

United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory

General
Technical
Report
FPL-GTR-109



Water Repellents and Water-Repellent Preservatives for Wood

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Abstract

Water repellents and water-repellent preservatives increase the durability of wood by enabling the wood to repel liquid water. This report focuses on water-repellent finishes for wood exposed outdoors above ground. The report includes a discussion of the effects of outdoor exposure on wood, the characteristics of water repellent and water-repellent preservative formulations, and methods for applying these finishes.

Keywords: water repellent, preservative, weathering, stain

January 1999

Williams, R. Sam; Feist, William C. 1999. Water repellents and water-repellent preservatives for wood. Gen. Tech. Rep. FPL–GTR–109. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 12 p.

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Water Repellents and Water-Repellent Preservatives for Wood

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Introduction

Some woods have natural durability against decay (rot). Others can be made durable through treatment with preservatives. Durable species such as redwood and cedar are commonly used for wood exposed outdoors, such as siding, shakes and shingles, decks, furniture, and fences (Table 1). Durability is imparted by natural chemicals, which are contained in extractives in the heartwood of these species. Heartwood is the center part of the wood; the outer part is sapwood (Fig. 1). Since only the heartwood contains extractives, lumber that contains a high proportion of sapwood does not have the natural durability of lumber that contains a high proportion of heartwood.

Nondurable wood species may be factory-treated with preservative for long-term durability for use in ground contact. These treatments are done in large cylinders, and the preservative chemicals are forced deep into the wood using high pressure. Preservative chemicals include creosote, pentachlorophenol, ammoniacal copper zinc arsenate (ACZA), ammoniacal copper quaternary compound (ACQ), and chromated copper arsenate (CCA). Wood treated with CCA is one of the most common types of preservative-treated lumber. Several other preservatives are currently used and still others are being developed. Preservative treatments of wood are done under carefully controlled factory conditions, and the wood usually has a manufacturer's guarantee. A number of wood preservers certify their treatment with a tag on each piece of lumber.

Water repellents (WRs) and water-repellent preservatives (WRPs) are penetrating wood finishes that increase the durability of wood by enabling the wood to repel liquid water (Fig. 2). This ability to repel water is imparted by a wax, an oil, or a similar water-repelling substance. By repelling water, WRs and WRPs enable wood to resist decay and discoloration by wood-decay fungi, which need moisture to live. The addition of a fungicide to the water repellent, which converts the WR to a WRP, further enhances the

effectiveness of the finish by inhibiting the growth of mildew and decay fungi. Water repellents and WRPs also decrease the swelling and shrinking that lead to cracking and warping. They protect painted wood from blistering, cracking, and peeling. In wood species that contain colored water-soluble extractives, such as redwood and cedar, WRs and WRPs help reduce the discoloration caused by extractive bleed.

Wood is the material of choice for many structures. As with any building material, how wood is used depends on its properties, such as strength and stiffness, as well as its finishing characteristics and maintenance requirements. Problems such as poor finish performance, mildew, checking and splitting, and wood decay can be controlled with proper care and maintenance. Such problems can be avoided or attenuated through knowledge about the factors that affect wood, particularly wood exposed outdoors. If wood structures are given proper care initially and are maintained periodically, they can be functional and structurally sound, as well as aesthetically pleasing, for decades.

This report includes a discussion of the effects of outdoor exposure on wood, characteristics of WR and WRP formulations, and methods for applying WRs and WRPs.

Effects of Outdoor Exposure

Properly seasoned wood that stays dry is not subject to decay, premature failure of paints and finishes, and problems associated with weathering, such as excessive splitting and checking, raised grain, extractive bleed, and discoloration.

Moisture Effects

Water is one of wood's worst enemies. Whether in the form of vapor or liquid, water can cause shrinking and swelling, which can lead to dimensional changes of the wood and degradation of the finish. Water causes decay or rot of the wood and early failure of paint, and it accelerates the weathering of wood exposed outdoors.

Table 1—Grouping of domestic wood species according to approximate relative decay resistance of heartwood

Resistant or very resistant	Moderately resistant	Slightly resistant or nonresistant
Baldcypress (old growth)	Baldcypress (young growth)	Alder
Catalpa	Douglas-fir	Ash
Cedar	Honeylocust	Aspen
Cherry, black	Larch, western	Basswood
Chestnut	Oak, swamp chestnut	Beech
Cypress, Arizona	Pine, eastern white	Birch
Juniper	Southern Pine, longleaf, slash	Buckeye
Locust, black ^a	Tamarack	Butternut
Mesquite		Cottonwood
Mulberry, red ^a		Elm
Oak		Hackberry
Bur		Hemlock
Chestnut		Hickory
Gambel		Magnolia
Oregon white		Maple
Post		Oak, red, black
White		Pine ^b
Osage orange ^a		Poplar
Redwood		Spruce
Sassafras		Sweetgum
Walnut, black		True fir, western, eastern
Yew, Pacific ^a		Willow
		Yellow-poplar

^aThese woods have exceptionally high decay resistance.

^bOther than longleaf, slash, and eastern white pine.

