Natural weathering of wood and its control by water-repellent preservatives

by William C. Feist

The exterior "natural wood" appearance is popular with many owners of homes and commercial buildings. As valued as this natural look is, however, it is difficult to maintain, and a professional painting contractor's knowledge and skill is usually needed for the maintenance.

Professional painting contractors must understand the natural weathering process and be able to recommend finishing techniques that will both protect the surface and maintain an appearance that is pleasing to the owner.

This article examines the weathering process that produces the "natural" look, and then considers the use of water-repellent preservatives to protect the surface and maintain a pleasing appearance.

Briefly speaking...

The combined weathering action of sunlight and water quickly changes the surface of woods. *Any* wood changes color and becomes rough when exposed to sunlight and water. The wood slowly wears away at a rate of about one-quarter inch per century for a common softwood like pine or redwood, Staining microorganisms (fungi) are the main causes of the gray color of

Weathering is not associated with decay (rot) but is caused by chemical changes in some of the wood's components. Water repellents and water-repellent preservatives can be used to slow down the natural weathering process, but the treatment will only last one to three years before refinishing will be required. Weathering can be prevented by using opaque finishes, such as paint and solid-color stains, which screen out the ultraviolet light

Natural weathering of wood is associated with early American tradition and can be considered as the first method of wood finishing. For the frost century or so of the American colonies, exterior surfaces were left to weather naturally. Only later were painted surfaces used by the general populace.

Recent interest in colonial traditions and furnishings has revived the popularity of naturally weathered wood and rustic finishes. Some wood houses have been left unfinished to weather naturally and have lasted for centu-

ries. Wood's aesthetic appeal, life expectancy and future compatibility with potential finishes is greatly affected by the weathering process.

Now for the details.

Weathering process

The natural weathering process, which modifies the wood's molecular structure, results from a complex combination of chemical, mechanical, biological and light-induced changes, all of which occur simultaneously and affect each other.

In general, after two months of exposure to sunlight, all woods will start to turn yellow or brown. After several more months of exposure, the woods will turn gray.

However, dark-colored woods eventually become lighter, and lighter-colored woods become darker during the first few months of exposure to sunlight.

After that, surface checks develop, and then cracks may develop. The grain raises and loosens, boards cup and warp, pulling fasteners loose, and the wood surface begins to disintegrate, with fraements separating from the surface.

After the rough gray weathered surface is developed, usually in a year or two, further changes are very slow to develop.

Steps in weathering

The fist step in the weathering process is the change to a yellow or brown color on the surface of light-colored woods. In redwood, cedar and hardwoods with a dark heartwood, the wood may first develop a bleached appearance before turning brown, but browning can also occur before bleaching.

This color change begins on the surface as soon as the wood is exposed to the sunlight. The color change is relatively shallow, ranging from less than l/64th to more than 1/8 inch in depth.

The change occurs because the sunlight, particularly the ultraviolet light, decomposes the lignin as well as the organic materials or extractives deposited in the cell lumens of certain wood species.

Lignin is the complex chemical structure that holds the individual cells together and constitutes from 15 to 35 percent of the extractive-free dry weight of wood.

As weathering continues, a gray layer, three one-thousandths to one one-hundredths inch thick, develops. This layer is composed of loosely matted fibers of nearly pure cellulose because rain or moisture leaches out the decomposed brown-colored lignin and extractives.

This classic silvery gray color is characteristic of wood exposed to the intense radiation of the sun in cooler climates with little rain, or wood exposed in coastal areas where salt is present in the air.

The gray color of the surface layer of weathered wood usually results from the growth of staining microorganisms called fungi and commonly called mold or mildew. Certain species of these organisms will grow wherever a sporadic supply of moisture is available, and can produce a uniformly weathered and gray appearance on the wood surface within a year.

Microorganisms may also produce dark-colored spores and mycelia, which can produce the dark gray, blotchy and unsightly appearance of some weathered wood.

