-wall drainage mats such as Benjamin Obdyke’s Home Slicker®—are simplifying this step.

Back-Priming. The major trade associations representing siding manufacturers all recommend back-priming and priming of cut ends. With cedar and redwood, back-priming will minimize the bleeding of extractives from the back of the siding, which can drip onto the face of the siding and stain the finish, and can also degrade sheathing wraps. With all sidings, back-priming will reduce the movement of moisture into and out of the siding, minimizing problems with cupping, warping, and checking.

Siding Over Foam. The need for back-priming and a ventilation air space is even greater when installing over foam sheathing. With no air space and no wood sheathing to temporarily store the moisture, any water that leaks through the siding or is driven in by the sun will tend to wet the back of the siding. The result, documented in a joint study conducted by wood siding and foam manufacturers, is increased cupping, cracking, and paint problems.

Plywood Siding. Plywood sidings are typically nailed directly to studs or through a layer of foam, and they provide a structural sheathing as well as an exterior finish. Most have vertical grooves to imitate vertical sidings. All plywood sidings should be painted or stained to protect the outer facing and prevent the panels from delaminating over time. Vertical joints are typically hidden by the vertical
grooves in the pattern. Horizontal joints must be protected by a Z flashing to shed water (Figure 1-8).

**Fastener Types.** Nailing requirements are shown in Table 1-3. In general, nails should penetrate the sheathing and studs or blocking by 1\(\frac{1}{8}\) inches, or 1\(\frac{1}{4}\) inches with ring-shanked or spiral-shanked nails. Although specialized siding nails with small heads and blunt tips are preferred, staples are acceptable for some applications.

Since the cost of fasteners is a small percentage of a siding job, it makes sense to use stainless steel, particularly with cedar and redwood, which can react with some types of nails (galvanized and copper) and cause dark stains (see Figure 1-9).

Ring-shanked or spiral-shanked siding nails can be set flush and painted over or countersunk and put-tied before painting.

**High-strength aluminum.** These are corrosion-resistant and can be used with all wood sidings. However, the aluminum can react with galvanized-steel flashing and cause corrosion.

- **Hot-dipped galvanized.** These can react with the tannins in cedar and redwood, causing black stains and streaking. Also the protective coating can chip when nailed, exposing the underlying steel to corrosion.

- **Electrogalvanized.** These are not recommended for any siding application since the coating is not thick enough and they are likely to corrode and stain the siding.

**Nailing Schedule.** Both the 2003 International Building Code (IBC) and the Western Wood Products Association require that solid wood siding products be nailed directly into studs or 2x blocking. Ring-shank nails should penetrate 1\(\frac{1}{4}\) inches into wood (combined sheathing and stud) and smooth-shank nails 1\(\frac{1}{2}\) inches.

With high-quality, dry, dimensionally stable siding materials such as kiln-dried redwood and red cedar clapboards, some contractors nail siding directly to nominal \(\frac{1}{2}\)-inch nail-base sheathings, such as OSB and plywood, using ring-shank nails. Check with local codes before taking this approach. To avoid problems, make sure joints fall on studs or solid blocking (see Figure 1-10).

- **Horizontal sidings.** Nailing should be maximum 24 inches on-center when over nail-based sheathing.
and 16 inches on-center over nonstructural sheathing. Trade associations such as the Western Wood Products Association recommend against “double nailing” for most horizontal wood-siding profiles, including bevel siding. That is, nails should be driven above the overlap line of the siding board below to reduce the risk of cracking. Despite this recommendation, many contractors nail 1/2-inch-thick clapboards just below the overlap line, catching the top edge of the piece below to avoid cracking the siding during installation. While this approach may be acceptable with dry, premium-grade siding, it will likely lead to problems with lower quality materials (Figure 1-11).

**Vertical sidings.** In general, vertical sidings are nailed to the top and bottom plates and to horizontal nailers installed every 36 inches for face-nailed siding and every 32 inches when blind-nailed. Because vertical sidings are vulnerable to leakage, they are not recommended for areas subject to wind-blown rain.

<table>
<thead>
<tr>
<th>Siding Patterns</th>
<th>Description</th>
<th>Nominal Sizes (inches)</th>
<th>Nailing: Boards up to 6” Wide</th>
<th>Nailing: Boards 8” or Wider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bevel or Bungalow</td>
<td>Bevel or Bungalow has 3/4” butt vs. 1/2” for bevel. Lap 1” with either smooth or rough side out.</td>
<td>3/4 x 6 1/2 x 8 1/2 x 10</td>
<td>One siding or box nail per bearing, just above the 1” lap line. Do not nail through overlap.</td>
<td>One siding or box nail per bearing, just above the 1” lap line.</td>
</tr>
<tr>
<td>Rabbeted Bevel or Dolly</td>
<td>Rabbeted Bevel or Dolly with rabbeted edge at overlap. Install with smooth or rough side out with 1/8” overlap. Allow 1/8” gap for wide boards or dry wood.</td>
<td>3/4 x 6 3/4 x 8 3/4 x 10</td>
<td>One siding or box nail per bearing 1” up from bottom edge. Do not nail through overlap.</td>
<td>One siding or box nail per bearing, 1” up from bottom edge.</td>
</tr>
<tr>
<td>Varden</td>
<td></td>
<td>1 x 6 1 x 8 1 x 10 1 x 12</td>
<td>Face-nail with one siding or box nail, 1” up from bottom edge. Do not nail through overlap.</td>
<td>Face-nail with two siding or box nails, 3”–4” apart, 1” up from bottom edge.</td>
</tr>
<tr>
<td>Shiplap</td>
<td>Many patterns in smooth, rough, or saw-textured. Horizontal or vertical installation. Tongue edge up in horizontal applications. Allow 1/8” overlap, with 1/8” gap for wide boards or dry wood.</td>
<td>3/4 x 6 3/4 x 8 3/4 x 10</td>
<td>One casing nail per bearing, blind-nailed at base of tongue. Do not nail through overlap.</td>
<td></td>
</tr>
<tr>
<td>Tongue and Groove</td>
<td>Available in many patterns. Horizontal or vertical installation. Tongue edge up in horizontal applications.</td>
<td>1 x 4 1 x 6 1 x 8 1 x 10 1 x 12</td>
<td>One casing nail per bearing, blind-nailed at base of tongue. Do not nail through overlap.</td>
<td>Face-nail two siding or box nails 3”–4” apart per bearing.</td>
</tr>
<tr>
<td>Channel Rustic</td>
<td>Available smooth, rough, or saw-textured for horizontal or vertical applications. 1” to 1 1/4” exposed channel allows maximum dimensional change. Place wide rabbet up in horizontal applications. Allow 1/8” overlap, with 1/8” gap for wide boards or dry wood.</td>
<td>3/4 x 6 3/4 x 8 3/4 x 10</td>
<td>Face-nail with one siding or box nail per bearing, 1” up from bottom. Do not nail through overlap.</td>
<td>Face-nail with two siding or box nails 3”–4” apart per bearing.</td>
</tr>
</tbody>
</table>

**Table 1-3 Nailing Recommendations for Wood Siding**
Wood Siding Details

Proper detailing at joints, corners, and openings makes for an attractive and durable job. Key details follow:

**Lap Joints.** The IRC requires that horizontal lap sidings have a minimum one-inch lap joint, or \( \frac{1}{2} \) inch if the siding is rabbeted.

**Butt Joints.** In most climates, it is a good idea to slip a small spline of asphalt-felt paper behind each butt joint in horizontal sidings. Layer the spline so it overlaps the piece of siding below, directing any water out onto the siding (see Figure 1-12).

All end grain in the siding should be sealed after cutting with a water-repellent preservative (WRP) or primer. With the spline, there is no need to caulk the joint. With no caulk, the joint is free to dry out when wet.

**Plywood sidings.** Plywood siding is often nailed directly to studs or through an insulating sheathing and serves as a structural sheathing as well as the exterior finish. Use 6d box, siding, or casing nails for nominal \( \frac{1}{2} \)-inch plywood siding nailed directly to studs. For nail spacings, see Table 1-4.

**FIGURE 1-9** Nail Stains.

Corrosion from galvanized nails produced the striped pattern above on cedar siding. With redwood or cedar, stainless-steel nails are recommended.

SOURCE: Photo by author.

**FIGURE 1-10** Siding Joints.

Locate all joints in bevel siding over studs, or the ends may cup and lift, as shown.

**FIGURE 1-11** Double Nailing.

Nailing through the overlap can lead to shrinkage cracks in lower quality wood sidings.

SOURCE: Photo by author.

**Wood Siding Details**

Proper detailing at joints, corners, and openings makes for an attractive and durable job. Key details follow:

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**Butt Joints.** In most climates, it is a good idea to slip a small spline of asphalt-felt paper behind each butt joint in horizontal sidings. Layer the spline so it overlaps the piece of siding below, directing any water out onto the siding (see Figure 1-12).

All end grain in the siding should be sealed after cutting with a water-repellent preservative (WRP) or primer.

**Corners.** Use overlapping 1x4s or 1x6s at outside corners or use \( \frac{3}{4} \) stock for a heavier look. Use a felt paper spline, wrapped around the corner and extending 6 inches beyond the corner board, to protect the joints where the siding meets the corner boards (see Figure 1-5, page 8). Use a square length of \( \frac{3}{4} \) stock at inside corners with a spline underneath. All end grain in the siding should be sealed after cutting with a water-repellent preservative (WRP) or primer. With the spline, there is no need to caulk the joint. With no caulk, the joint is free to dry out when wet.
Windows and Doors. If windows and doors are properly protected with splines of felt or flashing tape, there is no need to caulk the joints where siding meets the side casings. At the top of a door or window, always direct the sheathing wrap over the head flange or cap flashing. Never caulk the joint between the siding and the head casing or the sill, leaving these joints open to drain any trapped water.

At Step Flashings. Stop wood sidings at least 1 inch short of the bottom leg at step flashings and other roof flashings. Otherwise water will wick up into the

<table>
<thead>
<tr>
<th>TABLE 1-4</th>
<th>Nailing for Plywood Siding Direct to Studs or Over Foam Sheathing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel Siding Type</td>
<td>Nominal Thickness or Span Rating (in.)</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
</tr>
<tr>
<td>APA MDO EXT</td>
<td>$\frac{5}{6}$ and $\frac{7}{8}$</td>
</tr>
<tr>
<td></td>
<td>$\frac{7}{8}$ and thicker</td>
</tr>
<tr>
<td>APA-rated siding EXT</td>
<td>16 o.c.</td>
</tr>
<tr>
<td>APA-rated siding EXT</td>
<td>24 o.c.</td>
</tr>
</tbody>
</table>

*Use nonstaining box, siding, or casing nails.

**3 in. on-center (o.c.) for braced wall sections framed 24 in. on-center with $\frac{11}{16}$ or $\frac{3}{4}$ in. siding applied horizontally.


In areas subject to windblown rain and snow, protect joints in horizontal siding with felt-paper splines. Also, seal all end grain with a primer or water-repellant preservative.

FIGURE 1-12 Splines Under Bevel-Siding Joints.

FIGURE 1-13 Joints in Vertical and Plywood Siding.

Use a scarf joint to shed water to the building’s exterior at horizontal joints in vertical wood siding. With plywood sidings, use a Z flashing.

flashing leading to paint failures and decay (see Figure 1-6, page 8).

Vertical and Plywood Siding. Avoid horizontal butt joints in vertical siding. Where a butt joint is necessary, use a scarf joint sloped down toward the building’s exterior. With plywood sidings, use a Z flashing at horizontal joints to shed water to the outside (see Figure 1-13).
**WOOD SHINGLES AND SHAKES**

Cedar shingles and shakes are a popular choice for sidewall applications in coastal regions. Eastern white cedar shingles are often left unpainted in New England coastal areas. Red cedar shakes are often left unpainted on the West Coast. Red cedar shingles are sometimes left natural, but more often are painted or stained. Sidewall installation is similar for shakes and shingles with some variation in exposure (see Table 1-5).

**Grades**

Red cedar shingles come in four grades, but most sidewalls use grades No. 1 or No. 2. No. 1 is all heartwood and all edge-grain wood. They are available rebutted and rejoined (R&R) where a uniform appearance is desired and machine grooved for a textured surface. Red cedar shingles come either taper-split or untapered and are usually installed in Premium or No. 1 grade (see Table 1-6).

Eastern white cedar shingles are available in four grades. Most sidewall work uses Grade A (Extra), which is all clear heartwood, or Grade B (Clear), which has no knots on the exposed face (see Table 1-7).

**Installation**

The simplest and most common pattern for sidewall shingles and shakes is single coursing. For wider exposures and deeper shadow lines, shingles and shakes can also be installed in double courses. A rustic staggered pattern is also possible.

**Underlayment.** The Cedar Shake and Shingle Bureau recommends installation over Type 30 asphalt felt underlayment for red cedar shingles and shakes. Install the felt paper with minimum 6-inch overlaps on vertical joints, 2 inches on horizontal laps, and 4 inches wrapped each way at inside and outside corners. Creasing the felt at corners will help achieve a tight fitting corner.

For optimal performance, manufacturers of Eastern white cedar shingles now recommend installation over horizontal furring spaced equal to the shingle exposure or over a ventilating layer such as Benjamin Obdyke’s Home Slicker®. They acknowledge that most sidewall installations still go directly over the wall sheathing covered with felt paper or plastic housewrap. Field experience suggests that an air space or drainage/ventilation layer is critical for longevity on roofs, but on sidewalls, good quality white cedar shingles perform adequately without these extra steps.

**Single Coursing.** The first course of shakes or shingles is doubled, with the outer course dropped \( \frac{1}{4} \) inch lower to create a drip edge (see Figure 1-14). Tack up a length of 1x3 furring as a guide for the next course, moving up the wall with each successive course.