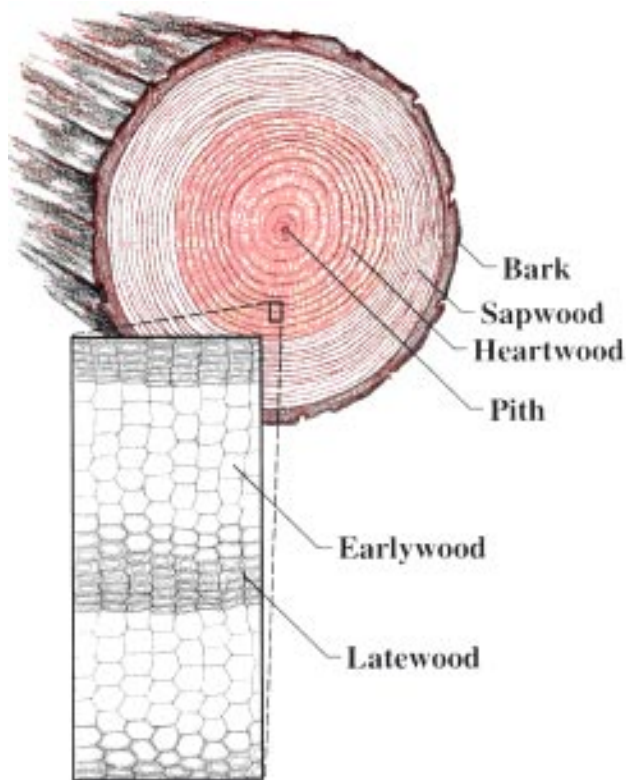


Figure 1—Cross section of log showing various wood components.

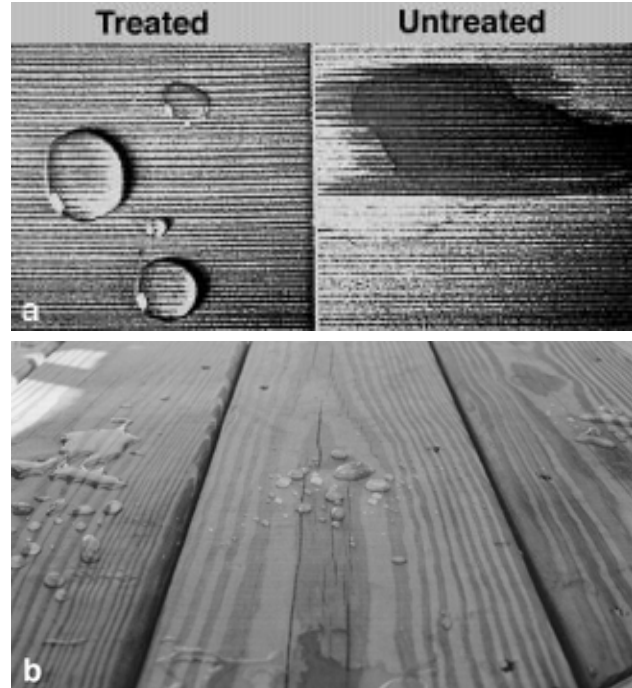


Figure 2—Effect of water-repellent preservative (WRP) treatment on western redcedar. (a) Close-up view of wood surface. Left: surface brush-treated with WRP resists penetration by liquid water. Right: untreated wood surface absorbs water quickly. (b) Deck treated with WRP.

Shrinking and Swelling

In general, wood shrinks as it loses moisture and swells as it gains moisture. More precisely, wood only changes dimension between an absolutely dry state (completely free of moisture) and its fiber saturation point (the point at which the wood fibers are completely saturated with moisture). This fiber saturation point typically occurs at about 30% moisture content for most species. At this point, all the water in the wood is bound within the cell wall. At moisture content changes above fiber saturation, the cell cavities take on or lose unbound water but the wood cell walls do not change dimensionally. Below the fiber saturation point, however, the wood changes dimension with changing moisture content. The magnitude of this change is dependent on species and is always different for the three axes: radial, tangential, and longitudinal (Fig. 3). A large percentage of wood finish degradation (e.g., paint defects, peeling, and cracking) results from moisture changes in the wood and subsequent dimensional instability.

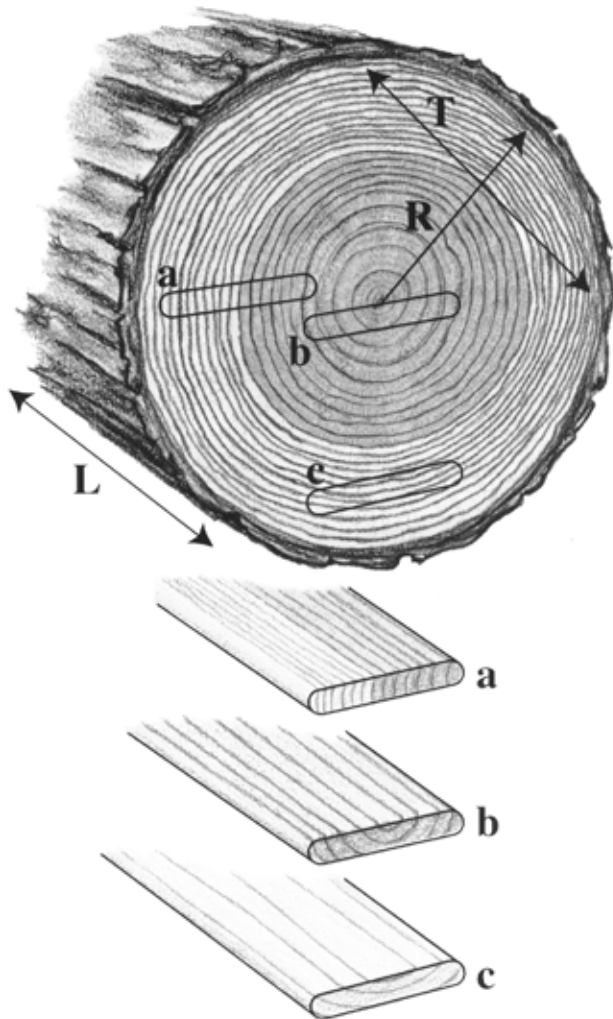


Figure 3—Grain orientation of wood in log in relation to lumber cut from log. R is radial; T, tangential; and L, longitudinal.

