PAINTS FOR EXTERIOR WOOD SURFACES[1]

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We might get this discussion underway with the question, "Why do we paint the exterior wood parts of buildings?" The answer is "We paint primarily for the purpose of decoration--to change, enhance or improve the natural appearance of wood."

Of course, paint also provides some protection for the wood. To understand the nature and the extent of this protection, we must know something of what happens to wood that is exposed out of doors. Wood exposed to the elements may be subject to one of two deteriorating influences--weathering or decay. Either of these actions, if permitted, will finally cause complete disintegration of wood.

Weathering of wood is due partly to physical and partly to chemical changes in the wood. The physical changes are the result of the repeated unequal swelling and shrinking that accompany wetting and drying of the exposed wood surface. These changes occur with the ever-changing humidity of the atmosphere and, of course, with rain and sunshine. The surface layers of wood respond very quickly to these changes, but the inner portion of the wood lags behind because of the relatively slow rate of transfusion of moisture in wood. This lag tends to keep the interior at a relatively uniform moisture content and a constant volume, so that when the outside wood fibers swell and shrink they are alternately squeezed together and pulled apart.

The chemical changes result from the action of sunlight, air, and water on the surface layers of the wood. A gray layer develops on the exposed surface. Both cellulose and lignin become partly solubilized and leached from this layer and the brown layer immediately underlying the gray layer.

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[1] Presented at a meeting May 22, 1956, of the National Association of Physical Plant Administrators of Universities and Colleges at the U. S. Forest Products Laboratory, Madison, Wis.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The combination of physical and chemical changes results in a very slow breaking down and wearing away of the surface fibers and more noticeably in grain raising, checking, cracking, splitting, cupping, warping and pulling at fastenings. In addition, it results in the wearing away of wood from the surface at the rate of about 1/4 inch in a century.

Decay, on the other hand, is caused by the action of wood-destroying fungi--small living organisms that actually feed on the wood substance. The visible effect is familiar to everyone as "rotten" wood. Wood that is rotten or decayed has not been simply disintegrated as is the case in weathering. It has been actually decomposed.

Weathering and decay are not usually found in the same place. Wood that is dry will not rot, because the fungi must have water to live. On the other hand, weathering is usually found where the wood as a whole remains fairly dry. The surface layers of the wood periodically take up moisture, but drying occurs before the water can penetrate to the interior of the wood and thus support decay.

Protection against weathering can be provided by coatings of paint or varnish. Such coatings, though they are not impermeable to moisture, protect the wood enough to prevent rapid changes of moisture content in the surface layers and thereby prevent weathering. Coatings do not preserve wood against decay. Where decay is likely to occur, a naturally durable wood should be selected or, better yet, the wood should be impregnated with a preservative chemical that is toxic to decay organisms. Some well known chemicals of this kind are creosote, pentachlorophenol, and copper naphthenate.

In the New England area and in other areas of the country, there are wood buildings more than 250 years old that were never painted. It is apparent from this and other evidence that wood is a durable building material and, in fact, is commonly referred to as a permanent building material. Wood will, on its own, outlast many, many times the most durable paint. It should be obvious then that we could not economically paint wood for the sole purpose of protecting it. On a dollar-and-cents basis we would be far ahead to give wood siding, for example, no protection and simply replace it when it wore out.

Among the various ways of dealing with the exterior wood surfaces of a structure, the least expensive procedure is to leave them completely untreated or unprotected. If this plan is to be followed, the wood should be one that weathers well, such as western redcedar, redwood or cypress. It is well also to nail with a little more care than is generally given where the wood is to be protected. Actually, weather-beaten wood is well adapted to only a limited number of architectural designs and to spacious rustic settings. This explains why so few buildings are treated in this manner.

The exterior woodwork of most buildings is commonly finished with one or more of three broad classes of finishes (1) stains, (2) natural finishes, and

(3) paints. Good shingle stains are inexpensive and durable. They come mostly in dark browns, greens, reds, and yellows. They penetrate into and color the wood, obscuring its grain but leaving little or no film on its surface. Rough-sawn or weathered wood surfaces are especially suitable for shingle stain. A good shingle stain should last at least 5 years and may last as long as 9 or 10. Since stain does not form a continuous film on the surface of the wood, it does not protect the wood against weathering. Therefore, if a wood is to be stained it is desirable to select a wood that weathers well and gives long service without any protection whatsoever. Best of our native species of wood on this score are the cedars, redwood, and cypress.