To create a weather-tight exterior, do not exceed the exposures shown in Table 1-5. Space No. 1 red cedar shingles \( \frac{1}{8} \) to \( \frac{1}{4} \) inch apart to prevent possible buckling. A \( \frac{1}{3} \)-inch space is recommended for No. 2 R&R red cedar shingles. White cedar shingles should be spaced from \( \frac{1}{16} \) to

---

### Table 1-5: Maximum Exposures for Sidewall Shakes and Shingles

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Grade</th>
<th>Single Course</th>
<th>Double Course</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number 1 Grade Products</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16” Shingles</td>
<td>1</td>
<td>7( \frac{1}{2} )”</td>
<td>12”</td>
</tr>
<tr>
<td>18” Shingles</td>
<td>1</td>
<td>8( \frac{1}{4} )”</td>
<td>14”</td>
</tr>
<tr>
<td>24” Shingles</td>
<td>1</td>
<td>11( \frac{1}{2} )”</td>
<td>16”</td>
</tr>
<tr>
<td>18” Shakes</td>
<td>1</td>
<td>8( \frac{1}{2} )”</td>
<td>14”</td>
</tr>
<tr>
<td>24” Shakes</td>
<td>1</td>
<td>11( \frac{1}{2} )”</td>
<td>18”</td>
</tr>
<tr>
<td><strong>Number 2 Grade Products</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16” Shingles</td>
<td>2</td>
<td>6”</td>
<td>10”</td>
</tr>
<tr>
<td>18” Shingles</td>
<td>2</td>
<td>7”</td>
<td>11”</td>
</tr>
<tr>
<td>24” Shingles</td>
<td>2</td>
<td>9”</td>
<td>14”</td>
</tr>
<tr>
<td>18” Shakes</td>
<td>2</td>
<td>7”</td>
<td>10”</td>
</tr>
<tr>
<td>24” Shakes</td>
<td>2</td>
<td>9”</td>
<td>14”</td>
</tr>
</tbody>
</table>

1 No. 2 exposures based on Cedar Shake & Shingle Bureau recommendations. Others based on International Residential Code.
### TABLE 1-6 Western Cedar Shingle and Shake Grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>Length</th>
<th>Min. Clear Length</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 1 Blue Label</td>
<td>16”</td>
<td>All clear</td>
<td>Premium grade for sidewalls and roofs. 100% clear, edge-grain heartwood. Available rebutted and rejointed (R&amp;R) with parallel edges and smooth butts. R&amp;R available with one face sanded or machine grooved.</td>
</tr>
<tr>
<td></td>
<td>18”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 2 Red Label</td>
<td>16”</td>
<td>(10”)</td>
<td>Suitable for many applications. Flat grain and limited sapwood permitted. Available rebutted and rejointed.</td>
</tr>
<tr>
<td></td>
<td>18”</td>
<td>(11”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24”</td>
<td>(16”)</td>
<td></td>
</tr>
<tr>
<td>No. 3 Black Label</td>
<td>16”</td>
<td>(6”)</td>
<td>Utility grade for economy applications.</td>
</tr>
<tr>
<td></td>
<td>18”</td>
<td>(6”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24”</td>
<td>(10”)</td>
<td></td>
</tr>
<tr>
<td>No. 4 Undercoursing</td>
<td>16”</td>
<td>(no min.)</td>
<td>Utility grade for undercoursing of double-coursed sidewalls. Not suitable for roofing starter course or other roofing applications.</td>
</tr>
<tr>
<td></td>
<td>18”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Shakes              |        |                   |                                                                                |
| Certi-Split Handsplit Shakes | 18” | All clear | These have machine-split faces and sawn backs. Blanks are run diagonally through a bandsaw to produce two tapered shakes. Premium Grade is 100% edge-grain heartwood. No. 1 Grade allows up to 20% flat grain per bundle. |
|                     | 24”    |           |                                                                                |
| Certi-Sawn Tapersawn Shakes | 18” | All clear (except Grades 2 and 3) | Sawn both sides. Premium Grade is 100% clear edge-grain heartwood. No. 1 Grade allows up to 20% flat grain per bundle. No. 2 and 3 Grades also available. |
|                     | 24”    |           |                                                                                |
| Certi-Split Tapersplit Shakes | 18” | All clear | Produced by hand using a steel froe and mallet. The natural shingle-like taper is achieved by reversing the block end-for-end with each split. Premium Grade only. |
|                     | 24”    |           |                                                                                |
| Certi-Split Straight-Split Shakes | 18” | All clear | Produced by machine or in the same manner as taper split shakes except shakes are same thickness throughout. Premium Grade only. |
|                     | 24”    |           |                                                                                |

**NOTE:** Based on grading criteria of the Cedar Shake & Shingle Bureau.

### TABLE 1-7 White Cedar Shingle Grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>Characteristics</th>
<th>Recommended Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Extra (blue label)</td>
<td>Premium quality, pale color, all clear heartwood.</td>
<td>Siding or roofing in harsh climates. Highly resistant and durable.</td>
</tr>
<tr>
<td>B. Clear (red label)</td>
<td>Standard quality, rich color, no knots on exposed face (first 6”).</td>
<td>Siding or steep-slope roofing.</td>
</tr>
</tbody>
</table>

1/4 inch apart depending on conditions—a 1/16-inch gap would be appropriate for green shingles, which are prone to shrinkage, and a 1/4-inch gap for kiln-dried shingles installed in a moist environment.

Also, offset joints in successive shake or shingle courses by at least 1 1/2 inches as shown in Figure 1-15.

Treat knots and other defects like an edge and offset adjacent courses at least 1 1/2 inches. With white cedar shingles, also make sure that two joints do not align if separated by only one course.

**Double Coursing.** For increased exposures and deeper shadow lines with red cedar shingles or shakes, apply in double courses, as shown (Figure 1-16).

Despite the greater exposures, considerably more material and labor are required. Installation starts at the
Nailing. Use corrosion-resistant box or casing nails of either stainless steel, hot-dipped galvanized, brass, or aluminum. For concealed nails, hot-dipped galvanized are adequate. For exposed nails at corners and under eaves and windows, stainless steel, brass, or aluminum are less likely to stain the wood.

For red cedar shingles and shakes, nail 2 inches above the butt line and 3/4 inch in from each end. Cedar shingles wider than 10 inches need two additional nails 1 inch apart near the center of the shingle. Nails should fully penetrate the sheathing (see Table 1-8). Aluminum or stainless-steel staples with 1/16- to 3/4-inch crowns are also an option for red cedar shingles if accepted by local codes.

White cedar shingles are nailed 1 1/2 inch above the butt line and 1/4 inch in from each end. Manufacturers recommend a 1/2 inch (3d) box or shingle nail for new construction and a 1 1/2 inch (5d) nail when going over another siding material. Drive nails flush with the surface. Do not overdrive and set the nails or leave them projecting from the surface.

Clearance at Flashings. Keep all shingle bottoms a minimum of 1/2 inch above the lower leg of any flashings to minimize the wicking of water, which can lead to staining and possible decay.

Corners. As extra protection, it is a good idea to add a layer of flashing or No. 30 felt paper at inside and outside corners. If felt is used, crease it at corners for a tighter fit. A simple, attractive inside corner can be achieved by butting the shingles to a 5/8-inch square cedar strip nailed
### TABLE 1-8 Fasteners for Red Cedar Shingles and Sidewalls

<table>
<thead>
<tr>
<th>Product Type</th>
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<th>Nail Type and Min. Length for Double Coursing</th>
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<td>5d box (1 3/4”) or same size casing nails</td>
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Source: Courtesy of Cedar Shake & Shingle Bureau, © 2005 CSSB. All Rights Reserved.

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**FIGURE 1-17** Shingle Corner Details.

For fast, simple corners, butt the shingles to corner boards. Woven corners are attractive but labor-intensive. With either approach, flash behind the corner with a metal flashing or extra layer of felt paper.


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**FIGURE 1-18** Prefab Shingles.

To speed up installation, several manufacturers offer sidewall shingle panels preassembled with either staples or adhesive. Panels can also simplify installation of outside corners, column wraps, and other labor-intensive details.

Source: Photo courtesy of Shakertown 1992, Inc.

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Into the corner. For fast and simple outside corners, butt the shingles to corner boards made from 1x or 5/4 stock (see Figure 1-17).

Another more labor-intensive approach is to “weave” inside and outside corners by alternating two shingles on one side with two on the other. On an outside corner shingled this way, the exposed edge alternates every course. To keep outside corners tight, nail through the butts with a small hot-dipped galvanized finish nail. On woven inside corners, alternating courses keep the joints tight.

**Panelized Installation.** To simplify and speed up installation, several manufacturers offer sidewall shingles attached to panels with either staples or adhesive (see Figure 1-18).

The panels range from one-course panels 32 inches wide to three-, four-, and five-course panels 2 feet wide by 8 feet long, including panels with decorative patterns. Some manufacturers also offer prefabricated inside and outside corners, radiused panels for curved walls, column wraps, and other types of labor-intensive details.
FIBER-CEMENT SIDING

Many synthetic alternatives to wood siding have fallen short either on aesthetics or durability. Fiber-cement, one of the newest entries into the field, holds great promise in that the material can be fashioned to resemble almost any exterior cladding, holds paint well, and is essentially impervious to decay, insects, UV radiation, and fire. It is also very dimensionally stable and resists shrinking and swelling, cupping, warping, and splitting. Warranties run from 30 to 50 years depending on the manufacturer and specific configuration. It is cost-competitive with vinyl and hardboard siding and significantly less expensive than premium wood sidings.

Fiber-cement is made up primarily of Portland cement, sand, and wood fibers. It is chemically similar to older asbestos sidings but contains no asbestos, glass fibers, or formaldehyde. It does, however, produce a very fine silica dust when cut with a saw or abrasive blade, which, if inhaled, can cause silicosis and other serious respiratory problems.

Fiber-cement boards are extremely straight and rigid when held edgewise, but they are much heavier than wood—about 20 pounds for a 12-foot length of 8\(\frac{1}{4}\)-inch siding. They are flexible along the flat dimension, however, so any lumps in a wavy framing job will tend to telegraph through the siding. The material is fairly brittle and, if not handled carefully, can crack.

**Styles and Sizes**

Fiber-cement is available in a wide array of styles and finishes modeled after other materials ranging from horizontal wood siding to vertical sidings, wood shakes, bricks, and stones. The wood patterns are generally available either smooth or wood-grained and most are available factory-primed or finished as well as unfinished.

Fiber-cement horizontal siding planks are typically 5\(\frac{1}{4}\) to 12\(\frac{3}{4}\) inches wide by 12 feet long and are designed for a 1\(\frac{1}{2}\) inch overlap. Vertical siding panels measure 4x8, 4x9, or 4x10 feet, and shake and shingle panels are typically 16x48 inches. The thickness of most siding materials is \(\frac{5}{16}\) inch. Smooth and textured soffit and trim boards are also available. Fiber-cement soffit material is typically \(\frac{1}{4}\) inch and most trim stock is \(\frac{3}{16}\) inch thick, but manufacturers have recently introduced thicker profiles (see section on fiber-cement trim, page 34).

**Lap-Siding Installation**

Fiber-cement siding products install similarly to the wood products they imitate. They can go over wood-based sheathings or rigid foam, but they must be nailed or screwed directly to studs or 2x blocking. Fasteners should penetrate solid wood by 1 to 1\(\frac{1}{2}\) inches, depending on the manufacturer’s specifications.

The 12-foot-long fiber-cement planks can be held edgewise by a single person, but the boards may break in
two or deform if picked up flat. One person can install a plank by driving a single nail near its center to hold it in place against guide nails driven into the sheathing to mark the upper edge.

Manufacturers recommend leaving \( \frac{1}{8} \) inch between board ends and window casings and trim and caulking with a paintable 100% acrylic latex caulk. Butt joints between two planks can be either lightly butted and painted over or gapped \( \frac{1}{8} \) inch and caulked. Manufacturers recommend priming cut ends on site if the joints are not being caulked. As with other siding products, leave at least \( \frac{1}{16} \) inch clear at step and other flashings so the bottom edge does not soak up water.

**Fastening.** Fiber-cement siding should be nailed directly to studs with nail penetration into solid wood of 1 to 1\( \frac{3}{4} \) inches, depending on the manufacturer’s specifications. Predrilling is required within \( \frac{1}{4} \) inch of an edge or near sharp angles or other fragile shapes to avoid cracking. Predrilling may also be required when nailing through foam sheathing to avoid cracking the siding.

Manufacturers require a hot-dipped galvanized or stainless-steel siding nail (or roofing nail for blind nailing) that should be driven flush with the surface. Overdriving of nails can cause the material to shatter around the nail, weakening its holding power and, with some products, voiding the warranty. Staples and clip-head nails tend to penetrate too far, but coil nailers with adjustable depth-of-drive work well. Some contractors hand-nail the siding to avoid problems. Given the longevity of the siding, a long-lasting corrosion-resistant nail is recommended.

If fastening to metal studs, use corrosion-resistant pneumatic pins or self-tapping bugle-head screws.

**Standard Nailing.** In most installations, horizontal fiber-cement siding is typically nailed top and bottom into each stud, with the lower exposed nail going through both layers of siding (see Figure 1-20).

Butt joints should lie over studs. This is the most durable installation. Color-matched galvanized nails are available for the exposed nails on prefinished sidings.

**Blind Nailing.** Recommendations vary among manufacturers, but most permit “blind nailing” with siding planks less than 8\( \frac{1}{4} \) inches wide installed over 16-inch on-center framing. In this technique, the fasteners are hidden just above the lap line of the overlapping plank and put a slight curve in the siding, pulling it tight to the wall. Roofing nails work well because of their large heads (see Figure 1-21).

An occasional face nail may still be required to hold the lower edge tight to the wall where there is a bump or bulge in the framing. Since the lower edges remain unsecured, blind nailing is not suitable for high-wind areas.

**Cutting.** When cut with a diamond abrasive blade in a circular saw, fiber-cement creates a cloud of very fine silica dust which can cause silicosis and other serious
respiratory problems. Ordinary carbide-tipped blades produce less dust but wear out within a few hours compared to a few months for abrasive blades. In the last few years, manufacturers have responded with specialized diamond-tipped blades and tools, making the work easier and safer. The new fiber-cement blades cut smoother, create less dust, and outlast ordinary carbide blades. When used with the new dust-collecting saws designed for fiber-cement, cutting is safe and effective.

Many contractors also use electric shears, similar to a sheet-metal nibbler but specially adapted for fiber-cement. These make a clean cut with little dust, but are not as fast as a circular saw and cannot cut through multiple boards at once. Scoring and snapping, as for drywall, is also an option for quick cuts where a crisp edge is not needed.

Finishing. After installation, small dents or chips can be filled with any cementitious patching compound. Before priming or applying the top coat to preprimed material, wipe away any dust from cutting with a damp cloth or sponge or lightly hose down the siding and allow it to dry thoroughly. If the siding has been hosed down or power washed (unprimed siding only), allow at least two sunny days before priming. Painting should be completed within 90 days of installation to avoid deterioration of the surface from prolonged exposure to water.