Water Vapor and Water Effects

Shrinking and swelling of wood occur whether the water is in the form of vapor or liquid. For example, wood swells during periods of high humidity and shrinks during periods of low humidity; it also swells and shrinks as it gets wet from liquid water and then dries. As discussed, wood can swell until it reaches fiber saturation. If wood is exposed to water vapor, such as occurs indoors, the moisture content can only reach the fiber saturation point. This requires exposure to 100% relative humidity for an extended period. Since wood is seldom exposed to this level of relative humidity for long periods, it seldom reaches fiber saturation because of high humidity. However, if the wood gets wet from liquid water, it can quickly reach, or even go beyond, fiber saturation. Problems with poor performance of wood occur when the moisture content of wood reaches or goes beyond fiber saturation — this is almost always caused by liquid water. Throughout the remainder of this report, the term water refers only to liquid water, the term water vapor to humidity, and the term moisture to both water and water vapor.

Weathering

Regardless of the care taken in building a structure, wood ages when exposed outdoors. This aging process is called weathering. Weathering is a degradation of the wood's surface caused by the combined effects of the ultraviolet (UV) radiation in sunlight, water, and abrasion by wind-blown sand or other particulates. This degradation should not be confused with decay.

Weathering is first manifested by a change in the color of the wood. The color of most preservative-treated lumber is either light green (from copper and chromium salts in the preservative) or brown (from added dye). Cedar and redwood have the freshly sawn natural color of these species. With weathering, dark wood, such as redwood and cedar, tends to get lighter, whereas light wood, such as pine and fir, tends to get darker. In some climates, such as along the seashore, wood tends to weather to a silvery gray. This color is a combination of mildew growth and cellulose enrichment of the surface. The weathering process removes the colored extractives and lignin, leaving cellulose. If protected from excessive moisture, redwood and cedar are prone to weather to silver-gray. Wood that has been pressure-treated with CCA but not treated with a WRP will initially turn to dull gray. Eventually, this wood will also become silver-gray.

The change in color is followed by a loosening of wood fibers and gradual erosion of the wood surface (Fig. 4). Rain washes the degraded wood materials from the surface. Rain and changes in humidity also cause dimensional changes in the wood that accelerate this erosion process. Erosion is more rapid in the less dense earlywood than in the latewood, which leads to an uneven surface (Fig. 4).

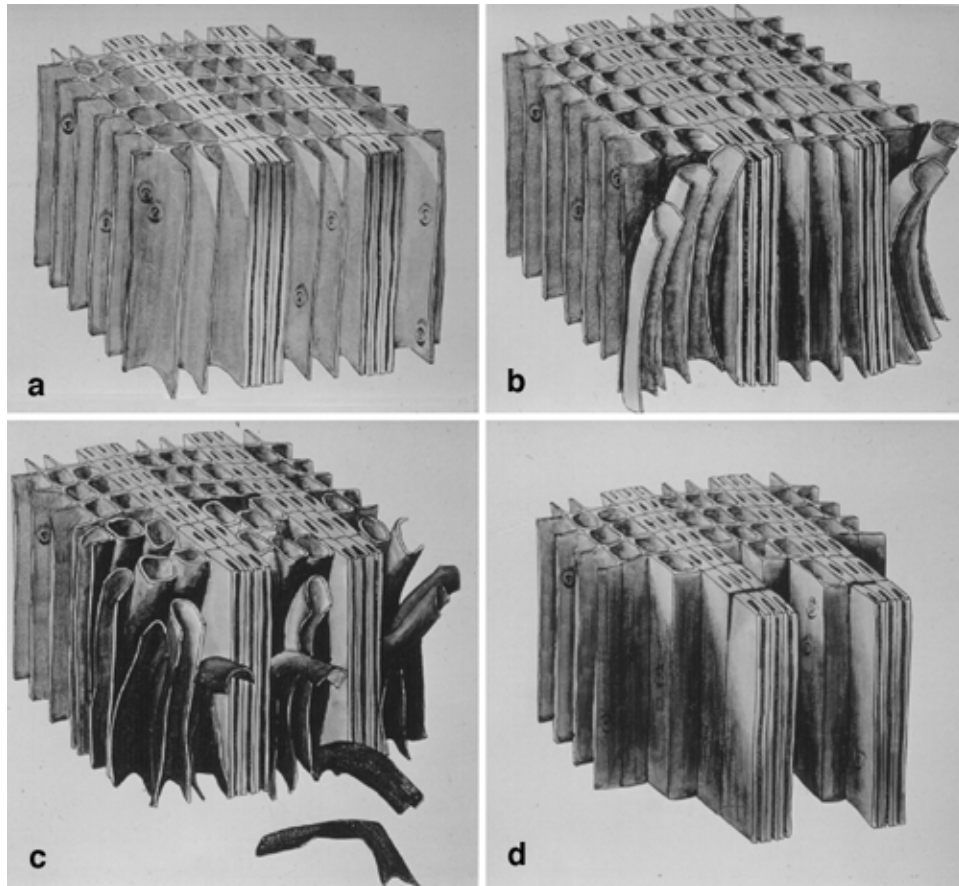


Figure 4—Weathering of wood. (a) Unexposed wood; (b) early phase of weathering—loosening of fibers; (c) early phase of fiber loss; (d) later phase of weathering—loss of earlywood, leading to "washboard" surface.