Natural Finishes

Natural finishes have become popular in the last 10 years. They are used in an effort to retain the natural appearance (color and grain) of wood. These finishes may be classified into two types: the penetrating finishes which may be clear or pigmented and the surface coating or film-forming finishes which are usually clear.

Natural finishes of the surface-coating type are chiefly spar varnishes. They may give a lustrous or glossy finish, or a dull or matte finish. No really durable natural finish of this type has been developed.

The penetrating natural finishes leave little or no continuous coating on the surface of wood. They include the oil finish, the wood-sealer finish, and the water-repellent finish. All three types look somewhat better and last longer if they contain some durable pigments. Usually, the reddish-brown iron-oxide pigments are used for this purpose.

Neither the penetrating nor surface-coating types of natural finishes are nearly so durable as paint and therefore need to be renewed much more frequently than paint, usually every year, or at the most, every two years. Even with such attention and care, the surface-coating types of natural finish may ultimately need to be removed completely to restore a satisfactory finishing surface. The penetrating finishes are less exacting in their maintenance requirements and do not fail as conspicuously as the surface-coating finishes, so they are to be preferred.

House Paints

House paint is by far the most widely used finish for outside woodwork. White house paint is still the most popular. A good white house paint should last at least 4 to 5 years before it must be renewed, tinted paints a year or two longer, and dark-color paints 6 to 8 years, occasionally longer than that.

To give you some understanding of the situation that prevails in the paint industry, there are approximately 1,500 paint manufacturers in this country. There is no general agreement between them concerning the best type or types of paint. There are no standards of quality in the paint industry. So, the buyer of paint has exceedingly little to go on. He cannot purchase a grade of paint as he can wood siding and many other things. In fact, it is the rare individual who can differentiate between good and poor quality paint even if the composition of the paint is printed on the label, and in some instances it is not. One is therefore left to his own resources, which are discouragingly meager--he must rely on his own past experience with a given manufacturer's paints (and the composition of paints is constantly subject to change) and perhaps on his own and others' experience with different types of paints. At the very least, then, he should have a statement of composition of the paints he is considering. With this information, we at least can help him by classifying the paints and apprising him of the strong and the weak features of the different types.

House paints may be classified simply, according to the pigments used in them, into six basic kinds or types: (1) titanium-lead-zinc paints, (2) titanium-zinc paints, (3) titanium-lead paints, (4) titanium paints, (5) white lead paint, and (6) dark-color paints.

Each of these types of paint has some of the characteristics generally considered essential in good house paint. These include durability sufficient to last 4 to 6 years before needing to be renewed, a normal form of wearing away that assures a good repaint surface with a minimum of preparatory work, and a sufficiently fast rate of wear to prevent the accumulation of an excessively thick film of paint when a reasonable maintenance schedule is used (1 coat every 4 or 5 years, or 2 coats every 6 years). Included, as well, are a clean, highly reflective color and the ability to remain free from excessive dirt collection in service. Paint should also be nonsensitive to moisture, and should not be stained by products of metal corrosion. Neither should it be discolored by hydrogen sulfide or organic sulfide.

No one type of house paint on the market has all of these characteristics. All have some desirable features and some that are not so desirable. In order to select the type of paint that is likely to give the most satisfactory service, one should be familiar with the conditions to which exterior paints are subjected in his area. He must also know which types of paint will stand up best under these conditions--which of the various properties of paint are important to him under the circumstances and which are relatively unimportant.

The type of paint now made in greatest volume is the titanium-lead-zinc paint. The content of lead and zinc in this type of paint varies over a wide range. In general, though, the lead content is steadily declining--some of the larger paint manufacturers have eliminated it altogether, with the result that the titanium-zinc type of paint is now made in a volume

approaching that of the titanium-lead-zinc type. Together, these two types of paints probably constitute as much as 75 percent of all house paint made in the country.