For unprimed siding, manufacturers recommend an alkali-resistant, 100% acrylic primer specifically approved by the paint supplier for fiber-cement. Back-priming is not necessary; in fact, some manufacturers recommend against back-priming so any trapped moisture can dry from the back of the siding.

For the top coat, use a 100% acrylic latex paint. Because fiber-cement is dimensionally stable and largely inert, it holds paint well. Estimates range from 7 to 15 years for a quality paint job. Some of the prefinished products carry 15-year warranties on the finish.

VINYL SIDING

Vinyl siding is the leading choice for residential siding in the United States, accounting for an estimated 36% of the siding market. It owes its popularity to its low cost and low maintenance needs. When first introduced in the late 1950s, vinyl was criticized for fading rapidly, turning brittle in cold weather, and buckling (or “oil-canning”) in hot weather. It is also vulnerable to blow-offs in high winds.

Through the use of additives to the resin and better installation techniques, however, manufacturers have addressed these concerns, and vinyl is finding its way onto more higher-end projects. Today’s premium products typically carry a 50-year, or “lifetime,” prorated warranty.

Materials

Vinyl siding is composed of the plastic polyvinyl chloride (PVC) blended with a number of additives for specific properties: plasticizers for flexibility; stabilizers to prevent oxidation; UV radiation absorbers, such as titanium dioxide, to prevent fading and degradation; and pigments to add color. Fillers are added to hold down costs, and the resin is extruded into a wide variety of the shapes that mimic natural siding materials. PVC is inherently fire-resistant and carries a Class 1(A) fire-rating.

Composition. While enhanced formulas have improved vinyl’s performance over the years, it is not impervious to the elements. Oxidation still occurs and, over time, may cause a white dusting on the surface, particularly in wet, cloudy climates such as the Northeast or Northwest. In freezing weather, a stray baseball can still shatter a panel. Also sunlight tends to fade dark colors, and excessive heat will soften and potentially distort the vinyl. To minimize the effects of heat and sunlight, most vinyl colors are muted, although some darker colors are available with special additives to stabilize the vinyl.

Thickness. Nowadays most vinyl siding is extruded in a two-layer process that puts the more expensive weather-resistant resins only in the outer layer to save costs. While building codes allow vinyl siding as thin as .032 inch (32 mils), premium products range from about 40 to 50 mils, with the thicker products typically costing proportionately more. Some contractors prefer a heavier material for residing jobs to better smooth over the irregular substrate.

Profiles. The rigidity of the siding, however, is more a function of its profile and particularly the thickness of the butt edge, which typically ranges from $\frac{1}{2}$ to $\frac{3}{4}$ inch (Figure 1-22).
In general, more rigid products are easier to install, but they have more pronounced shadow lines at joints. Siding panels come in several profiles, usually containing two to four courses of siding per panel. Panels range from 6 to 10 inches in width and are typically 12 feet long, although some manufacturers offer greater lengths. Finishes range from completely smooth to heavily textured. A lightly textured finish most closely mimics painted wood siding.

**Lock and Nailing Flanges.** All panels have a locking tab at the bottom of each panel that snaps over the top tab of the panel below. Because of problems with blow-offs in high winds, some of the premium panels feature reinforced nailing flanges, either with a thickened extrusion or a hem as shown in Figure 1-22.

**Installation**

**Waterproofing.** Vinyl siding is not waterproof. Since wind-driven rain will penetrate at lap joints, corner boards, and other penetrations, all new siding jobs should begin with the installation of a weather-resistant drainage plane consisting of building paper or plastic housewrap and integrated flashings. On residing jobs, any leaks should be repaired in the original flashing or cladding before installation begins.

**Thermal Movement.** Because of its high coefficient of expansion, the key to successful installation of vinyl siding is to allow it to move freely as temperatures change. A 12-foot length will vary in length up to \( \frac{1}{2} \) inch over a 100°F temperature change. For that reason, manufacturers recommend leaving \( \frac{1}{8} \) inch clearance at receiving trim located at corners, windows, mounting blocks, or other places where the siding terminates or is notched. Increase the clearance to \( \frac{3}{8} \) inch when installing in temperatures below 40°F. Do not caulk the panels at overlap joints or at ends where they meet receiving trim.

**Nailing.** Nails can also restrict movement and cause buckling problems. To prevent this, do not nail the siding tight. Instead, “hang” the siding by driving nails in the center of the nailing slots and leaving \( \frac{1}{32} \) to \( \frac{1}{16} \) inch (the thickness of a dime) between the fastener head and the siding. Drive nails straight since the head of an angled nail can pinch and distort the siding. Use corrosion-resistant nails with heads at least \( \frac{1}{5} \) inch in diameter, such as roofing nails, driven at least \( \frac{3}{4} \) inch into solid wood (Figure 1-23).

Standard nailing is 16 inches on-center for horizontal panels, 12 inches for vertical panels. In high-wind areas, use extra nails and choose a product with a hemmed or reinforced nailing flange.

When locking the panels into position, do not force them up or pull them down to adjust the alignment. Too-tight panels can tear and too-loose panels can unlock and come loose. One exception is at the band joint between the first and second floor where panels may come unlocked due to shrinkage of the framing. To compensate for this, some contractors pull the panels a little tight over the band joist area.

**Overlaps.** Where more than one panel is needed along a run, overlap the two panels by about an inch, with the overlapped edge facing away from high traffic areas so they will be less visible. Overlaps should be staggered at least 3 feet and in a random pattern to avoid creating a visual seam or step effect up the wall. Where possible, use a single piece of siding across the wall. The fewer joints, the more attractive and water-resistant the job will be.

**Mounting Blocks.** Exterior fixtures—such as light fixtures, electrical panels, and hose bibs—can also cause problems if they are fastened through the siding, restricting its free movement. Siding manufacturers sell mounting blocks with integral J-channel to hold panel ends and allow for movement. Or the contractor can install wood mounting blocks before installing the siding and trim them with J-channel or utility trim.

**Trim for Vinyl Siding**

The appearance of a vinyl siding job often has more to do with the trim details than with the siding itself. By using wider trim pieces and avoiding the overuse of J-channel, the installer can produce a more attractive finished product. Manufacturers sell a wide range of accessories in...
PVC, aluminum, or vinyl-coated aluminum. Most contractors fabricate at least some of their trim pieces on site from either prefinished or vinyl-coated aluminum coil stock, using a sheet-metal break and other specialized tools.

Like vinyl siding, aluminum trim has a high coefficient of expansion so installation details need to accommodate movement. Avoid putting nails in the face of flat pieces of coil stock and allow $\frac{1}{4}$ inch at edges for expansion and contraction. Where possible, use a vinyl receiving channel, roofing drip cap, or another piece of trim to support long runs of flat aluminum trim, minimizing the use of nails. Where nails are required, use slotted nail holes, which can be made using a slot punch. Prepainted aluminum or stainless-steel nails are available to match siding and trim colors. A one-inch hem placed along one edge of flat trim, such as fascia, will help minimize buckling or oil-canning.

**Soffit and Fascia.** Most vinyl siding jobs include aluminum fascia trim and vinyl or aluminum soffit panels. The fascia is typically secured at the top, either by the drip edge or a piece of vinyl utility trim, although it can also be fastened with a few face-nails (through slotted holes) if the nails will be hidden by a gutter. The bottom lip of the fascia should be nailed sparingly in slotted holes to allow movement (Figure 1-24).

The outside edge of the aluminum or vinyl soffit panels can be supported by the receiving channel (J-channel or F-channel) or by the L bend at the bottom of the fascia, as shown in Figure 1-24. The back edge of the soffit is either supported by receiving channel or a wood or vinyl frieze board. These details allow the fascia and soffit panels to move freely to accommodate thermal expansion and avoid buckling.

**Windows and Door.** Window and door trim is perhaps the most conspicuous part of a vinyl siding job. Good planning is important. If possible, plan the job so a full butt of the siding lands on top of the windows. At window bottoms avoid the use of $\frac{3}{4}$-inch J-channel, which lets the unrestricted siding buckle. Instead use utility trim or under-sill trim to hold the siding tight here and at other horizontal projections. Where the vinyl has been notched below a window, use a snap-lock punch to create raised lugs along the top edge of the siding, locking it into the under-sill trim.

At window side and head jambs, J-channel is the most common treatment, with end tabs on the top J-channel bent over the side channels to deflect water (Figure 1-25).

While this detail helps shed water, it is important to note that J-channel does not serve as window head flashing. The window head should be properly flashed with the window’s top flange or drip cap lapped under the sheathing wrap and sealed to the sheathing with flashing tape.

To simplify installation and avoid the conspicuous look of J-channel around windows, one option is to use solid vinyl windows with an integral J-channel (Figure 1-26).

For the more traditional look of flat trim around the window, you can use vinyl widow casing, which is typically $2\frac{1}{2}$ inches wide with an integral J-channel.
Corners. Set the inside and outside vinyl corner posts about 1/4 inch below the soffit or frieze above, and lock them in place with nails at the top of the uppermost nailing slots. Then nail in the center of the slots every 6 to 12 inches so that any movement is downward, not upward. Vinyl corner trim tends to be wavy, so following a snapped line is helpful (Figure 1-27).

Wood Trim. For those attracted to the low-maintenance appeal of vinyl siding but who want the look of traditional trim, builders can use wood or composite trim rabbeted or built out to create a receiving channel for the siding. For example, 1/4-inch corner boards can be rabbeted to receive the siding, or standard 3/4-inch stock can be furred out the thickness of the vinyl siding to create a similar effect (see Figure 1-28).

Window and door casings can be fashioned the same way. Either use a furring strip to raise the casing above the vinyl siding or use a thicker profile with a rabbet. At the bottom of the window, you can partially conceal the undersill trim in the rabbet. To shed water, the head casing will still need conventional head flashing and J-channel, but these will be relatively inconspicuous.

STUCCO

No stucco system is impervious to water penetration, whether traditional three-coat stucco, modern one-coat systems, or exterior insulation and finish systems (EIFS). Since water may enter through cracks, penetrations, or through the stucco finish itself, all stucco exteriors rely on a backup waterproof drainage plane to protect the structure. The drainage plane under stucco is essentially the same as under other exterior claddings, with building paper layered to shed water and carefully integrated with all flashings at doors, windows, and other penetrations.

In addition, stucco systems need a weep screed or similar perforated flashing at the bottom of the wall to safely drain away any trapped water at the foundation. Without a continuous drainage plane, stucco systems are subject to serious water problems. While older, traditional stucco walls were designed to get wet and readily dry out, the newer synthetic systems are less permeable to moisture. If trapped water cannot readily drain away or dry to the exterior, the underlying structure is more vulnerable to moisture damage.

Drainage Plane

Traditionally, stucco contractors have used Grade D building paper rather than asphalt felt when applying stucco to wood-frame walls. Grade D building paper is an
Membrane pans are recommended at the bottoms of windows and doors. As with other cladding systems, it is critical that the building papers layer over window head flashings and that window pan flashings drain on top of the building paper. Do not caulk the horizontal joints at window head and pan flashings; this way, any trapped water can drain out.

To complete the system, the drainage plane behind stucco must have a perforated flashing called a “weep screed” at the foundation line. According to the IRC, this must be at least 4 inches above grade and must allow trapped water to drain to the outside of the building. Without a weep screed, the stucco tends to bond to the top of the foundation, creating a moisture dam.

Three-Coat Stucco

Three-coat stucco using Portland-cement plaster has been used successfully in the United States for nearly 200 years. It is applied about \(\frac{7}{8}\) inch thick over metal lath, which creates a drainage space between the building paper and the stucco, allowing water to drain out through the weep screed at the foundation (see Figure 1-29). Stucco relies on this drainage plane for waterproofing, since the stucco material itself is relatively porous. It tends...
to soak up water when it rains, but it dries out quickly since it is highly permeable to water vapor.

*The Structure.* Portland-cement stucco shrinks as it dries, which normally creates small hairline cracks in the finished surface. Larger cracks may form, however, if there is significant movement in the structure, since stucco is nonstructural and relatively rigid. A well-designed foundation and good-quality, dry framing lumber with adequate bracing will minimize this type of movement. On stucco jobs with no structural sheathing, still common in some western states, adequate bracing for racking strength and rigidity is particularly critical.

Cracking can also result from thin sections in the stucco finish. To avoid these problems, fur out or straighten any bowed or irregular walls before applying stucco.

*Expansion Joints.* Where stucco is applied over metal lath on wood framing, the Portland Cement Association recommends expansion joints every 10 feet, forming panels of no more than 150 square feet. Expansion joints are particularly critical at joints between dissimilar materials, such as where wood framing meets masonry, or wherever excessive movement is expected, such as the band joist area between two stories. Many residential projects are built without expansion joints, which can lead to cracking given the excessive movement associated with today’s lower quality framing materials.

*Metal Lath.* Stucco will bond directly to most masonry surfaces, but on sheathed walls the stucco requires metal lath to form a mechanical bond to the wall. On residential projects, contractors use either expanded metal lath or “stucco netting,” a 17- or 18-gauge galvanized wire woven into a hexagonal mesh that looks like chicken wire. Lath should always run perpendicular to the studs, and expanded metal lath must be installed with the correct side pointed up or the plaster will slip off when troweled on.

The lath is nailed or stapled approximately every 6 inches at studs and other framing members. Galvanized staples are now widely used to attach metal lath. However, unless the lath is the self-furring type, it should be installed with special furring nails that space the lath about 1/4 inch from the wall, fully embedding it in the scratch coat, according to stucco expert Ron Webber, of Procoat Systems, in Orange, California.

Another common problem, according to Webber, is that lath installed too tightly at corners causes poor embedment of the mesh at the corners. This will cause cracks at the corners as the building undergoes normal movement with changes in temperature and humidity. To prevent corner cracks, installers should use a special corner bead called Cornerite™ or build up the corners with two layers of wire. Another option is to pull the lath away from the building at the corners to make sure it is properly embedded.

The corners at either side of window and door headers is another common location for stucco cracks. To reinforce these areas and reduce cracking, some contractors add a second layer of reinforcing at these corners using a rectangular section of metal lath placed diagonally at each corner.