Surface erosion, however, proceeds slowly. The erosion rate for solid softwoods in temperate zones is on the order of 1/4 to 1/2 in. (6 to 12 mm) per century and depends mainly on the intensity of UV radiation and on the wood species (Fig. 5). For hardwoods, the erosion rate is 1/8 to 1/4 in. (3 to 6 mm) per century. The erosion rate depends on the exposure of the wood to sun and rain and the care the wood receives. Control of water absorption by the wood retards weathering and decay.

Extractive Bleed

A common cause of discoloration is extractive bleed. All species contain extractives, but extractive bleed is most prevalent on highly colored woods. The discoloration often occurs around fasteners (Fig. 6) because the hole in the wood caused by the fastener cuts many wood cells. These cut cells increase water absorption. Water dissolves the extractives, and when the wood dries, the extractives accumulate at the surface and sunlight causes them to polymerize. Although extractive bleed can be a problem on wood siding, it is seldom a problem on horizontal wood surfaces such as decks

because the extractives are usually washed from the deck by rain before they polymerize. If extractive bleed is a problem, the extractives can be removed by scrubbing the wood with soap and water. Do not use a wire brush because the brush will contaminate the surface with iron, which will cause iron stain. Finishing wood with a WRP greatly minimizes extractive bleed.

Iron Stain

A common form of staining on wood surfaces results from contamination with iron. A portion of the extractives in wood includes a group of chemicals collectively called tannins. The amount of tannins depends on species; oak, redwood, and cedar are rich in tannins. Tannins react with iron to form a blue-black stain on wood. Iron stain and extractive bleed are compared in Figure 6. Note the darker color of the iron stain. Common causes of iron stain include use of ungalvanized or poorly galvanized fasteners, cleaning with steel wool or a wire brush, and contact of the wood with any iron or steel. Finishing wood with a WR or WRP greatly minimizes iron stain.

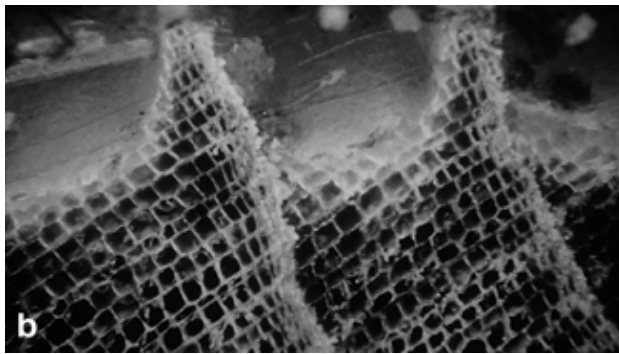
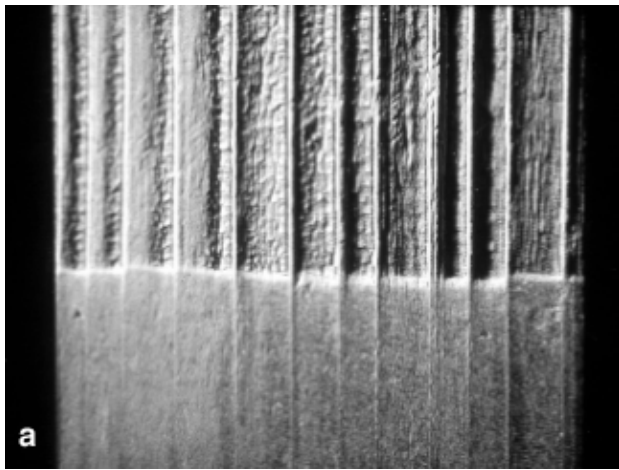


Figure 5—Surface erosion of western redcedar caused by weathering. (a) Weathered surface (unweathered top section was protected by a metal strip during exposure); (b) micrograph of end view of a weathered surface.

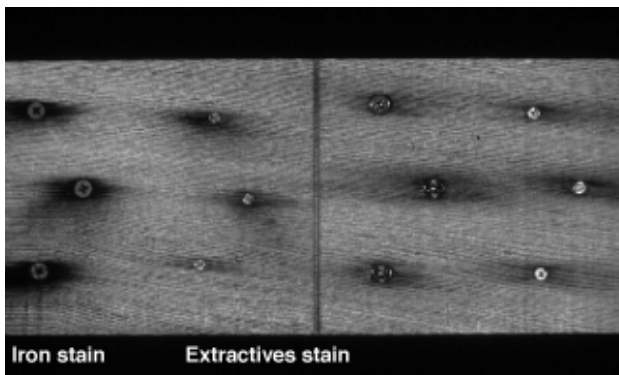


Figure 6—Iron stain and extractive bleed around fasteners on untreated cedar siding.

Removal of Iron Stain

Iron stain can be removed by scrubbing the stained area with a aqueous solution of oxalic acid in water. Oxalic acid is usually sold at drugstores and hardware stores. Dissolve 1 to 4 oz of oxalic acid in 1 qt of hot water. Scrub stained area using a stiff-bristle brush. Thoroughly rinse with water after treatment.
 [Note: 1 qt = 0.9 liter; 1 oz = 28 g]

Caution: Oxalic acid is toxic. Wear rubber gloves and avoid contact with skin. Work in a well-ventilated area. Avoid splashing the solution on plants because it can damage the foliage. Wash hands before eating or using tobacco products. Store in a locked space out of reach of children.

Raised Grain

The wetting and drying cycle of wood exposed outdoors can raise the grain of the wood, resulting in a rough surface. On flat-grained lumber, the raised grain may appear as thin knife-like feathers along the earlywood-latewood interface (Fig. 7). This degradation leads to a splintered wood surface and eventually to checking and cracking. Checking may increase the uptake of water, thus accelerating the degradation process.