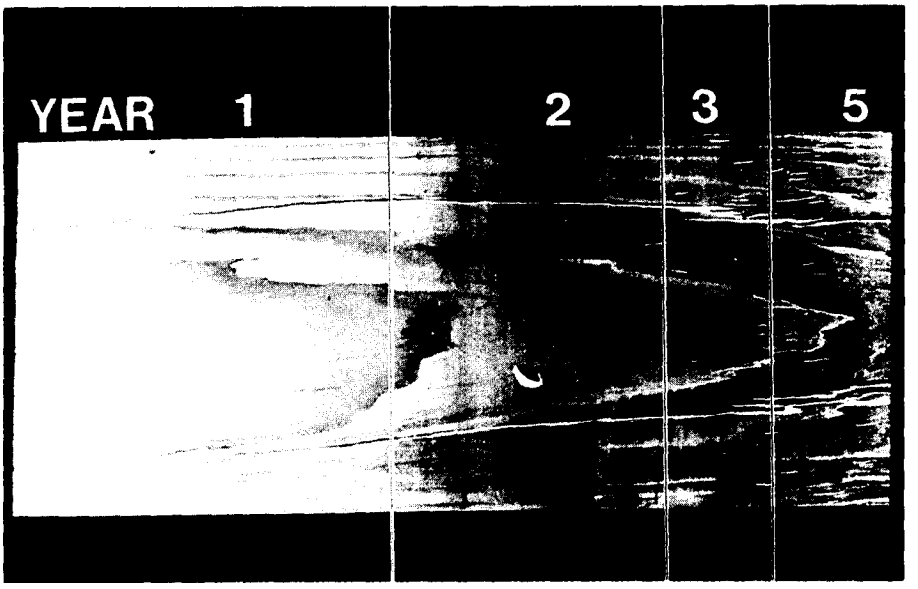
All wood surfaces will eventually turn gray when exposed to sun and rain. Some modern houses have natural weathered wood as siding.

Rate of weathering

Once the weathered gray color is produced, additional changes in the appearance of the wood occur very slowly because the process affects only the surface of the wood.

In general, for softwoods like pine, cedar, redwood and spruce, about one-quarter inch of wood thickness weathers away every 100 years. The maximum weathering rate reported is 5/8 inch per 100 years for slow-grown western red cedar exposed vertically facing south. For dense hardwoods like the oaks, the rate is only about 1/8 inch per 100 years.

The rate of weathering is affected by climatic conditions, the severity of exposure, wood density, the amount of



Artist's rendition of color and surface wood changes for a typical softwood during the outdoor weathering process. Photos courtesy U.S. Department of Agriculture's Forest Products Laboratory, Madison, Wisconsin.

early wood and latewood and ring orientation, as well as the rate of growth and probably lignin and extractives content.

In general, the less dense the material and the more severe the exposure, the faster the weathering and erosion rate.

Surface deterioration

In addition to chemical and color changes, mechanical damage occurs on the exposed wood surface, mostly as a result of moisture.

Water vapor is absorbed or dispersed with changes in relative humidity. Rain or dew in contact with the unprotected wood is quickly absorbed by the wood surface.

As the moisture content of wood changes, swelling and shrinking take place and stresses in the surface of the wood result.

The moisture, in combination with the sunlight, causes microscopic and then macroscopic intercellular and intracellular cracks and checks. Face-checking, warping and cupping can occur with subsequent nail loosening. Grain raising due to differential swelling and shrinking of earlywood and latewood can also result.

Cell wall bonds near the wood surface lose strength, and as rainwater continues to wash the softened surface, the surface becomes increasingly uneven and slowly erodes.

Although the appearance of weathered wood is attractive for certain architectural effects, it does take time to develop. Moreover, the change seldom takes place evenly over different parts of a building. Those portions exposed to the most sun and rain become weathered first. These are usually the lower portions of the building, particularly on the south side. The top portion of the building, particularly if protected by large overhangs, porches or other features, will weather more slowly.

For a year or two, or even longer in protected areas, there may be a mottled appearance varying from that of freshly cut lumber to gray weathered wood. Dark brown-colored extractives in species such as redwood and western red cedar may persist even longer in protected areas, not being removed by the washing action of the rain.