The metal lath should form a continuous layer around the building with all laps wired together and vertical laps staggered. With large-mesh reinforcement, lap vertical and horizontal joints at least one full mesh and a minimum of 2 inches. For small-mesh reinforcement, the laps should be at least 1 inch.

*Mixtures.* Stucco is a mixture of Portland cement, sand, and water, with a little lime or a plasticizer added for workability. A proper mixture has good tensile strength and weather resistance and the ability to bond well to the mesh or substrate. It is also easy to trowel on and resists sagging. In cold climates, it must also have freeze-thaw durability, usually obtained by using air-entrained plaster.

The cement base can be masonry cement, plastic cement, or Portland cement, which may have air-entraining additives. Do not add lime or a plasticizer to masonry cement or plastic cement since these already contain plasticizers. While approximate proportions are well established, the right mix for a job depends on the weather exposure of the wall and weather conditions during application (see Table 1-9).

Other than the right proportions, the keys to a good stucco mix are clean, good quality sand and clean potable water. Since sand makes up about 97% of the stucco mixture by volume, it is critical to use good sand. The sand should be free of vegetable matter, loam, clay, silt, and soluble salts and should conform to ASTM C897, which...
the finish coat is

scratch coat by rewetting it for a more complete cure. Any
to create a good bond between the two and strengthens the
troweled or machine-applied, it must be leveled with a
helps prevent new shrinkage cracks. Whether it is hand-
the scratch coat, and the additional sand in the brown coat
second coat without cracking, but at least 48 hours later,
on as soon as the first coat is hard enough to accept the

Application. Stucco can either be hand troweled or
blown with a machine. Some stucco contractors use a
pump for the base coats but apply the finish coat by hand. Although the mixes are slightly different for the two
approaches, both can produce a high-quality finish. In three-coat stucco, the first and second coats are \( \frac{3}{8} \) inch thick, and the finish coat is \( \frac{1}{8} \) inch for a total thickness of \( \frac{7}{8} \) to 1 inch.

Scratch Coat. The first, or “scratch,” coat, which forms
the base for the next two coats, should completely encase the reinforcement. While still wet, the plaster is scored horizontally with a special metal rake or trowel to create a good mechanical bond with the second coat (vertical scratching promotes cracking at studs). For proper curing, the scratch coat needs to be kept moist by misting or fogging with water for 48 hours. Except in very moist weather, misting should start as soon as the freshly applied stucco lightens in color and be repeated at the start and end of each day until the second coat goes on.

Brown Coat. The second, or “brown,” coat should go on as soon as the first coat is hard enough to accept the second coat without cracking, but at least 48 hours later, according to the IRC. The second coat fills any cracks in the scratch coat, and the additional sand in the brown coat helps prevent new shrinkage cracks. Whether it is hand-troweled or machine-applied, it must be leveled with a straightedge (“rodded”) and floated to produce an even surface for the final coat.

A short delay between the first and second coat helps to create a good bond between the two and strengthens the scratch coat by rewetting it for a more complete cure. Any cracks larger than \( \frac{1}{16} \) inch in the brown coat should be patched before the top coat goes on. In the Southwest,

where adobe is popular, the brown coat is often steel-troweled for an adobe look and serves as the final coat.

Finish Coat. After the second coat is allowed to cure for a minimum of 7 days (14 will allow a more complete cure), the top coat is applied to provide the finish color and texture. Many contractors now use premixed color coats, some with acrylic additives to increase water resistance and flexibility. Creating a uniform color and texture requires a skilled applicator, uniform mixing, favorable weather (avoid direct sun), and a uniform substrate without variations in texture or water absorption. Problems in the substrate will tend to show through the thin finish coat. It is best to do an entire side of the building in one batch with no cold joints. A modest amount of color variation is considered part of the character of traditional stucco, but too much is a sign of substandard work.

A certain amount of shrinkage cracking is also inevitable in stucco exteriors. Application over wood-frame construction results in more cracking than over concrete block or other more stable substrates. Coarse textures in the finish will tend to hide the cracks better than smooth finishes. Even under the best of conditions, small shrinkage cracks of less than \( \frac{1}{16} \) inch will occur in the finished stucco and are to be expected. Generally these do not leak or indicate substandard work.

Weather. Temperature will speed up or slow down the hydration process that cures the cement in stucco. It is best to avoid application in extremely hot or cold temperatures. In hot, dry, and windy weather, frequent misting will be required on the scratch coat or the installer may need to tape polyethylene sheeting in place for proper curing. Direct sun tends to dry out the fresh stucco too fast, so installers should try to follow the shade around the building. Also, retardants are available that can be sprayed on the scratch or brown coat in hot weather to slow down the curing.

Cold weather also presents problems. Stucco should not be applied under 40°F, and it should not be allowed to

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<tr>
<td><strong>CM</strong></td>
</tr>
<tr>
<td><strong>L</strong></td>
</tr>
<tr>
<td><strong>M</strong></td>
</tr>
<tr>
<td><strong>CP</strong></td>
</tr>
<tr>
<td><strong>P</strong></td>
</tr>
</tbody>
</table>

Source: Courtesy of Portland Cement Association; adapted from ASTM C926.
freeze within 24 hours of application. Accelerators can be added to the stucco mix in cold weather, but these can weaken the material, and calcium-based accelerators can lead to efflorescence. Heating the materials and, if necessary, tenting the structure can permit work to proceed in cold, even freezing, weather.

Cool, moist weather is ideal. In humid weather, with relative humidity over 70% or heavy fog, misting is not usually required.

**Thin-Coat Stucco**

In an effort to speed up stucco application time and simplify the process, several manufacturers have introduced proprietary thin-coat stucco systems variously referred to as one-coat, two-coat, thin-coat, or fiberglass-reinforced stucco. All these systems apply a single base coat and a top coat with a total thickness of \( \frac{3}{8} \) to \( \frac{7}{8} \) inch, compared to \( \frac{3}{4} \) to 1 inch for traditional three-coat stucco. The thinner finish weighs from 5 to 6 pounds per square foot, compared to 9 pounds for three-coat, and it is cost-competitive with traditional stucco.

Like traditional three-coat stucco, thin-coat is applied over wire mesh or expanded metal lath by hand or pump. It is backed up by a waterproof drainage plane consisting of Grade D building paper, integral flashings, and a weep screed along the top of the foundation to drain away any trapped water.

Some manufacturers, such as United States Gypsum, have introduced hybrid systems in which the stucco is applied to a cementitious board rather than to wire mesh. The advantage is that cement board is impervious to moisture. The drainage plane, and in some cases a layer of foam insulation, lies behind the cement board.

**Application.** The base coat in thin-coat systems has acrylic polymers and chopped fiberglass added to increase its strength and resistance to shrinkage cracking and to freeze-thaw cycles. The base coat is premixed with only sand and water added at the job site. Most contractors using these systems apply an elastomeric color coat, similar to a thick acrylic paint with fine aggregate, and formulated to bridge small gaps less than \( \frac{1}{16} \) inch. This produces a smoother finish that is more water- and stain-resistant and less prone to cracking than a traditional stucco. The top coat can also be a traditional cement stucco finish.

Most of these systems require a 24- to 48-hour moist cure and a total of six or seven days of curing before the top coat is applied. Some require a primer for acrylic finishes.

**Pros and Cons.** To their credit, properly applied one-coat systems are more waterproof and less prone to shrinkage cracking than traditional stucco. It is easier to obtain a uniform color and texture with the synthetic color coat than with a traditional cementitious finish coat. Whether a customer prefers the uniform color of a synthetic finish or the more muted and variable color of cement stucco is a matter of taste.

On the downside, one-coat systems are less impact-resistant than traditional three-coat stucco. And with a thickness of only \( \frac{3}{8} \) inch, one-coat systems are less able to hide irregularities in the framing and are more likely to have thin spots that are prone to problems. Also, one-coat systems are not completely waterproof. Over time, water will find its way in at joints, penetrations, or cracks, and the synthetic stucco will be slower to dry out than the more permeable traditional stucco.

Finally, each system is proprietary and must be installed according to the manufacturer’s approved specs and details, which vary from system to system. Otherwise, warranties are voided and code approvals, which are based on building code evaluation reports, are invalid. For both reasons, contractors should avoid mixing and matching components from different thin-coat systems.

**Exterior Insulation and Finish Systems (EIFS)**

When originally imported from Europe to the United States in the 1970s, most exterior insulation and finish systems (EIFS) were “barrier” type systems. They were designed to create a waterproof exterior skin consisting of a thin layer of acrylic polymer-based synthetic stucco directly applied to foam insulation. The expanded polystyrene (EPS) foam was glued to the building’s sheathing. A layer of fiberglass cloth embedded in the synthetic stucco provided reinforcement, and a thin acrylic finish coat added color and texture.

With the EPS glued directly to the sheathing, there was no place for building paper or conventional flashings at penetrations. Openings, joints, and penetrations relied on caulks and sealants for waterproofing. With no backup waterproofing or drainage layer, there was little margin for error.

While these systems performed adequately in Europe for nearly 25 years, the United States version had thinner base coats and lower polymer content, creating a weaker skin. Also, workmanship in the United States was often inferior due to lack of applicator training and quality-control programs. When water leaked into these systems through failed caulk joints, cracks in the stucco skin, or through the window frames themselves, it wet the foam insulation, sheathing, and sometimes the structural framework. This in turn led to more sealant failures and cracking of the surface and additional leakage. The EPS foam acted like a sponge, trapping water against the building, and the non-porous polymer coatings retarded drying. In many cases the leakage and resulting decay was extensive, resulting in widespread property damage and litigation.

**Drainage EIFS.** In response to these problems, most EIFS manufacturers have introduced new “drainage” or “water-managed” systems, which require the same type of waterproof drainage plane found behind traditional stucco systems (see Figure 1-30).
As with traditional stucco, layered building paper or plastic housewrap protects the framing and sheathing, and all exterior openings and penetrations are flashed to conduct any water to the outside of the sheathing wrap. Since window leakage was the single biggest contributor to EIFS failures, pan flashing is recommended at windows. Rather than glued the EPS foam to the sheathing, the new drainage EIFS typically use mechanical fasteners, rather than adhesive, to attach the foam insulation to the sheathing. Grooves cut in the back of foam board create a capillary break and drainage space.

As with traditional stucco, layered building paper or plastic housewrap protects the framing and sheathing, and all exterior openings and penetrations are flashed to conduct any water to the outside of the sheathing wrap. Since window leakage was the single biggest contributor to EIFS failures, pan flashing is recommended at windows.

Rather than gluing the EPS foam to the sheathing, the new drainage EIFS typically use mechanical fasteners and are designed with a capillary break between the back of the EPS and the sheathing wrap to promote drainage. Some use special corrugated or wrinkled sheathing papers to create the drainage space, while others have vertical grooves cut into the back face of the foam insulation. In all cases, the drainage plane leads to a perforated weep flashing at the foundation to drain away any trapped water.

**Workmanship.** The backup drainage layer, however, should not provide an excuse for sloppy workmanship on the exterior skin. The new kinds of EIFS should still be made as waterproof as possible, since any water that leaks past the skin may be slow to dry out. EIFS consultant Russell Kenney, who has worked with these systems for nearly 20 years, recommends exceeding the minimum specs required by EIFS manufacturers. For example, Kenney recommends a higher-density EPS foam with only 2% water absorption by volume instead of the 4% allowed by ASTM C584. In addition, Kenney recommends a heavier reinforcing mesh with versus the typical 3-ounce cloth, as well as special high-impact mesh in high-traffic areas. He also recommends a 3/16-inch base coat applied in two layers, with the first layer used to partially embed the fiberglass reinforcing and the second layer to fully cover and protect it. These steps will significantly improve the impact resistance of EIFS, but it is still less durable than traditional stucco or thin-coat stucco.

**Apply Sealant to Base Coat.** As with the original barrier EIFS, all penetrations require a high-quality elastomeric sealant. The sealant needs to be applied to the base coat since the finish coat tends to soften when wet, providing a poor substrate for sealant. For the caulk joints to last, they must be wide enough to tolerate the anticipated movement, typically 3/8 to 1/2 inch, and backed up by backer rod (see “Joint Design,” page 37). While control joints are generally not needed along the length of the wall—unless it exceeds 75 feet and is in direct sun—they are required between floors on multistory buildings. Silicone sealant is recommended at all joints for its longevity and flexibility in cold temperatures.

In theory at least, drainage EIFS should function the same as any other exterior cladding systems. Any water that manages to penetrate the outer skin should be stopped by the drainage layer and safely drained away. However, given the low permeability of polymer-based coatings and the tendency of EPS foam to soak up and hold water, EIFS are best avoided in residential projects unless high-quality workmanship and regular maintenance of sealants can be assured.

**WOOD AND COMPOSITE TRIM**

As costs rise and quality levels fall for solid wood board stock, builders have become more receptive to a wide range of alternative products introduced over the past 10 to 15 years. Some of the products are variations on the material used in hardboard siding, a product that has been largely discontinued due to widespread problems with moisture absorption and buckling. Others are fiber-cement-based and offer the same durability and longevity as the siding. Still others make use of PVC, urethane, or other types of plastics, which promise longevity and low maintenance but may cost significantly more than the solid wood they replace (see Table 1-10).

**Solid Wood**

Solid wood is still the first choice of many builders for highly visible trim such as porch columns that require tight miters and smooth edges and need to tolerate a certain amount of wear and tear. Softwoods have served well in this capacity for many years, since they were traditionally inexpensive, dimensionally stable, and held paint well.
**Decay Resistance.** As smaller, faster-growing trees replace older virgin timber stands, high-quality wood has become more expensive and harder to find. Even when using decay-resistant species, the smaller trees harvested today have less heartwood, which is where the extractives are found in sufficient quantities to be effective against decay (Table 1-11). With any wood species, the sapwood is more prone to decay.