Decay

Whereas weathering is degradation of the wood surface, decay (also called rot) affects the full volume of wood. Decay is degradation caused by a variety of decay fungi that are capable of breaking down the structural components of wood for food. The fungi tunnel throughout the full volume of the wood, degrading the polymers that form the wood cells through a complicated biochemical process. Since these polymers give wood its strength, considerable loss of strength occurs long before visible damage is apparent. Wood decay fungi must have adequate moisture to grow. Although the amount necessary for growth varies depending on the species of fungi, in general, the wood must be near fiber saturation for fungal growth.

Mildew

Mildew is caused by a type of stain fungi, which differ from decay fungi. Mildew is not capable of degrading the structural components of wood; therefore, it does not cause a decrease in wood strength. Unlike decay fungi, mildew fungi do not tunnel through the wood but live only on the surface. Like decay fungi, mildew fungi often flourish when excessive water is present. Moisture also encourages the growth of lichens and other microorganisms that discolor the wood surface (Fig. 8). Wood can develop mildew growth rapidly, particularly if treated with linseed oil or other natural oils,



Figure 7—Raised grain on flat-grained lumber (tangential).



Figure 8—Growth of micro-organisms on untreated deck rail.



Figure 9—Black stain on wood caused by mildew.



Figure 10—Growth of mildew on CCA-treated lumber. In cleaned section, mildew was removed with a bleach and water solution.

which form a food source for the fungi. Because the conditions that favor the growth of mildew fungi also favor the growth of wood-degrading fungi, be suspicious if wood has mildew or other discoloration.

Mildew can affect all species of wood, including naturally decay resistant species and wood treated with CCA. Some extractives are food for mildew. Thus, species with high extractives content are slightly more susceptible to discoloration by mildew.

Mildew fungi are objectionable because they discolor the wood. The most common discoloration is an overall gray. Mildew can also appear as black blotchy stains (Fig. 9). Mildew can be removed with a liquid household bleach-water solution (Fig. 10). (Liquid household bleach is a 5% aqueous solution of sodium hypochlorite. See section on removal of mold and mildew.) Better yet, periodic treatment of the wood with a WRP can prevent mildew.

Advantages of Water-Repellent Preservatives

- Retard decay in aboveground applications
- Decrease raised grain, checking, warping, and splitting
- Inhibit mildew growth on both painted and unpainted wood
- Stop extractive bleed
- Retard iron stain
- Improve paint adhesion

Formulations

Water repellents and WRPs are relatively simple wood treatments that slow the uptake of water and help keep wood dry. The only difference between WRs and WRPs is that WRPs include a fungicide or mildewcide. Otherwise, the composition of WRs and WRPs is similar: both contain 10% to 20% binder such as varnish resin or drying oil (linseed or tung oil), a solvent, and a substance that repels water (usually a wax). The oil or varnish resin penetrates the wood surface and cures to partially seal the wood surface. The oil or varnish also helps to bind the fungicide–mildewcide and water repellent to the wood surface. Solvents include organic liquids such as turpentine, naphtha, and mineral spirits or water. The amount of water repellent varies among brands. Some WRs and WRPs are formulated with a low concentration of water repellent so that they can be used as a pretreatment for other finishes (about 1% by volume). Others are formulated with a high concentration of water repellent (about 3% by volume) and are meant to be used as stand-alone finishes.

Preservatives

The chemical preservatives used in WRPs deserve special mention. They should not be confused with the preservatives used for pressure treating wood, such as CCA. The term preservative is used because the WRP chemical is a registered pesticide. These preservatives are moderately effective fungicides–mildewcides and give some decay resistance to wood in aboveground exposure. The chemical treatments described here are contained in the finish and are formulated for brush application. They are not available except as formulated in a finish. These formulations may contain one of the following preservations:

- 3-Iodo-2-propynyl butyl carbamate (commonly called Polyphase) is currently used in several commercial WRP formulations and pigmented stains. It is available in both solvent- and waterborne systems at ~0.5% composition by weight.
- 2-(thiocyanomethylthio) benzothiazole (TCMTB) is used alone or in combination with methylene bis (thiocyanate) (MTC or MTB). This preservative can also be effective as a fungicide for WRP and stain formulations. It is available in both solvent- and waterborne systems at ~0.5% composition by weight.
- Zinc naphthenate is available commercially in WRP formulations and possibly in some new stains, in both solvent- and waterborne formulations. Approximately 2% concentration by weight of zinc metal is recommended.
- Copper naphthenate is available commercially in WRPs. Solutions and treated wood are bright green; treated wood

weathers to pale green–brown in full sunlight. This preservative is available in solvent- and waterborne formulations at ~2% concentration by weight of copper metal. It is one of the few fungicides used to pressure-treat wood for belowground decay resistance. It is very effective for use on cut ends of posts before being placed in the ground.

- Copper-8-quinolinolate is available in commercial WRPs and may be available in stains. This preservative imparts a green–brown color to the wood. Effective concentrations range from 0.25% to 0.675%.
- A mixture of bis (tributyltin) oxide and N-trichloromethylthio phthalimide (the latter also commonly called Folpet) is in a number of commercial stain formulations at 0.5% to 1.0% composition by weight.
- Pentachlorophenol (penta) was used quite extensively in WRP formulations until about 1980. It is no longer readily available to the consumer in the ready-to-use (5% penta) or the concentrated (40% penta) formulation because of its high toxicity and status as a carcinogen. The use of pentachlorophenol is controlled and restricted to registered pesticide applicators.

Some European commercial formulations available in the United States may contain preservatives other than those listed here. Treatments containing borates are also being marketed as preservatives for wood products.