This unequal weathering effect is generally not acceptable, particularly in commercial buildings where the short-term appearance is critical.

Where painting is being considered, wood surfaces roughened from weathering obviously provide a very poor substrate for any film type finish. Even a few days of exposure to a new, clean wood surface will decrease its paintability and the life of the paint. On the other hand, somewhat weathered surfaces may be beneficial for penetrating finishes because weathering allows the wood to absorb more of the finish solution.

Weathering of wood-based materials

The use of plywood, hardboard and particleboard (including waferboard) and other wood composite materials for exterior exposure is increasing.

Plywood The weathering of plywood is directly related to the quality and type of the veneer exposed and to the adhesives used. In manufacturing veneer to produce plywoood, small checks are produced. Because these surface checks are initially present in plywood, exposure to the weather will enlarge these checks, thereby allowing moisture to penetrate deeply into the wood. This is called face-checking. Therefore, it is important that a water-resistant adhesive is used for exterior-grade plywood.

If water does enter through surface checks and becomes trapped, some decay in unprotected, nondurable wood species can be expected. For these species, a finishing system containing a wood preservative should be used.

Plywood veneers generally do not exceed one-fourth-inch in thickness. Therefore, excessive surface erosion, particularly of lightweight species such as western red cedar and redwood, can in time expose the dark-colored glue-line. This means plywood should always be protected with a finish that contains a pigment. The more pigment, the greater the protection. (Paints offer greater protection than do stains).

Hardboard and particleboard. Unprotected hardboard siding and particleboard siding present serious weathering problems. (Special grades of hardboard are made for roofing applications and the following comments do not apply to these grades.)

As the outer surfaces are exposed to changes in moisture content, shrinking and swelling of the wood particles or individual fibers or fiber bundles result. The individual particles or fiber bundles are loosened and separate from the surface. Deeper and deeper layers are subsequently affected at an accelerated rate. As wetting occurs, springback in wood particles due to compression set during the manufacturing process also occurs .

With only one or two years of weathering, significant lose of strength and increased swelling can result.

Cohesion is lost, and panels may fail under mechanical load

For best performance, hardboard and particleboard (especially the edges) must be coated with high-quality opaque finishes such as paints or solid-color stains.

Artificial weathering by contractors

Some alternatives to the natural weathering process for solid wood exist. Water repellents or water-repellent preservatives may be used to retain the bright color of freshly sawn lumber. This represents a "natural finish" to many consumers.

Also, penetrating oil-based stains (available in most colors except white) can be applied to protect the wood and provide a uniform color to the structure.

Another alternative is to apply a commercially prepared bleaching oil, bleaching stain or weathering stain. The oil or stain is essentially a water-repellent finish containing some gray pigments. To maintain a uniformly gray wood surface, the bleaching oil may have to be renewed as needed. Or, it may be allowed to wear off naturally, leaving the wood in a more uniform, naturally weathered condition.

In addition to the commercially available products, wood may be treated with several different experimental chemicals or chemical combinations to produce a weathered or aged appearance. Little quantitative information is available concerning these treatments, so some experimentation would be required to achieve an acceptable color.

Dark gray aged colors can be produced by brushing the wood with small amounts of a diluted solution (2 percent) of an iron salt such as ferric chloride, followed by a second treatment of tannic acid solution (2 percent). Iron tannate, an insoluble blue-black compound, will form on the surface of the wood.

The intensity of the gray color will depend on the concentration and the amount of the solution applied to the surface. Many woods have naturally occuring tannates (or related chemicals) and iron salt solutions will produce an instant gray color of various intensity.