**Paintability.** Solid wood has virtually no shrinkage along the grain and, if finished on all sides, limited seasonal movement across the grain. In general, the denser...
### Table 1-11: Decay Resistance of Domestic Woods (heartwood only)

<table>
<thead>
<tr>
<th>Resistant or Very Resistant</th>
<th>Moderately Resistant</th>
<th>Slightly or Nonresistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalpa</td>
<td>Cypress, tidewater red (young growth)(^1)</td>
<td>Alder</td>
</tr>
<tr>
<td>Cedars</td>
<td>Douglas fir</td>
<td>Ashes</td>
</tr>
<tr>
<td>Cherry, black</td>
<td>Honey Locust</td>
<td>Aspens</td>
</tr>
<tr>
<td>Chestnut</td>
<td>Larch, western</td>
<td>Basswood</td>
</tr>
<tr>
<td>Cypress, Arizona</td>
<td>Oak, swamp chestnut</td>
<td>Beech</td>
</tr>
<tr>
<td>Cypress, tidewater red (old growth)(^1)</td>
<td>Pine, eastern white(^1)</td>
<td>Birches</td>
</tr>
<tr>
<td>Junipers</td>
<td>Southern pine (longleaf or slash)(^1)</td>
<td>Cottonwood</td>
</tr>
<tr>
<td>Locust, black(^2)</td>
<td>Tamarack</td>
<td>Elms</td>
</tr>
<tr>
<td>Mesquite</td>
<td></td>
<td>Hemlocks</td>
</tr>
<tr>
<td>Mulberry, red</td>
<td></td>
<td>Hickories</td>
</tr>
<tr>
<td>Oak</td>
<td></td>
<td>Maples</td>
</tr>
<tr>
<td>Osage orange(^2)</td>
<td></td>
<td>Oak (red and black)</td>
</tr>
<tr>
<td>Redwood</td>
<td></td>
<td>Pines (other than longleaf, slash, and eastern white)</td>
</tr>
<tr>
<td>Sassafras</td>
<td></td>
<td>Poplars</td>
</tr>
<tr>
<td>Walnut, black</td>
<td></td>
<td>Spruces</td>
</tr>
<tr>
<td>Yew, Pacific(^2)</td>
<td></td>
<td>True firs (western and eastern)</td>
</tr>
</tbody>
</table>

\(^1\)Southern and eastern pines and tidewater red cypress are now largely second growth with mostly sapwood. Little heartwood lumber in these species is available.

\(^2\)Exceptionally high decay-resistance

**Source:** Prevention and Control of Decay in Homes, USDA, 1980.

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**Figure 1-31: Cupping of Flat-Sawn Lumber.**

To keep corners tight and prevent edges from lifting, always install flat-grained trim “bark-side down,” since the annual rings tend to straighten as the wood shrinks, causing the wood to cup as shown.

**Source:** Reprinted from Architectural Graphic Standards, Residential Construction, with permission of John Wiley & Sons, © 2003.

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A wood species is, the more it shrinks and swells with changes in moisture and the worse it is as a substrate for paint on a building’s exterior (Table 1-12). Vertical-grain, or “edge-grain,” softwoods, such as vertical-grain cedar or redwood, are the most stable and hold paint the best. The flat-grained woods more commonly used as trim are more prone to cupping and other moisture movement and do not hold paint as well.

To compensate for the cupping and to keep corners tight and edges from lifting, always install trim “bark-side down,” since the annual rings try to straighten as the wood shrinks (see Figure 1-31). To improve paintability, it may be necessary to rough up the surface of flat-grained trim with 80 to 100 grit sandpaper before priming. As with siding, it is best to prime all surfaces and to prime cut ends to minimize water absorption through end grain. Also, hold trim pieces back at least \(\frac{1}{2}\) inch short of flashings or other surfaces where water may collect and soak the end grain.

**Finger-Jointed Wood**

Many manufacturers now offer solid wood trim made up of short lengths of high-quality lumber that is finger-jointed and, in some cases, edge-glued to make boards as long as 24 feet. As with solid lumber, finger-jointed lumber is available in a number of grades and species.

**Telegraphing at Joints.** In general, finger-jointed stock is durable and dimensionally stable since short pieces of wood are less likely to warp and twist. The main concern is whether the glue joints will telegraph through the paint as the material swells and shrinks in response to changes in relative humidity. Because no two pieces of wood swell and shrink at exactly the same rate, the joints often do show through. The best protection is to keep excess moisture out of the wood by starting with quality preprimed stock or using a high-quality water-resistant prime coat and two top coats of paint.
When purchasing finger-jointed trim, look for long-term warranties against any delamination or glue lines telegraphing through the paint. As with any wood-based product, minimizing exposure to water and maintaining the finish are important for long-term performance.

**Hardboard Trim**

The leading alternative to solid wood trim, and the oldest in the marketplace, is hardboard, essentially the same material used in hardboard siding. Hardboard consists primarily of ground wood fibers and phenolic resin, the same adhesive used in exterior-grade plywood, along with additives to improve weather resistance. It is typically available with either a smooth finish or a wood-grain texture and is sold in 16-foot lengths. Hardboard weighs about 4 pounds per square foot for 1-inch stock, roughly twice as much as softwood.

**Paintability and Dimensional Stability.** To its credit, hardboard trim is very uniform in consistency and holds paint well. However, because it has no grain, it shrinks and swells equally in all dimensions—up to twice as much as wood along its length. In very dry or very humid climates this can lead to gaps or buckling over long sections. Most manufacturers recommend leaving an \( \frac{1}{8} \)-inch gap at butt joints and caulking with a high-quality paintable sealant to avoid problems.

**Workability.** While hardboard is relatively easy to nail, it does not hold nails well and is prone to split if edge-nailed. Drilling pilot holes will help. Compared to solid wood, it is more difficult to set nails and fill the holes in hardboard. Finish nails and pneumatic nails tend to pucker the surface, which must be sanded smooth before filling the holes. Round-headed nails driven straight in at a 90° angle leave a clean hole for filling. Most manufacturers recommend face nailing flush to the surface of the board to avoid these problems. If nails do penetrate the surface, sand the material smooth and fill the hole before painting.

**Water Penetration.** The biggest problem with hardboard is swelling and delamination where water has penetrated the material at unpainted cut edges, nail holes, or other penetrations (see Figure 1-32).

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**TABLE 1-12 Finishing Characteristics of Selected Wood Species**

<table>
<thead>
<tr>
<th>Wood Species</th>
<th>Paint Holding Ability (1—best; 5—worst)</th>
<th>Resistance to Cupping (1—best; 4—worst)</th>
<th>Conspicuousness of Checking (1—best; 2—worst)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Softwoods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cedar, western red</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cypress</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Eastern white pine</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Ponderosa pine</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Redwood</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Southern yellow pine</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Spruce</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Western hemlock</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Hardwoods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lauan (plywood)</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Oak, white or northern red*</td>
<td>4–5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Yellow birch</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Yellow poplar</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

*These woods have large pores that require filling for durable painting. With pores properly filled, paint-holding ability = 2.

**Source:** Adapted with permission from *Finishes for Exterior Wood*, 1996, R. Sam Williams, Mark Knaebe, and William Feist. Courtesy of Forest Products Society.
Even if primed, the material is vulnerable in wet locations, for example, at the bottom of an exterior door casing or in direct contact with a concrete slab or foundation. Sharp edges are also vulnerable to chipping, making this not the best choice where wear and tear is expected. To avoid problems, corners should be butted, not mitered.

**Laminated-Veneer Lumber (LVL) Trim**

Widely used in beams and headers, LVL has also been put to good use as a trim material with some minor modifications such as water-resistant edge sealing and adding a couple of cross-laminated layers to minimize cupping. Like LVL beams, LVL trim is dimensionally stable and is easy to cut, nail, and install, similar to a piece of plywood. Its weight falls in between solid wood and hardboard. It can be used for fascia, casings, corner boards, and most other exterior trim, and is available in lengths from 8 to 24 feet.

**Facing Materials.** One manufacturer, Pacific Wood Laminates, makes a preprimed Douglas-fir LVL trim faced either with textured wood veneer (Socomi Lam®) or medium-density overlay (Clear Lam®). Medium-density overlay (MDO) is a highly durable resin-impregnated paper that resists surface checking and holds paint well. It has a 20-year track record as a durable facing in concrete forms, outdoor signs, and other exterior applications. Pacific Wood’s LVL trim is sealed on all edges with a water-based elastomeric coating that hides the end grain and resists moisture penetration. It is then primed on all faces, with a second prime coat applied to the finish face and edges.

**Installation.** As with other engineered trim products, all cut ends of LVL should be primed in the field and butt joints gapped $\frac{1}{8}$ inch and caulked. Miters and scarf joints can be used. Cut ends should be kept 6 inches off the ground, concrete, or other wet materials. Resistance to
swelling and delaminating will be similar to plywood siding panels such as T-111. The manufacturer recommends that the nails be set below the surface either by hand or pneumatic nailer and caulked. Use a small-headed finish nail or siding nail so as not to make too large a hole in the MDO facing.

**MDO Plywood.** Conventional plywood with MDO facing also makes an attractive and economical smooth soffit material. Combined with LVL fascia, this should produce a durable and attractive eaves detail.

**Fiber-Cement Trim**

Contractors who install fiber-cement siding are looking for equally durable materials to trim out their houses. Some have found their answer in fiber-cement trim, which boasts the same dimensional stability, paint holding ability, and resistance to rot, insects, and fire as the siding. Standard 7/16-inch fiber-cement trim is comparable in price to midgrade softwoods and is available with either a smooth face or a wood-grain texture.

**Workability.** Like the siding, fiber-cement trim is heavy, requires special tools and procedures to cut and machine, and presents a dust hazard to those cutting the material. Although special diamond-tipped tools make it easier to cut and form, standard fiber-cement trim is not easy to miter or to make complex cuts in, and it is too hard to hand-nail. Since it is not a nail base, all pieces need solid wood backing. Like the siding, fiber-cement trim must be face-nailed with the nails set flush to the surface.

**Applications.** Because of its durability and resistance to moisture, fiber-cement is a good choice for soffits, using 1/4-inch-thick panels. For other trim, most manufacturers sell 7/16-inch planks, which contractors typically build out with 1/2-inch plywood or oriented-strand board (OSB) to create a thicker profile. In some markets 3/16-inch fiber-cement board stock is also available, eliminating the need to fur out the trim but adding considerable weight.

**Lightweight Option.** To simplify installation, James Hardie Building Products has introduced a low-density fiber-cement trim board called HardiTrim XLD that handles and installs more like wood trim. The new material can be installed with pneumatic finish nails set below the surface and puttied. Unlike standard fiber-cement, XLD holds nails and can be mitered and edge-nailed, simplifying details like corner boards. The 1-inch-thick material weighs about 4 1/2 pounds per square foot versus about 2 pounds for an equal sized piece of white pine.

**Polymer Moldings**

Molded from high-density polyurethane, polymer moldings have been in use for over 20 years and have proven their durability in both interior and exterior applications. Because of its high cost, almost four times the price of premium-grade softwood, urethane is used almost exclusively for complex profiles, such as dentils, window pediments, and decorative brackets (see Figure 1-33).

**Installation.** Most material is sold preprimed and can be cut, planed, and sanded like wood, only more easily because of the lighter weight. Polymer moldings are installed with adhesive rather than nails, although a few finish nails are often used to hold it in place while the glue dries. Butt joints and miters are bonded with the same adhesive used to hold the molding to walls or soffits. Most manufacturers provide a proprietary adhesive for installation.

Because polyurethane foam expands and contracts with changes in temperature, installers should cut long runs of molding 1/8 to 1/4 inch long and “spring-fit” the material into place. If installed slightly compressed, the molding will not leave gaps when the temperature drops and the material shrinks. When joining two pieces of molding,
apply a generous amount of adhesive on both surfaces and clean the squeeze-out with a putty knife. Solvent may be needed to clean adhesive from the joint after it dries.

**Painting.** Before painting, fill any holes or dents with an exterior spackling compound and paint. Avoid leaving cut edges exposed, since without its hard skin, the material has a rough, irregular surface, even after painting. Since polyurethane will degrade from prolonged exposure to UV radiation, it should be painted soon after installation. If the surface is undamaged, it holds paint well.

**Cellular PVC Moldings**

Also called expanded PVC, or cellular vinyl, this relatively new material is a form of PVC that has been expanded with foaming agent and extruded into boards and a wide range of exterior molding profiles. Like other plastics and fibercement, cellular PVC is impervious to moisture and insects and is approved for contact with ground or masonry, making it well suited to moisture-prone applications such as garage-door trim. Warranties typically run to 25 years. Since cellular PVC is cost-competitive with premium wood, it is an attractive option for those seeking a more durable alternative.

**Boards, Panels, and Moldings.** Trim stock is available in thickness from $\frac{3}{16}$ to 1 inch and in lengths up to 20 feet. Sheet stock, which can be used for soffits and other panel applications, is available in $\frac{3}{8}$- to 1-inch thicknesses, with a smooth or beaded face. Manufacturer Marley Moldings makes a wide array of molding profiles, while Azek offers a wide range of trim materials, including a 1-inch-thick prefabricated corner board for use with any type of siding (Figure 1-34).

**Workability.** Similar in density to pine, expanded PVC can be cut, drilled, sanded, and even routed like wood. It has moderately good nail holding ability and is installed similarly to wood trim, although with allowances for thermal expansion and contraction.

**Thermal Expansion.** Although it has less thermal expansion than polymer (polyurethane) foam, cellular PVC expands and contracts considerably more than wood, so it requires special detailing to avoid gaps, buckling, and other movement problems. Manufacturers recommend leaving a $\frac{1}{8}$-inch gap for movement for every 18 feet of length. This space is required where trim terminates into an inside corner or against an intersecting piece of trim, such as where corner boards meet the frieze board. A small back cut at the end of the board can help conceal the gap. This amount of movement assumes that the PVC trim board is secured with two nails every 16 inches on-center to a solid substrate (three nails for boards 12 inches or wider). Nailing along the length of the board restricts its overall movement. You can further restrict movement in PVC trim by gluing it to a wood substrate with construction adhesive.

**Installation.** Because cellular PVC has less strength and stiffness than wood, it must be installed over a solid substrate, and material $\frac{3}{4}$ inch thick or less should be glued to a solid substrate. It will tend to conform to an uneven substrate, showing any waviness. Using PVC cement to weld one piece to the next, contractors can fashion corner
boards, window surrounds, or other trim assemblies, using screws or nails to hold the pieces in position while the glue dries (Figure 1-35). The assembled sections are then nailed or glued in place.

For long runs like fascia, scarf joints are best since they provide the greatest gluing area. Manufacturers recommend nailing on each side of the scarf joint to hold the trim in place while the glue dries. Construction adhesive behind the scarf joint—for example, between the PVC fascia and the wood subfascia—will also help reinforce the joint. As with other PVC joints, the plastic surfaces must be in direct contact to bond properly since the glue will not fill any voids.