Terminology

The word preservative is a general term that includes many different chemicals used on wood to make it less susceptible to attack from a variety of organisms. These organisms include insects, marine borers, and various types of fungi such as stain and decay. Some of these chemicals are effective against a range of organisms. Others are very specific and protect wood from only one type of organism. No single chemical will protect wood from all degrading organisms.

Terms often used interchangeably with preservative include pesticide, fungicide, insecticide, and mildewcide. These chemicals are all preservatives, but they protect wood from specific organisms. Fungicides protect wood from wood-degrading fungi. Many fungicides will also protect wood against mildew. In turn, mildewcides can sometimes provide protection against decay fungi, but they are most effective against mildew and similar staining fungi. The chemicals used to formulate WRPs are generally fungicides and impart resistance to both mildew and decay fungi.

Changes in Formulations

Penetrating finishes were traditionally formulated using organic solvents as carriers for the binder and water repellent. The organic solvents facilitated the absorption of these components, thus giving a penetrating finish. The formulations were relatively simple solutions of binder, wax, and fungicide. About 1980, WRP formulations started to change because of concerns about solvent evaporation from these finishes in urban areas with smog. A number of waterborne formulations were introduced. In addition, several manufacturers began marketing low volatile organic compound (VOC) formulations for use in some areas. (VOC is a general term for volatile solvents and co-solvents used in both solvent- and waterborne finishes.)

Under provisions of the New Clean Air Act (1991), more stringent regulations that affect paint formulations were developed. On September 11, 1998, the Environmental Protection Agency published a rule in the Federal Register for the limitations of solvents used in architectural coatings. The regulation takes effect in September 1999 for coatings that do not contain preservatives. For those coatings containing preservatives, the rule takes effect in September 2000. This legislation will have the greatest effect on the formulation of penetrating finishes such as WRs, WRPs, and semitransparent stains. Other formulations will also continue to change to meet these regulations. The restriction of solvents has caused manufacturers to reformulate penetrating finishes by either removing solvents to give high solid finishes or by relying on waterborne systems.

Penetrating Characteristics of Water-Repellent Preservative Formulations

There is considerable variation in the penetrating characteristics of waterborne formulations. Many waterborne formulations absorb into the wood in the same way as solvent-borne formulations, but others tend to form thin surface films. The manufacturer's product literature may indicate the absorption characteristics of the finish.

In high solid formulations containing large amounts of natural or synthetic oils, the proper absorption of the finish can be hampered by the sheer volume of oil on the surface. If the oil is a drying oil, it may dry before absorbing into dense areas, such as wide latewood bands on flat-sawn lumber. The resulting film will appear as shiny areas on the surface (Fig. 11). Some WRPs are formulated with nondrying oils that act as solvents (such as paraffin oil). These oils penetrate the wood but do not dry. They protect the wood from degradation and mildew attack as do other types of WRPs. Since the oils do not dry, the wood surface may remain oily until the finish absorbs. Absorption usually takes several days, depending on the application rate and porosity of the wood. Since the oil does not dry, there is the possibility of tracking

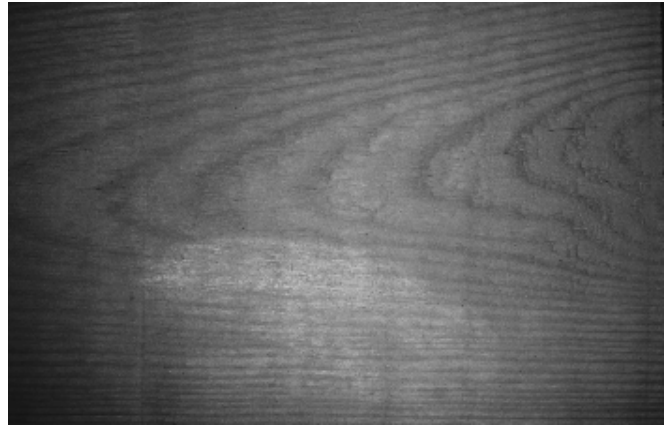


Figure 11—Shiny area on wood surface caused by excessive buildup of binder from waterborne WRP.

it indoors if this finish is used on decks. These products are easy to apply to decks and have about the same durability as other penetrating clear finishes.

Preparation of Water-Repellent Preservatives

Although directions for mixing a WRP were published in 1978, this formulation was possible only because of the availability of pentachlorophenol (penta).¹ This pesticide is no longer available to the consumer. In addition, the fungicides listed in Feist and Mraz (1978) are usually unavailable. Therefore, it is not possible for the consumer to formulate a WRP. A wide variety of commercial finishes are available, and many of these contain effective mildewcides.

Resistance to Decay and Mildew

Water repellents and WRPs are effective when used on wood exposed outdoors above ground. In areas where decay is a serious problem or where wood will be in contact with the ground (wood foundations or fence posts, for example), wood will need far more protection than that afforded by surface treatment with a WR or WRP. In such cases, wood properly protected by treatment with a commercial preservative is recommended. Such pressure-treated wood is normally available at lumber yards and should conform to recognized standards for maximum service life.

For naturally decay resistant wood species, WRPs provide mildew resistance for both the heartwood and sapwood; if the lumber contains portions of sapwood, treatment with a WRP is essential to provide aboveground decay resistance.

¹ (Feist, W.C., and Mraz, E.A. 1978. Wood finishing: Water repellents and water-repellent preservatives. Research Note FPL-0124 (revised). Madison, WI: USDA Forest Service, Forest Products Laboratory)

Treatment with CCA provides resistance to decay only, not mildew (Fig. 9). Treatment of the preservative-treated wood with a WRP provides resistance to mildew. The WRPs also provide aboveground decay resistance for sections of the wood that did not take the preservative treatment (heartwood) and the interior of large cross sections exposed by cutting or drilling.