The titanium-lead-zinc and titanium-zinc types of paints are very much alike in their properties. The chief difference is that the titanium-zinc paints contain no lead or other pigments that react with hydrogen sulfide to form metallic sulfides of dark color. It is for this reason that they are often called "fume-proof" paints and recommended for use where sulfide discoloration is a problem. Desirable properties which these two types of paint have in common include a brilliant, highly reflective color, good drying properties, mildew resistance, the ability to remain clean in service, and good durability. However, they are generally hard, so they wear away comparatively slowly. They normally fail by cracking, curling, and flaking which necessitates precautions--the film of paint must not be permitted to become too thick and, on the other hand, the failure must not be permitted to advance too far before repainting is done.

We, at the Forest Products Laboratory, have found that zinc-containing paints swell much more than wood when wet and, of course, much more than paints made without zinc oxide. Such paints blister more readily on contact with water than those paints containing no zinc-oxide. Under some conditions, contact with water may not result in blistering but may simply bring about premature cracking, curling, or flaking. We believe that sensitiveness to water is the most serious shortcoming of the zinc-containing paints.

Paints of the titanium-lead, straight white lead, and titanium types, as well as those dark color paints made without zinc oxide, swell more on the order of wood when wet by water. The extent of swelling is much less than is the case with the zinc-containing paints. Therefore, such paints have much less tendency to blister than do the zinc-containing paints. Hence, we refer to them as "blister-resistant" paints. The type of "blister-resistant" paint with which there has been most experience is, of course, white lead paint, which prior to about 75 years ago was the only white paint used on exterior woodwork. We might dwell for a moment on the properties of white lead paint. It is a durable paint that fails normally by checking and crumbling a pattern of failure that leaves a good repainting surface requiring little preparatory work. It is a comparatively soft paint that wears away at a faster rate than most other paints. This is desirable because it means that there is less risk of building the paint film up to excessive thickness. It is resistant to staining by rusting metal. Probably the most important of its properties is its nonsensitiveness to water. Even when exposed to water for a long time, it swells only about as much as wood does when wet. As a consequence, it has little tendency to blister.

White lead paint also has some disadvantages, some of which have led to preference for other types of exterior paint. For one, it has an off-white

color that does not compare favorably with the intense, brilliant white of most other paints. For another, it is given to serious dirt retention. Despite the fact that it wears away faster than other paints, it collects more dirt and retains it longer than most other types of paints. Another serious objection is its property of discoloring on contact with hydrogen sulfide and some organic sulfides that cause the formation of black lead sulfide. Finally, white lead paint is somewhat more expensive than the other types of exterior paints.

In recent years, paints made with titanium and lead pigments, but no zinc oxide, have appeared on the market. Some paints of this kind are sold as "breather-type" paints. In addition to titanium and lead, such paints contain a considerable quantity of transparent or extending pigment, and are made with a high proportion of pigment to binder so they are characterized by a lack of gloss.

A few paints pigmented with titanium and lead are sold as "titanized white lead." Some paints of this kind contain no extending pigments. They are made with the conventional ratio of pigment to binder and therefore have as much gloss as the zinc-containing paints.

Paints of the titanium-lead type are nonsensitive to moisture and therefore blister resistant. They have high opacity and generally stand between white lead paint and the zinc-containing paints in color, in resistance to soiling by dirt and staining by rusting metal, and in the rate at which they wear away. They do, however, fail by checking and crumbling, which is desirable because it provides a surface that is easy to repaint. On the other hand, they, like pure white lead paint, are discolored by hydrogen sulfide.

Paints made with titanium pigment (but no lead or zinc) and one of several special vehicles are now available. One of the vehicles used is a long-oil alkyd resin; another is referred to as a copolymer solution. This type of paint is sold as "blister-and stain-resistant" paint. Like the breather type of paint, it has little or no gloss. In opacity, color, and resistance to soiling by dirt and staining by rusting metal, it is like the titanium-lead paints. It differs from such paints in that it is enamel-like in its characteristics and resists sulfide discoloration. Such paint normally fails by cracking, curling, and flaking, and indications are that it wears away at a rate similar to that of the titanium-lead paints.