Predrilling is generally not necessary as long as you use small diameter, blunt-head nails. Either galvanized or stainless-steel box nails are recommended, but contractors have used pneumatic nailers with ring-shank nails successfully. In general, the nailing pattern is the same as for wood trim except nails should be kept 2 inches from the ends of boards. Typically nails are set and puttied before painting.

**Long Runs.** Long runs of fascia require expansion space at each end or in the middle. Where a long run turns a corner, for example on a hip roof, one option is to glue the outside corners and leave an $\frac{\pi}{4}$-inch space along the center of each run where it will be less conspicuous than at the corner. To hide the joint, either leave an unglued scarf joint or butt the two pieces of fascia and fill the gap with a polyurethane caulk. If building in hot weather, it is best to construct tight joints, since they will open in colder weather as the material contracts.

**Painting.** Like PVC windows and vinyl siding, PVC trim has UV inhibitors and does not need painting. However, if you want a color other than white, use 100% acrylic latex paint and avoid dark colors, which can cause the vinyl to overheat in direct sunlight. PVC trim requires no special preparation to paint and reportedly holds paint well.

**TRIM DETAILS**

The best exterior trim details are designed to keep water out but to provide easy drainage for any water that penetrates the exterior. This is particularly important when using trim materials that are vulnerable to decay or moisture damage, such as nondecay-resistant softwoods or hardboard. Caulking trim joints with sealants is a double-edged sword, since all caulk joints will eventually fail, and when they do, the remaining sealant will tend to keep the joint from drying.

Trim that is subject to frequent wettings from the weather, such as corner boards, water tables, or wrapped porch posts or balusters, is a good candidate for rain-screen...
installation, where a ventilation and drainage space is left behind the trim (Figure 1-36).

Make sure to leave \( \frac{1}{8} \) inch free at the bottom edge of the trim to drain to daylight. To create the drainage space, either use shims (do not block the drainage path) or synthetic drainage materials, such as Benjamin Obdyke’s Home Slicker®. Foundation drainage materials can also work. If shims are used, add metal screening or drainage mutting at top and bottom to block insect entry.

Regardless of the specific detail, the following principles will help create long-lasting exterior trim:

- Wide roof overhangs, 8 inches minimum, at rake and eaves keeps water away from the side of the house, preserving siding and trim.
- Avoid wide horizontal wood surfaces exposed to water. Slope for drainage or cap with metal flashing. Cut drip groove under edge to shed water.
- Slope top edges of exterior railings and horizontal trim boards, such as water tables, to shed water.
- Avoid exposed end-grain facing upward in vertical trim boards. Heavily prime all end grain and exposed edges.
- Avoid exterior miter joints, which tend to open and absorb water.
- Use Z- or drip-cap flashing at horizontal joints, such as above windows or where corner boards meet the water table. Leave \( \frac{1}{8} \) inch clear above the flashing, and do not caulk the horizontal joint.
- Avoid caulk joints. Instead, flash well behind joints and leave a gap of \( \frac{1}{8} \) inch for ventilation. Where caulking must be used, apply a properly shaped caulk bead (see “Joint Design,” below).

### Caulks and Sealants

While no residential exteriors should rely solely on caulks and sealants to keep water out, many details require caulk either to mask an expansion joint between materials or as the first line of defense against leakage. When choosing a caulk or sealant (another name for a high-performance caulk), look for a product that will bond well to the substrate materials and be sufficiently flexible to tolerate the anticipated movement (Table 1-13). Just as important is how the caulk bead is applied. The best quality caulk will fail if applied 1 inch thick and bonded on three sides of the joint.

#### Joint Design

The ideal caulk joint where movement is anticipated is an hourglass shape about twice as wide as it is deep (see Figure 1-37).
This shape allows a caulk bead to stretch without either failing in “adhesion” to the substrate materials or failing in “cohesion” by tearing itself. A good rule-of-thumb is that a caulk joint should be four times the width of the anticipated movement, limiting the sealant’s stretching to 25%. For most residential building details, this requires at least a \( \frac{1}{4} \)-inch-wide joint.

In general, the sealant should be no more than \( \frac{1}{2} \) inch deep. For deep joints, it is best to pack the joint with a backer rod, a flexible foam material that controls the depth of sealant and shapes it into the hourglass profile. Backer rod is made of either open-cell or closed-cell foam and comes in diameters from \( \frac{1}{4} \) inch to as much as 2 inches. In wet locations, such as concrete control joints, use closed-cell foam, since it will not absorb water. Use a backer rod a little bigger than the joint being sealed.

**Bond Breakers.** In addition to controlling the depth and shape of a caulk bead, the backer rod acts as a “bond breaker,” preventing the caulk from sticking to the back side of the joint. A three-sided caulk joint tends to tear when the materials move. Corner joints subject to movement are also prone to fail. For corner joints, use a small-diameter backer rod or any other material that will not bond.
to the sealant. Plastic and foam tapes sold for weather-stripping can work in corners (see Figure 1-38).

**Cleaning and Priming.** Since dirt, debris, and loose paint act as bond breakers, sealing to a dirty or flaking joint will fail when the joint moves. Also, the joint should be dry unless using a sealant approved for damp surfaces, such as some polyurethanes and some of the newer synthetic-rubber “Kraton” type sealants. Do not use compressed air to clean the joints unless a line filter is also used, since the oil from the compressor may coat the joint, interfering with the bond. Although priming is not required for most sealants used in residential construction, some metals may need priming with acid-cure silicones. Consult the sealant manufacturer’s specifications.

**Specifications.** For critical joints where movement is anticipated, choose a caulk that complies with ASTM C920 and is rated for $+/-25\%$ movement. ASTM C920 indicates that the sealant is highly weather-resistant, durable, and shrinks no more than 10%. For stationary joints, a $+/-12.5\%$ rating for joint movement is acceptable.

**Silicones**

Silicones bond well to nonporous surfaces, such as glass, tile, and metals, and they are the most flexible sealants made. A good silicone will stretch as much as 50% of its original width before tearing. Silicones are good in cold-temperature work and can be applied from well below 0°F to over 100°F. Once cured, they can also tolerate temperatures from well below 0°F to about 400°F, or higher for special high-temperature formulations. Unlike most sealants, silicone stays flexible when cold. Silicones are also very resistant to UV radiation and water, making them a good choice for exteriors as well as kitchens and baths.

The main disadvantages of silicone are that it is messy to work with, difficult to tool, and does not hold paint well. Cleanup when wet requires acetone or special-order silicone solvent, and the residue is hard to remove when it is time to reapply. Because of the residue, once you’ve sealed a joint with silicone, it is best to reseal with silicone as well. Silicone does not bond well to unpainted wood and can stain or degrade porous stone and masonry materials.
Silicones come in two types: acid-cure (acetoxy) and neutral-cure (sometimes called “noncorrosive” silicone). The acid-cure type has a distinctive vinegarlike odor. Both types will stick well to glass, ceramics, and other nonporous surfaces. Acid-cure silicones, however, requires primer with most metals to bond well and to avoid corrosion. Neutral-cure silicones are compatible with most metals and metal finishes and bond somewhat better to wood.

**Polyurethanes**

Polyurethane is a versatile, water-resistant, high-performance sealant and has become the first choice of many contractors for exterior work. Polyurethanes provide excellent adhesion to a wide variety of materials from wood to masonry and remain flexible across a wide temperature range. Furthermore, they are relatively easy to tool, and some brands accept wet tooling with soapy water. Tooling time is adequate and shrinkage minimal. Polyurethanes are available in only a few colors, but the cured sealant holds paint well.

Although polyurethane is not naturally UV-resistant, UV inhibitors give it good durability in exterior applications. Because of its aggressive bond, polyurethanes are good for sealing between different materials. Polyurethanes are widely used on metal roofs, concrete and masonry control joints, flashing, and exterior trim.

**Butyl**

Butyl is a high-quality, tough, rubberlike sealant that is ideal for exterior jobs requiring a durable, watertight seal. Because of its longevity, temperature range, and high UV resistance, it has long been used as a glazing compound. Notable for its stickiness, butyl bonds very well to a wide range of materials, including wood, concrete, masonry, glass, and metal. Its stickiness, however, can also make its application messy and tooling difficult. Before curing, it can be cleaned with mineral spirits.

Because of its good adhesion and water resistance, butyl is often used to seal metal gutters, metal roofing, and around foundations. It is approved for use below grade. Butyl should not be used, however, in contact with modified-bitumen flashing tapes or roofing membranes, which can degrade it.

**Acrylic Latex**

The most economical and widely used caulking compound in residential work, acrylic latex caulks come in a wide variety of formulations and prices. To their credit, latex caulks are easy to apply, easy to tool, and can be cleaned before curing with water. They bond moderately well to a wide variety of materials and have a long tooling time. When cured they are highly paintable, making acrylic latex popular for caulking paintable trim in both the interior and exterior.

Lower-end acrylic latex caulks do not have the same flexibility, temperature range, and long-term durability as butyl, polyurethane, or silicone. Newer premium products, however, promise performance on par with some of the high-performance sealants. Added plasticizers make the material more flexible and other additives provide better UV and water resistance. For exterior work in joints subject to movement, look for an ASTM C920 rating and a rated joint movement of +/-25%.

Most latex caulks cannot be applied under 40°F and should not be allowed to freeze in the tube or in place before cured. Also do not apply to wet surfaces or where rain is likely to fall before the caulk has a chance to fully cure.

**EXTERIOR ADHESIVES**

No exterior millwork should rely entirely on adhesives, since no glue is 100% waterproof, and any adhesive can fail with enough moisture cycling and movement in the wood. It is always wise to back up an exterior glue joint with mechanical fasteners, design the woodwork to shed water, and protect it with a good paint job. Still, there are several good options for gluing exterior work that should last indefinitely if well maintained (see Table 1-14).

There are several factors to consider in selecting a glue. For exterior woodwork, the biggest concerns are typically water resistance, strength, and cleanup. Working temperatures, clamping time, and gap filling abilities may also be important, depending on the specific job and conditions.

A glue’s water resistance is classified as Type I or Type II. A Type I designation indicates that the glue bond can survive repeated submerging in boiling water. Type I glues are used for laminating structural timbers such as glulams. The most common Type 1 glue, resorcinol, has strict temperature and clamping requirements and is rarely used on residential job sites. Type II glues must maintain their bond after being soaked for four hours and then dried three successive times. These are suitable for all but the most punishing residential applications.

**Type II Yellow Glue.** Polyvinyl acetate (PVA) is the most common glue on residential job sites due to its low price, long shelf life, easy cleanup, and overall ease of use. The Type II version provides good water resistance and provides a very strong bond, and it is only slightly more expensive than the regular yellow glue. Similar to the older style white glue, yellow glue is formulated with a higher solids content to make it less runny and with other additives to make it set up quicker. Clamp time is about one hour. Any squeeze-out is simple to remove with a damp rag. Once the glue dries, however, it will resist paint and stain and needs to be scraped or sanded off.

In general, yellow glue should not be applied in temperatures below 50°F or allowed to freeze before it cures.
<table>
<thead>
<tr>
<th>Type II yellow glue</th>
<th>Easiest to use and to clean up. Excellent strength.</th>
<th>Dried glue resists finishes. Not gap filling.</th>
<th>Low</th>
<th>3,500 + psi</th>
<th>Moderate. ANSI type II</th>
<th>&gt;55°F</th>
<th>5 minutes</th>
<th>1 hour</th>
<th>Cleans with water when wet. Scrape or sand dry.</th>
<th>One year in tightly closed container.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyurethane</td>
<td>Easy to use. Bonds to damp materials. Hardened glue sands easily. Very strong and water-resistant.</td>
<td>Cannot be cleaned from skin. Gap filling is not structural.</td>
<td>Medium</td>
<td>3,400 – 1,356 psi (hot-melt type)</td>
<td>Excellent. ANSI type II</td>
<td>40°F–130°F For best results: 68°F–130°F</td>
<td>15 minutes</td>
<td>1–4 hrs., depending on manufacturing.</td>
<td>Mineral spirits or acetone when wet. Scrape or sand dry.</td>
<td>Up to one year in tightly closed container (squeeze air out of container)</td>
</tr>
</tbody>
</table>
In freezing weather, store the glue indoors, since a couple of freeze-thaw cycles may ruin the glue. For exterior work subjected to moderate weather exposure, Type II yellow glue is a good option.

**Polyurethane.** One-part polyurethane glues have grown in popularity over the past few years due to their excellent strength and increased water resistance compared to yellow glue. Since polyurethane requires moisture to cure, it will bond to wood that has up to 25% moisture content. For wood that has less than 10% moisture content or appears dry, you should moisten one of the two surfaces being joined with a sprayer or damp cloth and apply a thin coating of glue to the other. Polyurethane bonds well to wood, stone, most metals (not stainless steel), and ceramics, as long as at least one of the surfaces being glued is porous.

Polyurethane foams up as it cures, expanding to three to four times its original size and filling any small gaps in the joint. But unlike epoxy, the filled gaps have no strength. Clamping time is one to four hours, depending on the specific formulation. For maximum strength, clamp for 24 hours.

Because of its tenacious grip, you should protect any materials or finished surfaces from drips and protect your hands with latex gloves, as the glue cannot be removed except by abrasive cleansers. If wet glue drips onto a finished surface, wipe with a dry cloth, since anything wet will activate curing. After the glue has dried, scrape away the squeeze-out with a sharp chisel and sand any residue. The glue dries to a brownish tan, which can be painted.

Where clamping is not practical, another option is hot-melt polyurethane. Hot-melt polyurethanes have been used in industrial settings for many years, but they have only recently been introduced for job-site use. Unlike its moisture-cured cousin, hot-melt polyurethane does not foam up and needs no clamping. It sets in about 30 seconds and provides the same level of water resistance as regular polyurethane but less than half the strength. Still, this is more than enough for many applications. Remove any squeeze-out with a putty knife or scraper as soon as it firms up, as it is difficult to sand clean.

**Epoxy.** Long the adhesive of choice for boat builders, epoxy has high adhesive strength and rigidity, low shrinkage, and good resistance to water and chemicals. It bonds well to wood, concrete, foam insulation, and other porous substrates—and to nonporous surfaces as long as they are lightly roughed up. It is comparable in strength and water resistance to polyurethanes, requires minimal clamping, and can fill gaps with little loss of strength, making it an ideal choice for less-than-perfect carpentry joints.