A number of commercial wood treaters are using a combined WR-CCA treatment for 5/4 by 6 in. (32 by 152 mm) radius edge decking. This lumber is marketed under trade names such as Ultrawood, Wolman Extra, MELCO, and Weather-shield. This dual treatment gives the wood more resistance to weathering. Since the process is quite new, the durability of the WR treatment is not yet well established. Although the WR is supposed to thoroughly saturate the wood, the wood may nevertheless require periodic maintenance with a WRP. In addition, the commercial preservative treatments

do not contain a mildewcide, so added treatment with a WRP is necessary to prevent mildew growth. These treatments should improve the wood characteristics and extend the product service life, particularly with regard to weathering (i.e., surface checking, cracking, splitting, and erosion).

Finish Application

A WR or WRP can be applied to all exterior wood that is normally painted. It can usually be used as a pretreatment for paint or as a stand-alone finish. The stand-alone finishes generally have a higher wax content. If you use a WR or WRP as a pretreatment for paint, be sure to read the manufacturer's recommendations. *Not all WRs and WRPs can be used as pretreatments for paints.*

Water-repellent preservatives are usually intended for exterior use because the preservatives or fungicides in them are toxic to humans, animals, and plants. Solvents and other additives may also be harmful. It is important to read the label on the original container carefully to determine if the material is allowed and recommended for indoor use. When in doubt, consult the manufacturer to determine which fungicide was used in the WRP and whether it is appropriate for your proposed use.

Be sure to follow the manufacturer's directions for temperature limitations because finishes do not cure properly if the temperature is too low.

Procedures for Unpainted Wood

Water repellents and WRPs can be applied to wood by brush, roller, or spray, or the wood can be dipped into the finish. A WRP can be used as a natural finish on many wood species to help maintain their natural appearance. For example, finishing western redcedar with a WRP brings out the golden-tan color of the wood. This finish is not recommended for exterior or brushed plywood.

Treatment with a WR or WRP will be more durable on weathered or roughsawn surfaces because such surfaces absorb a greater quantity of the finish than does a smooth surface. During the first few years of exposure, the natural color of the wood can be partially restored by scrubbing the surface with a wood brightener-water mixture, such as aqueous solutions of household bleach or oxalic acid or a commercial wood cleaner. Scrub the wood with a stiff bristle brush and rinse thoroughly with water. Allow the wood to dry for several days before refinishing. However, if the wood has been exposed for several years without a finish, it may not be possible to restore the wood to its original color. Using a wood brightener may return some original color and remove the mildew. The amount of color that returns depends on how much the surface has weathered.

Safety

Care should always be exercised in applying a WR or WRP. The solvent-borne formulations are volatile, flammable mixtures. Do not breathe their vapors or expose the solutions to flame or sparks. It is wise to wear protective clothing on the hands and arms and to take care that the solution is not splashed in the eyes or on the face. Be especially careful using a WRP because these solutions contain fungicides, some of which are toxic.

If rags, paper towels, and uncleaned brushes and rollers containing finishes are not disposed of properly, they can spontaneously ignite. Store finishes in original containers in a locked space, out of reach of children and pets, and away from foodstuff. Use all finishes selectively and carefully. Follow recommended practices for the disposal of surplus preservatives and preservative containers. Immerse finish-contaminated materials in water, then seal in plastic or an empty paint can until they can be disposed of by proper incineration or burying.

Caution: Wood preservatives can be injurious to people, animals, and plants. Therefore, for safe and effective usage, it is essential to follow the directions and heed all precautions on container labels. The application of preservatives using any spray method can be especially hazardous and extra precautions must be taken. Avoid spraying whenever possible.

Do not use any preservatives indoors unless they have been specifically approved and recommended for such use.

Regardless of whether the wood is unfinished or finished, particular care should be taken to apply a liberal amount of the WR or WRP to the ends of boards, at joints between boards, and to all newly exposed wood such as drill holes. Capillary flow will cause water to climb the back of bevel siding from the lap joints. This flow of water can be prevented by applying WR or WRP to the lap joints. In addition, the finish should be applied to the butt ends of horizontal siding; edges and top and bottom ends of vertical siding; and edges and corner joints in window sashes, sills, window frames, doors, and door frames. Bottoms of doors and window sashes are often overlooked. These are areas where water can penetrate deeply and cause extensive damage if the wood is not treated. Treatment with a WR or WRP will eliminate many such problems.

New Wood

Applying WR or WRP solution to the surface of unfinished wood by brushing or dipping is an effective treatment for siding and exterior millwork (doors, window sashes, door and window frames, sills, moldings, and fascia), wood fencing, and lawn furniture. Millwork is often dipped in a WRP during manufacture to improve its durability. If treated millwork has been purchased, only freshly cut surfaces need to be brush- or dip-treated. Dipping is more effective. Care should be taken to treat ends of boards and joints between boards.

Refinishing

The weathering of wood finished with WRs and WRPs is similar to that of unfinished wood. The surface of the wood degrades but at a slower rate than that of unfinished wood. Timely refinishing is essential to avoid excessive wood degradation. Smoothly planed wood surfaces often require cleaning and retreatment after the first year of exposure. After this maintenance, refinishing is required only when the surface starts to show uneven discoloration or small black spots, which indicate mildew.

Specific Applications

Decks

A WRP is an effective finish for a fully exposed deck. Although the deck will need to be refinished frequently, there is no need for laborious surface preparation, as is required by film-forming finishes. Annual refinishing can be done quickly using a brush, roller, or pad. Brush application works the finish into the wood better than do other methods. The finish should be applied liberally to decay-prone areas around fasteners and end grain.