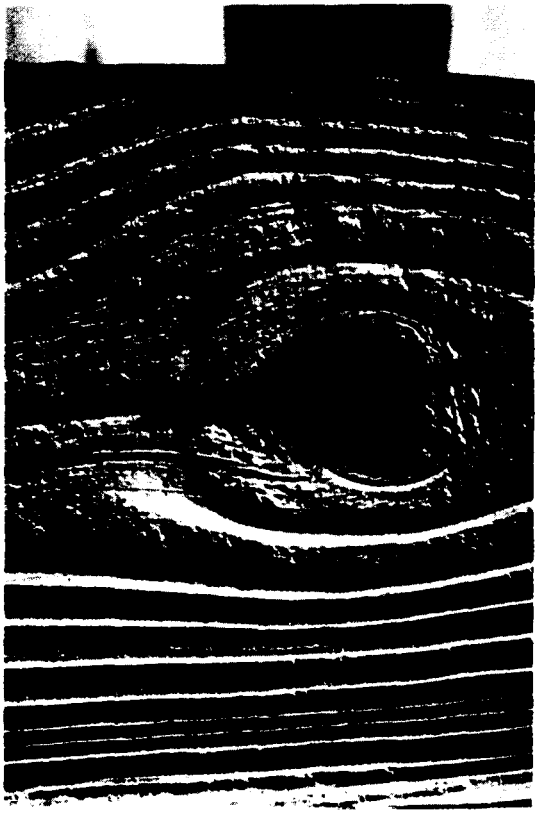
Artificially stressed and weathered barn boards are also available commercially. The surface texture of this weathered wood is produced by rough sawing, sand blasting, wire brushing and planing with notched knives or other mechanical means. Color is usually controlled by staining or chemical treatment.

Precautions

When wood or wood-based products are left to weather naturally, certain precautions should be exercised.

First, wood that becomes wet, even at periodic intervals, can decay. This decay must not be confused with the surface weathering process just described. Wood decay is the biological deterioration of the cellulose and/or lignin *throughout the entire thickness of the board*.

To help guard against decay problems,



Note the weathered surface of this southern yellow pine after 20 years of exposure.

which may take from one to three years to develop, all structures should be built so that exposure to moisture (both atmospheric and ground) is minimized, and moisture is not trapped. Furthermore, the naturally durable heartwood of certain species, such as the cedars and redwood, or preservative-treated wood should be chosen.

Raised grain, checking and warping will be minimized with edge-grained lumber and low-density species as compared to flat-grained lumber and high-density species. Warping and cupping can be minimized if the width of the board does not exceed eight times the thickness. Low-density defect-free softwoods tend to warp less than the lower grades of lumber *or* high-density species, especially hardwoods.

Water-repellent preservatives

Finishes are applied to exterior wood surfaces for a variety of reasons. The particular reason will determine the type of finish selected and subsequently the amount of protection provided to the wood surface, as well as the life expectancy of the finish.

Finishes can be divided into two general categories: 1) *opaque coatings* such as paints and solid color stains; and 2) *natural finishes* such as water repellents, water-repellent preservatives and semi-transparent penetrating stains. In addition, wood preservatives and fire-retardant coatings might also be called "finishes" in some respects.

Use of a "natural" finish

In many locations throughout the United States, there is a growing trend toward the use of natural color finishes to protect exterior wood siding and trim. Architects, builders and owners are increasingly specifying a "natural look for homes, apartments, churches and commercial buildings.

To some, a natural look means rough, gray and weathering. This is nature's "natural finish." To others, a truly successful natural exterior wood finish is one that will retain the original, attractive appearance of wood with the least change in color and the least masking of wood grain and surface texture.

In this case the finish should inhibit the growth of mildew microorganisms and protect against moisture and sunlight without changing the surface appearance or color of the wood.

The natural weathered appearance of wood is, of course, achieved without a protective finish. Unfortunately, in this normal weathering process, unprotected wood exposed outdoors is soon changed in appearance by the adverse effects of light, moisture and the growth of microorganisms on the surface as explained earlier.

Where salt in the atmosphere inhibits excessive mildew growth, natural weathering may create a changed but desirable silvery-gray appearance in the exposed wood. In dry or cold climates, a rustic, brown-to-gray patina may result. In many humid locations, however, weathering is often accompanied by a surface growth of dark gray, blotchy mildew that may remain uneven and unsightly until the wood has weathered for many years. In these climates, application of a water-repellent preservative as a natural finish is often desirable.

A water-repellent preservative is often used as a clear natural finish. This treatment reduces warping and checking, prevents water staining at the edges and ends of wood siding, and helps control mildew growth.