Dark-color paints, sometimes called trim paints or trim-and-trellis enamels are most extensively used on exterior wood trim. They consist chiefly of dark-color pigments and little, if any, titanium dioxide, white lead, or zinc oxide. In most trim paints the major portion of the vehicle is varnish, usually an alkyd-resin varnish. Iron-oxide paints--the familiar red barn paints--may also be classified as dark-color paints. If properly made, they are very durable. In general, good paints of dark colors are more durable than any white or light-colored paint and less sensitive to water than are white or light-colored paints made with zinc oxide.

Now a word about paint primers, since the choice of a primer can do much to insure a long-lasting, trouble-free paint job. In particular, a primer should be free of zinc pigments, even if a zinc-containing paint is used for the finish coat. Most paint makers provide special, zinc-free house-paint primers or undercoaters for use with their mixed-pigment paints containing zinc. Some paints made without zinc oxide may be used as self-primers. In any case, it is wise to use primer and finish paint of the same brand.

Flat-grained woods with wide summerwood bands such as Douglas-fir and southern yellow pine, or wood with knots, should be primed with a special primer. We have found that aluminum house paint, sometimes called "aluminum paint for wood", is best for this purpose.

Selection of a particular type of house paint requires careful thought. The experience of others in the neighborhood and city may be helpful in determining what types of difficulties with paints are common and which paints serve best. The construction of the building should also be considered. Does it have a wide roof overhang to shield the walls? Has it adequate gutters and down-spouts, and are they properly installed? Is there a good vapor barrier along with the insulation? If the answers are "yes" to all of these, a zinc-containing paint stands a fair chance of success (but only over a zinc-free primer) and only if a sensible maintenance program is adopted. If there is doubt, or if one or more of these conditions cannot be met, one of the zinc-free paints is the wiser choice.

We often hear the claim that the quality of exterior paint is better now than it has ever been--that the widespread difficulties being experienced with paint on wood buildings is due to the fact that our wood is of lower quality than it used to be. This is not a true picture of the situation.

Let us look at wood for a moment. The Forest Products Laboratory more than 20 years ago classified the commercially important species of this country into five groups on the basis of their paintability: Group 1, the cedars, redwood, and baldcypress; Group 2, eastern white pine, sugar pine, and western white pine; Group 3, white fir, the hemlocks, ponderosa pine, and the spruces; also such hardwoods as aspen, basswood, cottonwood, magnolia, and yellow-poplar; Group 4, Douglas-fir, southern yellow pine, and western larch of the softwoods; of the hardwoods, beech, birch, the gums, and maple; and Group 5, ash, chestnut, elm, hickory, oak, and walnut, all of which are hardwoods with large pores.

Among the softwoods, the painting characteristics of a board depend primarily upon the amount and distribution of summerwood. The width of the summerwood bands in softwoods usually varies with the density of the wood and the rate of tree growth, being narrower when the density is low or the tree growth is slow. Edge-grained boards have narrower bands of exposed summerwood than flat-grained boards and, therefore, hold paint better and longer.

It is true that less than 10 percent of the wood available to us for exterior building use is of the more desirable species with respect to paint-holding ability. But this situation has not altered greatly in the last 25 years, at least not enough to account for the increasing incidence of paint failures. Edge-grained western redcedar holds paints as well and as long today as it did 25 years ago. Conversely, it is about as difficult to maintain coatings of paint on the softwoods that have wide summerwood bands today as it was 25 years ago.

We have been making mistakes with our paints: first of all, we have gone heavily to water-sensitive types of exterior paints, paints that blister with less provocation than the paints of old; our paints now are made with less nonvolatile per gallon--less film-forming material per gallon, than used to be the case and yet we try to get by with two coats for the original paint job on exterior woodwork. The Forest Products Laboratory did a great deal to establish two-coat painting as a sound practice, but the paints for this purpose have to be made specially. Today's paints will not meet the requirements--three coats are required for the original paint job.

We now think of building construction as a year-round occupation. Structures completed in the winter months are usually primed, but an interval of 4 to 8 months may elapse before the topcoat is applied. Too often the top coat fails to bond properly to the prime coat--it separates from the prime coat in what we refer to as "intercoat peeling." It is better to delay all the painting of the exterior woodwork of such buildings until warmer weather arrives because the individual coats of a given paint job should be applied within weeks of each other.