As a two-part system—with various hardeners to choose from and additives such as fillers to improve gap filling—epoxy is also the most complicated and costly approach. Once the resin and hardener are mixed, the working time ranges from about 10 minutes to an hour, depending on the ambient temperature and whether a slow or fast hardener is used. Heat speeds up the curing, so a slow hardener is recommended in hot weather, a fast hardener in cold weather. It is important to mix the correct proportions and mix thoroughly or unreacted resin or hardener may remain in the cured epoxy.

For best results, use a disposable brush to coat both sides of the joint with liquid epoxy. After coating the joint, add fillers to the mix if required. Fillers change the viscosity of the mix and enable it to bridge gaps with minimal loss of strength (you can bridge small gaps up to about \( \frac{1}{8} \) inch without fillers). A small amount of filler helps keep the mix from running. Once the fillers have been added, apply the thickened epoxy to one side of the joint and clamp just enough to squeeze out a little epoxy. A common mistake with epoxy is clamping too tightly. This will create a weak, “glue-starved” joint. Cleanup of the wet epoxy requires solvents such as acetone or lacquer thinner. Workers should use rubber gloves to protect their skin.

Any kind of clamping that holds the joint still is suitable, including staples, nails, or wood screws. Scrape off any squeeze-out with a putty knife or dry rag. Once the epoxy has cured to a solid state that cannot be dented with a fingernail, it has reached 90% of its final strength. Then the clamps can be removed and any excess sanded off. The epoxy continues to gain strength for several days and is paintable.

**EXTERIOR WOOD FINISHES**

The USDA Forest Service Forest Products Laboratory (FPL) has done extensive research on how to keep paints and stains on wood sidings and trim. In general, they recommend paint for the longest lasting finish and best protection of the underlying wood, followed by solid or semi-transparent stains. Clear finishes need the most frequent recoating and offer the least protection from water damage and UV radiation (see Table 1-15).

How long a finish will last depends on many variables, including the quality of the finish, type and texture of wood, application conditions, and exposure. South- and west-facing walls get the most sun and are, therefore, often the first to need recoating. Whether painting, staining, or finishing in any manner, the FPL makes the following recommendations:

**Moisture Content.** Never paint wood with a moisture content over 20%. Ideally, the wood should be painted at its average moisture content for that climate—about 12% for most of the United States, 9% for dry southwestern states (see Table 1-2, page 9).

**Wood Surface.** A rough-sawn wood surface will hold paint and stain much longer than a smooth, planed surface, which is why many contractors prefer to install siding rough side out. Also most lumber and siding today is...
flat-grained, which holds paint less well than vertical (or edge) grained. The combination of flat grain and planing can create a burnished surface called “mill glaze,” which can cause problems with paint adhesion. To avoid problems, it is best to lightly sand with 50 to 80 grit sandpaper before painting smooth siding. The optimal approach is to first wet the lumber to raise its grain and then let it dry for two days before sanding.

Weathering Before Finishing. Some painters recommend letting smooth siding weather for a few weeks to open up the grain. However, research at FPL has shown that after two weeks of exposure, the wood surface begins to degrade and to loosen the wood fibers on the surface, which weakens the paint adhesion. The FPL therefore strongly recommends painting within two weeks of installation, whether the rough or smooth side is facing out. If you need to paint wood that is badly weathered, the wood should be sanded, power rinsed, and allowed to dry before priming. Once the primer is dry, the top coat should be applied as soon as possible.

Species and Grain. In general, less dense woods hold paint better than more dense woods. Also, within a single species, vertical-grain (also called edge-grain) wood holds paint much better than the more common flat-sawn lumber, primarily because flat-sawn wood shrinks and swells more from changes in relative humidity. Also vertical-grain wood has narrower bands of latewood, the denser and harder portion of each annual ring in a tree. When paint, particularly oil-based, becomes brittle with age, it tends to peel from the latewood.

Dense woods with wide, flat grain will present the greatest problems in holding paint. This is true for most

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**Table 1-15: Expected Life of Exterior Wood Finishes**

<table>
<thead>
<tr>
<th>Type of Exterior Wood Surface</th>
<th>Water-Repellent Preservative and Oil</th>
<th>Semitransparent Stain*</th>
<th>Paint and Solid-Color Stain (One Prime Coat, One Top Coat)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar/redwood siding (vertical grain)</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Cedar/redwood siding (rough-sawn)</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Pine, fir, spruce siding (smooth, flat-grained)</td>
<td>High</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Pine, fir, spruce siding (rough, flat-grained)</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Shingles</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Plywood (sanded or smooth-textured)</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Plywood (rough-sawn textured)</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Plywood—MDO</td>
<td>Not suitable</td>
<td>Not suitable</td>
<td>Excellent</td>
</tr>
<tr>
<td>Hardboard (smooth or textured)</td>
<td>Not suitable</td>
<td>Not suitable</td>
<td>High</td>
</tr>
<tr>
<td>Millwork (usually pine)</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Decking—new (smooth)</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Decking—weathered (rough)</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

---

*Expected life for average location in the continental United States. Will vary for extreme climates or exposure.

**Need for refinishing determined by presence of mildew on surface.

One coat on smooth, unweathered surface; two coats on rough-sawn or weathered surface—the second coat applied while first is still wet.

Applying a second top coat (three-coat job) will approximately double the life. Top quality, 100% acrylic latex paints have best durability.

Exterior millwork, such as windows, should be factory-treated. Liberally treat other trim by brushing before painting.

Source: Adapted from *Finishes for Exterior Wood*, 1996, by R. Sam Williams, Mark Knaebe, and William Feist. Courtesy of Forest Products Society.
hardwoods as well as dense softwoods with wide, flat grain, such as southern yellow pine and Douglas fir, especially if planed smooth.

**Paints**

Paints offer wood the greatest protection from the elements and can last from 7 to 10 years if properly applied with one prime coat and two top coats of quality paint. The longevity of a particular job will depend on a number of variables, including paint quality, surface preparation, climate and exposure, and the type of wood.

**Latex vs. Oil-Based.** In addition to its easy cleanup, latex paint has always held certain advantages over oil. Perhaps most important, latex paints stay flexible over time while oil-based paints get brittle as they age. This is particularly true of 100% acrylics, which makes them less likely to crack due to seasonal movement of the substrate. Also, while oil is more resistant to liquid water, latex is more permeable to water vapor, making it less likely to blister in situations where moisture must pass through. Latex also fades less over time, is not prone to chalking, and is less likely to support mildew growth than oil-based paint. The best quality latex paints use 100% acrylic binders, offering increased flexibility and durability over latex-vinyl blends.

Oil-based paints, however, are still favored by many professional painters for their better appearance and better adhesion due to the oil penetrating the surface of the wood. Oil paint’s flow characteristics help hide brush strokes and provide better coverage, particularly in high-gloss paints. Also, window sash and doors painted with oil paint dry to a harder finish that is less likely to stick to other painted surfaces.

In the past two decades, however, manufacturers have greatly improved the quality of latex paint, overcoming many of the problems associated with it in the past, while oil-based paints have suffered somewhat as manufacturers have had to adjust their formulas to comply with air-quality regulations that restrict the use of VOCs (volatile organic compounds) found in paint solvents. Since latex now dominates the market in residential paint sales, most development efforts now and in the future will focus on improving latex rather than oil-based paints.

**Oil-Based Primers.** Many painters still prefer oil as a primer for woods with water-soluble extractives, such as redwood and red cedar, although specially formulated stain-blocking latex primers can also work for this application. Many painters also favor oil primer when repainting over chalky or degraded surfaces because of its penetrating oils and strong adhesion. Painting over high-gloss surfaces also may be easier with oil-based paints.

Finally, oils offer greater temperature flexibility in both hot and cold weather. In hot weather, latex may dry too fast; while below about 50°F, latex should not be used without special additives. Oil-based paints can be safely used to about 40°F. Newer formulations of latex paints, however, promise to extend their temperature range.

**Solid-Color Stains**

Solid-color, or “opaque,” stains are not true penetrating stains, since they form a film on the surface of the wood as paint does. In fact, they are formulated the same as paints, only with fewer solids, leaving a thinner, less protective film. They may also contain water-repellents and preservatives. Like paints, they help protect wood from UV degradation; but also like paints, they can peel and blister if applied incorrectly. Most require a primer for best results.

The thinner coating of these products tends to hide the wood grain but allows the wood texture to show through, particularly on rough-sawn siding (see Figure 1-39).

Most solid-color stains sold today are latex-based, which makes them fast-drying and likely to show lap marks if not applied carefully. The most durable latex solid-color stains are 100% acrylic. Oil-based solid stains are sometimes used on redwood and cedar.

Two coats of top-quality latex solid stain over a primer on a solid-wood siding should provide 3 to 7 years of service versus as many as 10 years for an acrylic latex paint of equal quality.

**Application of Paints and Solid Stains**

The best paint in the world can fail within the first year if applied over a wet, dirty, or degraded substrate. So the first priority is to make sure that the material being painted is sufficiently dry and clean.
Sealers. For the best protection of the underlying wood and the longest lasting finishes, bare wood should be sealed with a water-repellent preservative (WRP) before priming and painting or staining. WRPs contain a small amount of wax or other water repellent and a mildewcide, fungicide, or both, usually in a solvent base. The preservatives help prevent mildew and decay in above-ground applications but are not meant for ground contact. Some WRPs contain UV blockers as well, which slow down the degradation of the outer wood fibers.

While sometimes formulated as a finish treatment for siding, some WRPs can be used as a pretreatment for painting and are recommended for that use by the USDA Forest Products Laboratory (FPL) and Western Wood Products Association (WWPA). Research shows that WRPs resist water entry better than acrylic primers. On bevel siding, they also reduce warping, splitting, and mildew growth. They can also improve paint performance on hard-to-paint woods, such as southern yellow pine and Douglas fir.

In new construction, the FPL recommends that siding and trim be coated on all sides with a paintable WRP such as DAP Woodlife® or Cuprinol’s Clear Wood Preservative, preferably by dipping or with a brush, roller, or pad. If the siding or trim is already installed, they suggest treating all places vulnerable to water entry, including door bottoms, window sills, lap and butt joints, edges and ends of trim, and any end grain on panel products such as plywood sidings.

If used as a pretreatment for paint, apply to bare, dry wood when it is above 50°F, and use only a single coat or excess wax buildup on the surface could affect the paint adhesion. Allow two days of warm weather to dry, or up to a week if the material was dipped. If painted before the solvent has evaporated and the wax absorbed, the paint can be discolored and not bond well.

Priming. All paints and most solid stains require priming on new wood. Primers are formulated with a higher ratio of binder to pigment than paints. This forms a durable film that bonds well to the surface and blocks water. However, without much pigment, it offers limited UV protection.

For woods with water-soluble extractives, such as cedar and redwood, use an oil-based primer or a stain-blocking acrylic primer formulated to seal in the extractives. Also use a stain-blocking primer on any knots. Otherwise the extractives can bleed through the finish and stain the siding. For wood species relatively free of extractives, use a 100% acrylic latex primer. If sprayed or rolled on, back brushing is recommended for a good bond.

Many manufacturers now sell siding and trim preprimed. In addition to the convenience for the contractor, the factory-applied coating is applied uniformly without the risk of bad weather or other job-site variables. The only concern is the thickness of the primer. While most major manufacturers of preprimed siding do a good job, some third-party prefinishers may ship material with too thin a coating. In general, the primer should be 1.5 to 2 mils thick—thick enough that it hides the wood grain.

Back Priming. Most paint failures are related to moisture moving through the wood either from wind-driven rain that reaches the back of the siding or moisture escaping from the house. In some cases exposed end grain picks up moisture and causes localized peeling. Use of a water-repellent preservative or primer on the back of the siding and on all edges and cut ends, in addition to the visible face, will minimize these problems. Sealing the wood properly also helps prevent moisture from being driven through the siding by solar radiation.

Top Coats. For paints and solid stains, apply the top coat as soon as the primer is dry but not more than two weeks later. For best performance, apply two top coats. Latex paints can typically be recoated within a few hours. Oil must cure for one or two days between coats. Apply paint at the coverage recommended on the can. Too thin a coat will wear quickly and too thick a coat may crack.

While brushing provides the best adhesion, a properly done spray job can yield good results. When spraying or rolling, the best results are achieved by back-brushing the paint to help work it evenly into the wood, particularly on rough-sawn surfaces.

Temperature and Time of Day. Oil-based paints should be applied when it is over 40°F; for latex coatings the temperature should be at least 50°F during application and for 24 hours after. Also it is best not to apply paint too early or too late in the day. If the dew has not evaporated in the morning, both oil and latex may have adhesion problems. If applied within two hours of sunset and a heavy dew forms before the paint dries, latex paints may streak and oil-based paints may not cure properly.

Finishing Pressure-Treated Wood. Wood that is pressure-treated with waterborne preservatives, such as chromated copper arsenate (CCA), ammoniacal copper zinc arsenate (AZCA), and ammoniacal copper quaternary (ACQ), present special problems for painted finishes. First, pressure-treated lumber is often shipped to lumberyards with very high moisture contents. If painted while wet, the moisture may get trapped by the paint film and cause peeling. Also the species most commonly pressure-treated—flat-sawn southern yellow pine in the eastern United States and Douglas fir and Ponderosa pine in the West—do not hold paint well to begin with.

Whether or not you intend to paint the wood, pressure-treated exterior trim should be sealed with a water-repellent preservative as soon as the surface is sufficiently dry. This will protect cut ends and help keep the wood from checking, cupping, and warping as the wood dries out. If this is the only treatment, it will need recoating every one to two years. Factory-sealed treated lumber is now available that only requires treatment of cut ends when installed.

The most common treatment for pressure-treated wood is an oil-based, semitransparent stain. Since this type...
of finish is relatively permeable to moisture, for best results apply it over a sealer or over factory-sealed lumber. While the sealer can be applied to wood that is still wet inside, it is best to air dry the wood before staining. This will take from a few days to a few weeks, depending on conditions, with two weeks on average. Two coats of an oil-based, semitransparent stain over a sealer should last several years. The second coat should be applied before the first coat dries completely, or the second coat cannot penetrate the wood.

If a painted finish is desired, you will need to seal the wood first and allow it to dry for two to three weeks before applying a compatible primer and two coats of 100% acrylic top coat. The longer the wood dries, however, the greater the risk that UV radiation will damage the wood surface, interfering with the paint’s adhesion. To avoid these problems and the long delays, consider using kiln-dried treated lumber that can be finished immediately.