Water-repellent preservatives contain a fungicide, a small amount of wax

As an example of a Colonial "natural finish" house, the old Fairbanks House, Dedham, Massachusetts, was built in 1637. Most of the white pine clapboard siding was replaced in 1903, and has stood 80 years without paint.

as a water repellent, a resin or drying oil, and a solvent such as turpentine or mineral spirits. Some water-borne formulations are also available.

The wax in the formula reduces the absorption of liquid water by the wood and somewhat reduces the erosion due to weathering. The preservative prevents wood from darkening (graying) by inhibiting the growth of mildew, mold and decay organisms.

Water-repellent preservatives do not contain any coloring pigments, but they will darken the color of the wood. The resulting finish will vary in color depending upon the original wood color itself, but the wood will usually weather to a clean, golden tan.

The initial application of a water-repellent preservative is effective for only a short period of time, usually one to two years on smooth surfaces and one to three years on roughsawn surfaces.

When a surface starts to show a blotchy discoloration resulting from extractives or mildew, it should be cleaned with a solution of liquid household bleach and detergent or a solution of oxalic acid in water, dried and retreated.

During the first few years, a fresh finish may have to be applied every year or so. But after wood with a smooth surface has gradually weathered to a uniform tan color, additional treatments may last two to four years because the weathered boards absorb more of the finish than do the new boards.

Relatively small quantities of tinting colors can be added to the water-repellent preservative solution to provide special color effects, and the mixture is then classified as a pigmented penetrating stain. Normally, 2 to 6 fluid ounces of tinting color or colors in oil, per gallon of treating solution, are used. Colors that match the natural color of the wood and extractives are preferred.

As with semi-transparent penetrating stains, the addition of pigment to the finish helps stabilize the wood color and increase the durability of the finish.

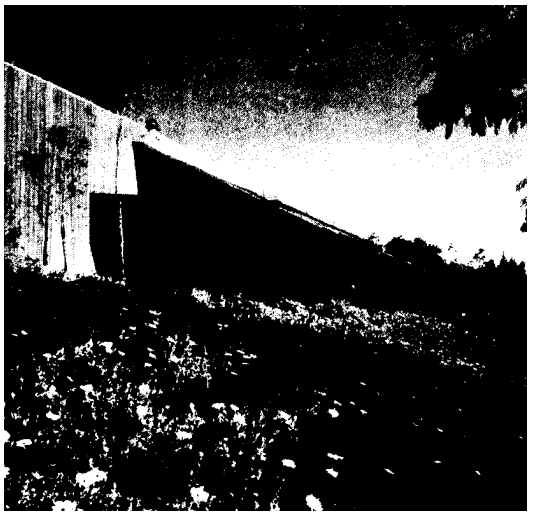
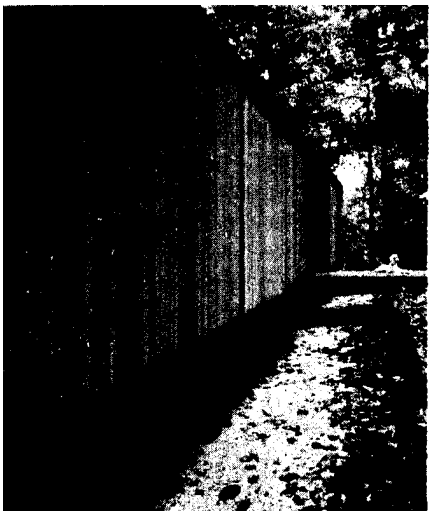
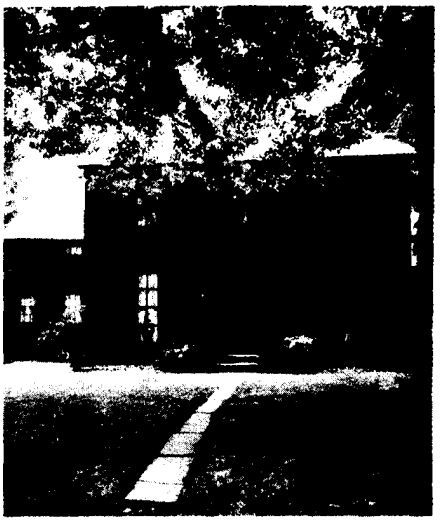
Use of a treatment before painting

Water-repellent preservatives may also be used as a treatment for bare wood before priming and painting, or in areas where old paint has peeled and exposed bare wood (particularly around butt joints or in corners).