The same thing is likely to happen when the paint on a new structure, that received a scanty coating of paint to begin with, fails after a year or two and the owner feels prompted to apply just one more coat of paint at that time. To be on the safe side, a paint film should be permitted to weather a minimum of 3 years, and preferably 4, before new paint is applied over it.

Possibly the most serious form of paint failure is blistering and peeling. Most, but not all, blistering and peeling is caused by water, that gets into the side walls back of the paint coating. Such water may come from several sources, but the two most important are: (1) cold-weather condensation--water vapor within the structure passes into the side walls where, during cold weather, it condenses out as liquid water and may later diffuse through the sheathing and siding and cause the exterior paint to blister. (2) Rainwater that penetrates into the lap and butt joints to the back of the siding.

Much has been said and written about cold-weather condensation as the cause of paint blistering, but it is not generally known that rainwater is an equally serious cause of paint blistering. We, at the Forest Products Laboratory, have reason to believe that rainwater that works through the joints to the back of the siding is the cause of as much, if not more, paint blistering than cold-weather condensation.

Fortunately, there are symptoms that enable one to determine the source of water that is causing paint failure. When blistering results from cold-weather condensation the blisters appear in the very early spring; blisters are usually more extensive on the north side of the building because that is the coldest side, and the blisters may be concentrated outside of rooms in which the relative humidity is higher than in the balance of the building. Blisters from this source occur on siding that is protected by roof overhang as well as on unprotected siding, but they occur only on heated buildings.

In contrast, blisters brought about by the penetration of rainwater through the joints in siding and in other woodwork occur later in the spring and through the summer (during the rainy season). The blistering is usually most severe on the south and west sides of the building because the prevailing winds and rains are from those directions, and it occurs only on woodwork that is unprotected--the paint on siding immediately under roof overhang is not ordinarily wet by rain and therefore does not blister under these circumstances. Paint blistering caused by rainwater may occur on unheated as well as on heated buildings.

Cold-weather condensation is best eliminated by providing a vapor barrier on the warm side of the exterior walls and on the ceiling. In the colder areas of the country, a vapor barrier should be installed at the time of construction. Aluminum foil, polyethylene film, and some asphalt-coated papers serve as good vapor barriers. In existing buildings built without a vapor barrier, the practicable means of providing one is by painting the interior surface of the exterior walls with a paint of high moisture-excluding effectiveness. Aluminum paint serves this purpose well and some of the oil-base and latex paints are nearly as effective.

Penetration of rainwater through the joints in siding and in other woodwork can be eliminated by treating the joints with a water-repellent preservative prior to applying paint. This is a solution of a small amount of wax, some resin and drying oil, together with a fungicide in a paint thinner, such as mineral spirits. Such solutions have been used in the millwork industry for nearly 20 years, and today most millwork is treated at the plant with a water-repellent preservative.

The user of paint brings some troubles upon himself, troubles that he might avoid if he were educated in the use of paint. For one thing, it is the rare individual who remembers, from one repaint job to the next, what type of paint he last applied on his woodwork. When it comes time to repaint, he selects a paint without regard for the paint previously applied, and runs the risk of building up a paint film of widely dissimilar paints, which may fail as the result of incompatibility. He should properly select a good-quality paint at the time of the construction of the building and continue to repaint with that same type of paint throughout the useful life of the structure.

Too much exterior woodwork is overpainted, either to restore a clean, fresh appearance or to change colors in keeping with the style. A safe paint-maintenance schedule consists of 2 coats at 6-year intervals or, at the most,

1 coat at 4- or 5-year intervals. Painting more frequently may ultimately lead to excessive film thickness at which point cross-grain cracking may occur. Once this type of failure occurs, the only truly satisfactory means of restoring a good painting surface is to remove the old paint completely down to the bare wood and start over. This is a time-consuming and expensive chore and the individual faced with this task cannot be blamed for looking around for substitute covering materials to cover over his mistakes. Unfortunately, this too often results in the loss of a proponent of wood and paint for wood. This is a needless loss, one that might have been avoided had the individual been educated in the proper use of paint and wood.