Treated Wood

Wood that has been pressure treated with waterborne chemicals such as CAA can easily be finished with a WRP if the

wood is clean and reasonably dry. If the wood is still waterlogged from the preservative treatment, it should be allowed to dry for several days once the structure is built. During summer weather conditions, this is usually enough time for the wood to dry sufficiently to accept a WRP.

Marine Uses

Docks and similar structures in marine environments are particularly susceptible to rapid weathering and decay. Treatment with a WRP helps preserve wood in this environment.

Fences

Like decks, fences are fully exposed to the weather. Many fences are left to weather naturally. If a finish is desirable, a penetrating finish such as a WRP or semitransparent stain that contains a mildewcide should be used. Periodic treatment with a WRP can slow weathering and decay, thus prolonging the life of the fence. In addition, a WRP will preserve the natural weathered appearance of the wood.

Roofs

Although wood shingles and shakes on standard buildings have been superseded to a great extent by composition and asphalt-based shingles, they are still used in certain areas of the country and on expensive homes. Wood shakes and shingles are often left to weather naturally if they are made from durable species such as western redcedar. Depending on exposure and climate conditions, the wood generally turns silver, dark gray, or dark brown. However, in warm, humid climates common to the southern United States and on heavily shaded roofs, mildew, moss, and lichens can occur. These conditions are also conducive to decay. A WRP protects the wood while preserving the natural appearance. It is best to dip-treat the shakes or shingles before they are installed so that the backs and butt ends absorb the finish. The finish may be applied by dipping the shingles to at least two-thirds their length and then letting them stand vertically until the finish has dried.

Pretreatments for Painted Wood

New Wood

Water repellent and WRP formulations to be used as pretreatments for paint have less wax or other WRs compared with those formulated for use without paint. When used as a pretreatment before painting, a WRP can be applied in the same way as when used as a natural finish. Freshly treated wood must be allowed to dry. If the treatment is applied with a brush, allow 2 days of drying in warm weather before painting. If the wood is dipped for 10 or more seconds, 1 week of drying is necessary before painting. If enough time is not allowed for most of the solvent to dry from the wood and for the wax to absorb, the paint applied over the treated

wood may not cure or bond properly. Open joints, such as in siding, millwork, and fascia, should be caulked after treating with a WR or WRP but before priming.

Refinishing

When applying a WR or WRP to previously painted wood, loose paint must be removed; the WR or WRP should be brushed into the joints and unpainted areas. Remove excess WRP from the painted surfaces with a rag. Allow 3 days of drying in warm weather before repainting.

Removal of Mold and Mildew

If mildew is present, pretreat the wood with a commercial cleaner or a chlorine bleach–water solution. Allow the wood to dry for 1 or 2 days before refinishing.

Removal of Mildew

Commercially available wood cleaners work quite effectively to remove mildew and other stains on wood. A mildew cleaner can also be made by dissolving 1 part liquid household bleach and some powdered detergent in 2 to 4 parts water.

Suggested formula:

1/3 cup household detergent

1 quart (5%) sodium hypochlorite (liquid household bleach)

3 quarts warm water

(1 cup = 0.2 L; 1 quart = 0.9 L)

Caution: Do not use a detergent that contains ammonia; ammonia reacts with chlorine-containing bleach to form a poisonous gas. Many liquid detergents may contain other additives that react with bleach.



Figure 12—Window units after 5 years of exposure. Top: Sash and frame not treated before painting. Bottom: Sash dipped in WRP for 3 min before painting and WRP brushed onto frame

Service Life

The service life of WRs and WRPs is about 1 year on exposed wood surfaces. However, WRPs are extremely easy to reapply to some structures, such as decks. Water repellents and WRPs absorb readily into the end grain of lumber and can stop water absorption for many years.

The effectiveness of pretreatment of millwork with a WR or WRP has been confirmed in outdoor exposure studies. The differences between WRP-treated and untreated window sashes and frames are significant after exposure for 5 years

(Fig. 12). The window sash had been dipped in a WRP for 3 min. This treatment is similar to those used by most millwork manufacturers. The window units shown in Figure 13 are still being tested after 30 years of exposure. Window units treated with only a WR were in reasonable condition. Window units treated with a WRP that had extra high water repellency had the best durability. The combined effect of a preservative and a good water repellent was the crucial factor for long-term durability. Untreated window units decayed severely and actually fell from the test fence after only 6 years of exposure (Fig. 14).



Figure 13—WRP-treated window unit after 20 years of outdoor exposure. The WRP-treated wood is firm and resists penetration by the knife blade.



Figure 14—Decay of untreated window unit. Window unit fell apart after 6 years of outdoor exposure.

Concluding Remarks

Wood is the material of choice for many structures. As with any building material, how wood is used depends on its properties, such as strength and stiffness, as well as its finishing characteristics and maintenance requirements. Problems such as poor finish performance, mildew, checking and splitting, and wood decay can be controlled with proper care and maintenance. Such problems can be avoided or attenuated through knowledge about the factors that affect wood, particularly wood exposed outdoors. If wood structures are given proper care initially and are maintained periodically, they can be functional and structurally sound, as well as aesthetically pleasing, for decades. Water-repellent preservatives can be used as natural finishes and can greatly improve the durability and appearance of wood exposed outdoors. They can also be used as pretreatments prior to the initial painting of wood. The water repellent improves the dimensional stability of the wood, and the preservative improves the mildew resistance of the paint. These properties work in concert to extend the service life of the paint.