This treatment keeps rain or dew from penetrating into the wood, especially at joints and on end grain, thus decreasing the shrinking and swelling of the wood. As a result, less stress is placed on the paint film, and its service life is extended. This stability is achieved by the small amount of wax present in the water-repellent preservative.

If the entire board has been treated, the wax also decreases the capillary movement of water up the back side of lap or drop siding. The fungicide in this treatment inhibits surface decay, mold and mildew.

Water-repellent preservatives will

These photos give three examples of the "natural" appearances that painting contractors can achieve by using various finishes. In each case, the building material was redwood. The finishes applied to the buildings were (from left to right) semi-transparent stain, bleaching oil, and a solid or opaque stain. Photos courtesy California Redwood Association.

not protect the surface from ultraviolet light damage unless ultraviolet light inhibitors are added to the finish.

Water repellents

Water repellents are simply water-repellent preservatives with the fungicide left out. Water repellents are not good natural finishes because they will not control the growth of staining organisms, but they can be used as a stabilizing treatment before priming and painting. They can also provide some decay resistance in low- to medium-decay hazard areas for outdoor woodwork used above ground and is painted.

Research on window units has shown that a water-repellent treatment can protect the wood from decay for 20 years or more in a northern climate. Untreated units were badly decayed within six years. All units in this research were initially painted.

Care should be exercised when purchasing water repellents or water-repellent preservatives. Manufacturers' specifications should be read carefully and followed completely.

Any type of water-repellent preservative can be used as a natural exterior finish by itself, but only some are paintable. Manufacturers have also developed water-repellent preservatives specifically for exterior natural finishes.

In areas where decay is a serious problem, or where wood will be in contact with the ground or water, wood that has been pressure-treated with an appropriate preservative should be used.

The approximate composition of typical water repellents and water-repellent preservatives is given in table on the next page.

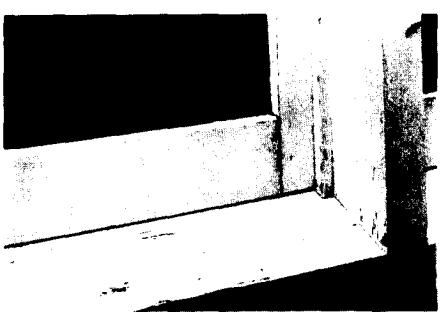
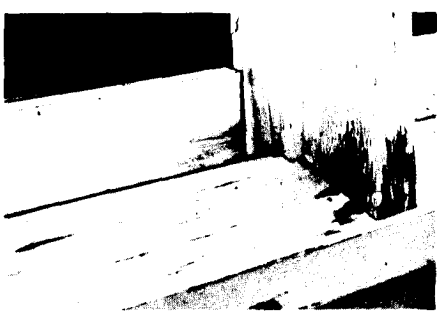



Photo left shows a window sash and frame treated with a water-repellent preservative and then painted. Photo right shows a window sash and frame that was not treated before painting. Both were weathered for five years. The painted on the treated surface is less weathered, the wood is in better condition, and the glazing is intack.

Application Techniques

The most effective method of applying a water-repellent preservative or water-repellent is to dip the entire board into the solution. However, brush treatment is also effective.

When wood is treated in place, liberal amounts of the solution should be applied to all lap and butt joints, edges and ends of boards, and edges of panels where end grain occurs. Solution should be heavily applied to areas especially vulnerable to moisture, such as the bottoms of doors and window frames.

One gallon of solution will cover about 250 square feet of smooth surface or 100 to 150 square feet of rough surface. Repeated brush treatment to the point of refusal (when no more will be absorbed) will enhance the finish durability and performance.