Discoloration Problems

Extractive bleeding and mildew can discolor either bare wood or finished surfaces. They should be removed before finishing or refinishing. After washing, it is important to allow the surface to dry before applying the new finish.

Extractive Bleeding. Excess moisture in wood species such as cedar, redwood, Douglas fir, and mahogany can dissolve the natural tannins in the wood and cause them to migrate to the surface, leaving a reddish-brown stain on the finish. Sealers and stain-blocking primers help to minimize this problem but do not always eliminate it. If staining occurs, the first step is to eliminate the moisture problem. Then, if the extractive bleeding is mild, remove the stains with a mild detergent and water. More severe cases will require cleaning with an oxalic acid solution.

Carefully follow the manufacturer’s instructions when using oxalic acid, as the bleaching solution will harm plants and may bleach existing finishes on siding, trim, and other woodwork. After washing, the oxalic acid must be thoroughly rinsed with clean water and the wood dried before finishing or refinishing. If the extractive bleeding has been allowed to bake in the sun, it may have hardened and be difficult to remove. In this case, you will need to apply a stain-blocking primer before refinishing.

Mildew. This common fungus grows on just about any surface with sufficient moisture and heat. In new construction, it can be minimized by storing wood off the ground and providing adequate ventilation. Although sealers and stains contain a mildewcide, any mildew should be removed before finishing or refinishing, or it will continue to grow through the new finish.

To remove mildew, use a sodium hypochlorite solution, which can be made with household chlorine bleach. Depending on the severity of the problem, the solution should range from 1 to 8 parts bleach to 1 part water. Spray the solution onto the siding (avoid sprayers with aluminum parts), starting at the top and working down. If two applications do not remove the stains, you may need to scrub in the solution with a brush. Thoroughly rinse everything with water.

Bleach can harm plants, discolor the finishes on trim, and corrode aluminum, brass, and copper. It is best to cover plants with tarps and protect any stained or painted surfaces.

Semitransparent Penetrating Stains

Most semitransparent stains are oil-based, and they penetrate the surface of the wood. They have a moderate level of pigment that offers some UV protection and provides some color without hiding the wood grain. Because these stains do not form a film on the surface, they are not subject to blistering and peeling like paints and solid-based stains.

Penetrating stains last longer on rough than on smooth siding materials. One coat of oil-based penetrating stain on rough-sawn siding or plywood will last two to five years, depending on exposure and other variables; two coats may last as long as seven or eight years. In general, subsequent coats last longer than the first coat because the weathered wood will accept more stain. For decks, steps, or other wood subject to foot traffic, use a special deck stain formulated with better abrasion resistance (see “Finishes for Decking,” page 154).

Like paints, penetrating stains can be applied by brush, spray, or roller. If sprayed or rolled on, back-brushing will improve the penetration and performance. Also spraying without back-brushing can cause a splotchy appearance. If two coats are desired, apply the second coat before the first has fully dried or the second coat will not be able to penetrate the surface.

Because oil-based stains are thin and dry quickly, lap marks may form if the applicator is not careful to maintain a wet edge. It is best to work on a small area at a time and, if possible, to work in the shade to extend the drying time.

Clear and Lightly Tinted Finishes

Some customers want to retain the look of “natural” wood siding, particularly with the warm-toned hues of premium red cedar or redwood. Unfortunately, there is no finish that will magically preserve the look of new wood.

Wood turns gray as UV radiation degrades the outer surface and as mildew spores develop. Clear water-repellent preservatives (described under “Sealers,” previous page) with UV blockers can slow down this natural aging process, but will need to be reapplied every year or two to keep the wood from turning a weathered gray.

To retain the tone of new wood, the best approach is to use a WRP or penetrating oil with UV blockers and a tint added to match the redwood or cedar. Amteco’s Total Wood Protectant (TWP®), Flood’s Clear Wood Finish (CWF®), and Penofin® (Performance Coatings Inc.) are proprietary
formulations designed to maintain a natural wood appearance. A similar product called Sikkens Translucent Cetol® (Akzo Coatings) darkens the wood somewhat and creates a thin film, but it does not peel like paint or varnish. Apply one to three coats, according to the manufacturer’s recommendations. Even with “one-coat” finishes, a second coat may be worthwhile on south or southwest sides of the building due to increased UV exposure.

If applied correctly, a high-quality tinted finish can keep redwood or cedar siding looking close to new for three to five years. Before recoating, you may need to clean the siding with a bleach solution to remove any mildew and dirt that has started to discolor the siding. After cleaning, another coat of the original finish should restore the new wood look for another three to five years.

### Bleaching Oils

In some regions, homeowners like the silver-gray, weathered look of unfinished cedar shingles, but they do not want the splotchy, uneven coloring that sometimes results from uneven wetting and sun exposure. Bleaching oils solve this problem by combining a lightly pigmented semi-transparent stain with a bleaching agent. Initially, the pigment colors the wood a silver-gray color, and over time, the bleach lightens the underlying wood to a uniform color.

The uniform weathered look can last for a number of years, but the oil and pigments in the original finish protect the wood for only two or three years. Beyond that, a clear water-repellent preservative can be used periodically to protect the wood from UV degradation and decay. If, after several years, the siding begins to darken or lose its uniform appearance, another coat of bleaching oil should restore the original look.

### Unfinished Siding and Trim

Due to their high level of extractives, the heartwood of some species is naturally resistant to decay and insects and can be used on the exterior unfinished. The woods most commonly used this way are western red cedar, northern white cedar, redwood, and bald cypress (see Table 1-16).

In salty coastal air with good exposure to sunshine, untreated wood tends to weather to an attractive silver gray. In other regions, uneven staining from mildew is likely. Even in coastal regions, areas of the house that get frequent wetting from splashback, snow, or other types of weather exposure may become darkened from mildew (see Figure 1-19, page 19).

Also, the wood extractives do nothing to prevent cupping, warping, or cracking from uneven absorption of moisture. For a uniform appearance without leaving the results to chance, it is best treat the wood with a WRP or bleaching agent.

### TABLE 1-16 Relative Decay Resistance of Untreated Heartwood

<table>
<thead>
<tr>
<th></th>
<th>Moderately Resistant</th>
<th>Slightly or Nonresistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bald cypress (old growth), cedar, white oak, redwood</td>
<td>Bald cypress (new growth), Douglas fir, western larch, eastern white pine, southern yellow pine (longleaf, slash), tamarack</td>
<td>Pines other than longleaf, slash, and eastern white; spruces, true firs</td>
</tr>
</tbody>
</table>


### RESOURCES

**Suppliers**

**Unfinished Siding and Trim**

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**Resources**

**Suppliers**

**Grade D Building Paper**

**Fortifiber Co.**

www.fortifiber.com

**Hal Industries**

www.halind.com

**Plastic Housewrap**

**Benjamin Obdyke**

www.benjaminobdyke.com

*Homelsicker drainage mat and Homelsicker Plus Typar*

**DuPont**

www.construction.tyvek.com

*Tyvek, HomeWrap, and StuccoWrap*

**FirstLine**

www.firstlinelcorp.com

*FirstWrap*

**Johns Manville**

www.jm.com

*ProWrap perforated housewrap*

**Ludlow Coated Products**

www.ludlowpc.com

*Barricade housewrap, Weathertrek draining housewrap*

**Owens Corning**

www.owenscorning.com

*PinkWrap and PinkWrap Plus*

**Pactiv**

www.pactiv.com

*Classic wrap, Ultra wrap, and Raindrop Housewrap*

**Reemay**

www.typarhousewrap.com

*Typar housewrap*
Flashing Tapes and Membranes

Avenco
www.avenco.com
Butyl flashing tape

Bakor, Inc.
www.bakor.com
Blueskin self-adhesive, rubberized-asphalt flashing tape

Carlisle Coatings and Waterproofing
www.carlisle-ccw.com
Self-adhesive, rubberized-asphalt flashing tapes and membranes

Dupont
www.construction.tyvek.com
StraightFlash and moldable FlexWrap Butyl flashing tapes

Fortifiber
www.fortifiber.com
Moistop and FortiFlash self-adhesive and nonstick rubberized-asphalt flashing tape

Grace Construction Products
www.graceconstruction.com
Vycor self-adhesive, rubberized-asphalt flashing tapes and membranes

Illbruck Sealant Systems
www.willseal.com/usa
Self-adhesive butyl and foil-faced butyl flashing tapes

MFM Building Products Corp.
www.mfmbp.com
FlexWrap (foil-faced) and FutureFlash self-adhesive, rubberized-asphalt flashing tapes and membranes

Polyguard Products
www.polyguardproducts.com
Windowseal self-adhesive, rubberized-asphalt flashing tapes and membranes

Protecto Wrap Co.
www.protectowrap.com
Standard and moldable (Protecto Flex) self-adhesive, rubberized-asphalt flashing tapes

Sandell Manufacturing Co.
www.sandellmfg.com
Rubberized-asphalt, PVC, and EPDM flashing tapes

Prefabricated Cedar Shingle Panels

Cedar Valley
www.cedar-valley.com

Maibec Industries
www.maibec.com

Shakertown
www.shakertown.com

Fiber-Cement Siding and Trim

Cemplank
www.cemplank.com
Cemplank fiber-cement siding and trim

James Hardie
www.jameshardie.com
Hardiplank, Hardipanel, fiber-cement shingles

Nichiha Wall Systems
www.n-usa.com
Fiber-cement lap siding and simulated shakes, brick, and stone

Certainteed
www.certainteed.com
Fiber-cement lap, vertical, and shingle sidings, and soffits and trim

GAF
www.gaf.com
Weatherside fiber-cement siding

Exterior Insulation and Finish Systems (EIFS)

Dryvit Systems
www.dryvit.com

Parex
www.parex.com

Senergy
www.senergyeifs.com

Sto Corp.
www.stocorp.com

Hardboard Trim

ABTco
www.abtco.com

The Collins Companies
www.collinswood.com

Georgia-Pacific
www gp.com

Masonite Corp.
www.masonite.co

Temple-Inland Forest Products
www.templeinland.com

Polyurethane Trim

Custom Decorative Mouldings (CDM)
www.custom-moulding.com

Focal Point Architectural Products
www.focalpointap.com

Flex Trim
www.flextrim.com
Flexible polymer composite moldings
**Resources**

**Cellular Polyvinyl Chloride (PVC) Trim**

- **AZEK Trimboards**
  www.azek.com
- **Edge Building Products**
  www.permatrimboard.com
- **Gossen Corp.**
  www.gossencorp.com
- **Marley Moldings**
  www.marleymoldings.com
- **LVL Trim**
- **Pacific Wood Laminates**
  www.pwlonline.com
  Clear Lam (textured wood facing) and Socomi Lam (MDO facing)

**Caulks and Sealants**

- **Bostik**
  www.bostikfindley.com
  Construction sealants
- **Chemrex**
  www.chemrex.com
  Polyurethanes and other high-performance sealants
- **DAP**
  www.dap.com
  Acrylic latex caulks
- **Dow Corning Sealants**
  www.dowcorningsealants.com
  Silicone sealants
- **GE Silicones**
  www.gesilicones.com
  Silicone sealant
- **Geocel Corp**
  www.geocelusa.com
  Acrylic latex, tripolymer, copolymer, Kraton, and clear sealants
- **Macklanburg-Duncan**
  www.mdteam.com
  Acrylic latex sealants
- **OSI Sealants Inc**
  www.osisealants.com
  Polyseamseal PVA-based caulk. Pro Series includes latex, polyurethane, and Kraton sealants.
- **Phenoseal**
  www.phenoseal.com
  Phenoseal vinyl adhesive caulk
- **Red Devil**
  www.reddevil.com
  Acrylic, silicone, and butyl sealants
- **Sashco Sealants**
  www.sashco.com
  Big Stretch and Mor-Flexx water-based sealants, Lexel Kraton sealant
- **Sika Corp**
  Complete line of Sikaflex polyurethane-based sealants, butyl sealant
- **Tremco Inc.**
  www.tremcosealants.com
  High-performance, architectural-grade sealants,
- **UGL**
  Acrylic latex caulks
- **White Lightning**
  www.wlcaulk.com
  Tripolymer, butyl, polyurethane, silicone, elastomeric, and other high-performance sealants

**Exterior Adhesives**

- **Abatron**
  www.abatron.com
  Epoxy, BestBond polyurethane glue
- **Ambel**
  www.excelglue.com
  Excel polyurethane glue
- **Elmer’s Products**
  www.elmers.com
  Yellow glues, ProBond polyurethane glue
- **Custom-Pak Adhesives**
  www.custompak.com
  Resorcinol and yellow glues
- **DAP Inc.**
  www.dap.com
  Weldwood contact cement, resorcinol, and construction adhesives
Franklin International  
www.titebond.com  
Titebond yellow glue, Liquid Hide Glue, and construction adhesives

Gloucester Co. Inc.  
www.phenoseal.com  
Phenoseal adhesive caulk

Gougeon Brothers  
www.westsystem.com  
West System epoxy

Gorilla Group  
www.gorillaglue.com  
Gorilla polyurethane glue

MACCO Adhesives  
www.liquidnails.com  
Liquid Nails construction adhesive

OSI Sealants  
www.osisealants.com  
PL400 construction adhesive

System Three Resins  
www.systemthree.com  
Quick Cure epoxy

Water-Repellent Preservatives (WRPs)  
Cuprinol  
www.cuprinol.com  
Cuprinol Clear Wood Preservative

Dap  
www.dap.com  
DAP Woodlife

Wolman  
www.wolman.com  
Premium Water-Repellent Sealer

Clear Wood Finishes  
Amteco  
www.amteco.com  
Total Wood Protectant (TWP)

The Flood Company  
www.floodco.com  
Clear Wood Finish (CWF)

Performance Coatings Inc.  
www.penofin.com  
Penofin wood finishes

Sikkens/Akzo Nobel  
www.nam.sikkens.com  
Sikkens Cetol finishes

For More Information  
California Redwood Association  
www.calredwood.org

Cedar Shake and Shingle Bureau  
www.cedarbureau.org

USDA Forest Products Laboratory (FPL)  
www.fpl.fs.fed.us

Vinyl Siding Institute  
www.vinylsiding.org

Western Wood Products Association (WWPA)  
www.wwpa.org