It maybe beneficial to allow the wood to weather before applying water-repellent preservatives. Weathering opens up checks and cracks, which allows the wood to absorb and retain much more of the preservative or stain.

Reapplication

Water-repellent preservatives and water-repellents can be renewed by simply cleaning the old surface with a bristle brush and applying a new coat of finish. In some cases a mild

scrubbing, with a detergent followed by rinsing with water is appropriate.

The second coat of water-repellent preservative will last longer than the first because more solution can be applied, and it will penetrate more into the small surface checks that have opened as the wood has weathered.

To determine if a water-repellent preservative has lost its effectiveness, splash a small quantity of water against the wood surface. If the water beads up and runs off the surface, the water-repellent properties are still effective. If the water soaks in, the wood needs to be refinished.

Refinishing is also required when the wood surface starts to show blotchy discoloration caused by extractives or mildew, because this indicates that the fungicide has lost its effectiveness.

Caution!

The pesticides, wood preservatives, mildewcides and fungicides reported on and recommended here were registered for the uses described at the time this publication was prepared. Registrations of pesticides are under constant review by the EPA. Therefore, consult a responsible state agency on the current status of any of these pesticides. Use only pesticides that bear a federal registration number and carry directions for home or garden use.

Pesticides used improperly can be injurious to humans, animals and plants. Follow the directions and heed all precautions on the label. Avoid inhalation of vapors and sprays; wear protective clothing and equipment if specified on the label.

If hands become contaminated with a pesticide, do not eat, drink or smoke until washing. In case a pesticide is swallowed or gets in the eyes, follow first aid treatment given on the label and get prompt medical attention. If a pesticide gets onto skin or clothing, remove the clothing immediately and wash skin thoroughly.

Store pesticides and finishes containing pesticides in their original containers out of the reach of children and pets, under lock and key. Follow recommended practices for the disposal of surplus finishing materials and containers. Scraps of chemically treated wood or finished wood should never be burned, either for heat or for disposal. Toxic fumes may be released.

Water repellents and water-repellent preservatives should always be mixed and applied carefully. The safest place for mixing is outdoors. Solutions with solvents are volatile and flammable. Their vapors should not be inhaled or exposed to flame or sparks. Wear protective clothing on hands and arms and take care not to splash the solution into eyes or onto the face. Remember the water-repellent preservatives may contain toxic materials. Read all labels carefully. ■

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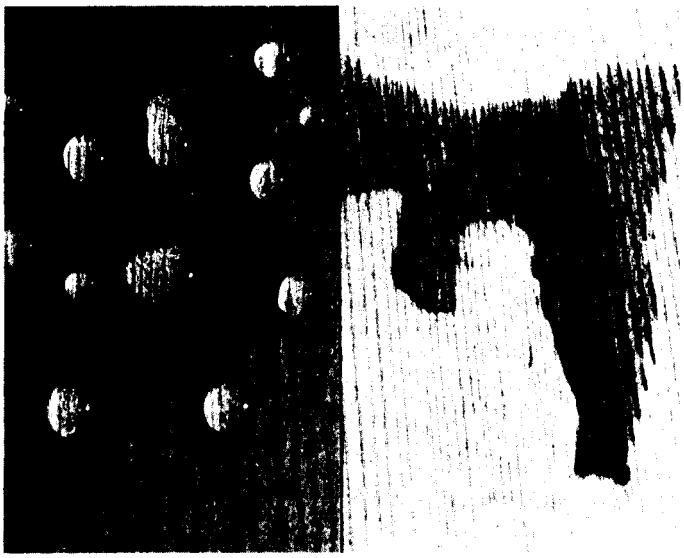
Composition of typical water repellentand water-repellent preservatives (approximate composition):

Ingredient	Water repellent	Water-repellent preservative
Preservative	0%	0.15 to 5%
Resin or drying oil	10%	10%
Paraffin wax	0.5 to 1%	0.5 to 1%
Solvent	89%	84-89%



The wood surface on the left was brush-treated with a water-repellent preservative. It resists penetration by water, whereas the untreated wood on the right quickly absorbs water.

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