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# Canadian Building Digest

Division of Building Research, National Research Council Canada

**CBD 91**

## Exterior Coating for Wood

*Originally published July 1967.*

*H.E. Ashton*

### **Please note**

This publication is a part of a discontinued series and is archived here as an historical reference. Readers should consult design and regulatory experts for guidance on the applicability of the information to current construction practice.

There are many opinions as to which organic finishes should be used on the exterior of buildings, particularly wood surfaces. Such disagreements undoubtedly arise in part from differing individual experiences. Most coatings can be expected to give satisfactory results under favourable conditions. It is necessary, however, for those advising on the use of coatings to consider over-all experience with various types and to allow for circumstances where unfavourable factors may be combined.

### **Coatings and Wood**

Coatings are not essential for the protection of wood from the weather. There are wooden buildings that have remained in good structural condition for 100 years or more without benefit of paint. Weather effects result in a slow change of the exposed wood surface, indicated mainly by a change in appearance. Wood which is frequently wetted turns grey; but with a minimum of wetting it will, over a long period of exposure, turn a rich reddish brown. These natural colours are preferred in some countries to the colour of new wood, and stains are often used on new construction to produce an aged wood appearance. On this continent, the appearance of new wood is often preferred and there is much interest in clear coatings that will preserve it.

Wood that is unprotected and exposed to wetting and sunlight will also exhibit quite serious checking (cracking), probably the result of the rapid moisture changes and corresponding dimensional changes associated with such conditions. Coatings may therefore be desirable in order to minimize the rate and range of changes in moisture content in wood. In contrast to this, coatings may occasionally be detrimental when, in conjunction with poor detailing of exposed wood parts, they serve to retain water and thus produce conditions conducive to rotting.

Appearance is a major factor in the use of coatings. The ability to develop, with the aid of colour, any desired appearance and to renew it or to change it as desired is of great importance. Once a coating has been applied, however, failure to maintain it leads to undesirable appearance, and this usually forces renewal or replacement at intervals of a few years.

Some of the fundamental properties of wood become involved in a major way in the performance of coatings. Thus it is not possible to devise a good coating without taking these

properties into account. Dimensional changes in wood resulting from changes in moisture content are of particular importance. This property and some of its implications have been discussed in [CBD 85](#), [CBD 86](#). It may be recalled that wood may shrink as much as 5 per cent or even more across the grain with a change in moisture content from 30 per cent to the oven-dry condition, with corresponding expansion or swelling upon rewetting. Although such a range of moisture content would be unusual in painted wood, changes leading to as much as 2 per cent expansion or contraction can reasonably be expected. The attached coating must therefore exhibit sufficient extensibility throughout its useful life to permit it to follow these changes in the dimension of the wood without rupture.

A further complication is introduced when the coating itself is of a type that swells when wetted with water. Wetting of the paint and of the wood may also affect the strength of the bond between the coating and the wood. When this is reduced, there is the possibility that the coating may separate from the wood under the influence of dimensional changes in the wood or the coating.

New coatings are usually capable of withstanding elongations in excess of 5 per cent. Oil paints, however, rapidly lose extensibility upon exposure, although it has been shown that aged oil paint films swell at least as much as wood when water-saturated. The type of failure may, therefore, depend upon the amount of liquid water present at the wood-film interface. The rate of swelling of wood as well as the amount is an important factor in coating failure. In general, coatings that do not have or retain the required extensibility fail by cracking, peeling and flaking.

Another paint problem associated with wood is blistering. Blisters can be readily produced in the laboratory by applying heat and moisture to the back of a piece of painted wood and there is general agreement that moisture and its migration toward the paint film is responsible for blistering. The moisture associated with blistering may get into the wood in a number of ways. It is known that water vapour from humidified rooms in a building can migrate outwards and be condensed within the construction when the outdoor temperature is low. Correspondingly, the outward leakage of moist air can bring water vapour into contact with cold parts of the construction. Wetting of siding frequently also occurs from the outside from rain or melting snow, which may even enter at one point and create difficulties at another. The obvious remedy in all cases is to identify and correct the defects that lead to extensive wetting. This is easy to say, but is often very difficult to accomplish.

It has been shown that blistering is closely related to the permeability of coatings to water vapour and to their adhesion to surfaces that have become wet with water. Work carried out in Scandinavia and in DBR/NRC laboratories shows that coatings can be classified as having high or low permeability and good or poor wet adhesion, as indicated in Table I.

**Table I**

Wet Adhesion	Permeability	
	Low	High
Poor	Oil Paints	Latex

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Coatings with low wet adhesion and permeability blister badly when conditions are such as to cause continuous condensation at the coating-substrate interface. Those with high permeability but low wet adhesion tend to resist blistering in all but severe conditions because they allow some moisture to escape through them. The opposite combination of properties, high wet adhesion but low permeability usually has good blister resistance also. Alkyds can be formulated to have high permeability through over-pigmentation, but this reduces wet adhesion and makes the film brittle. Efforts are continuing to develop coatings in the fourth category, those having substantial permeability combined with good wet adhesion, but as yet there has been only limited success.

Knots in wood have been a perennial problem. If they are not treated, resin from the knot may exude into the coating and discolour it. Pre-treatment with shellac or specially developed knot sealers can lead to loss of adhesion of subsequent coatings. The result in either case is often visually objectionable. The best procedure is to select wood, whenever possible, that has a minimum number of knots.

Resin streaks exuding from pockets on new wood should be removed with solvent before coating. Wood containing such pockets may cause trouble several years after it has apparently been painted successfully. A colour change on repainting from a light to a dark-coloured coating has been known to induce resin problems because of the increase in surface temperature under sun conditions arising from the colour change. The problem is always more severe with woods that are rich in resin, and should not be confused with moisture-induced blistering.

### **Types of Coatings**

*Oil Paints.* These are deficient in the two properties that favour good resistance to blistering. In addition, it has been shown that they have low initial extensibility and lose even this soon after exposure<sup>1</sup>. Despite this they have been and are still widely used. In past years they were the best materials available. The binder of such coatings gradually degrades under the action of sunlight and water, so that the surface erodes. This characteristic is often an advantage since surface dirt is carried away, keeping the paint clean and preventing build-up, with time, of thick coats that lead to cracking.

The self-cleaning feature is not desirable with colours, however, or where white is used above other materials such as brick or stone. Erosion causes colour to appear faded, and the chalk run-off leaves an unsightly stain on masonry or other surfaces below. This stain cannot be removed with the acid solution used to dissolve efflorescence from brick because it results from pigments that are acid insoluble.

When wood to be painted with oil paints is located above masonry, the pigmentation can be altered to reduce considerably the rate of erosion. Such paints are referred to as tinting or chalk-resistant whites. They naturally do not have the two advantages of the chalking type, but their other properties are similar.

*Alkyds.* Alkyd enamels have been used extensively for trim work because of their good gloss and colour retention. They have not, in spite of good wet adhesion, moderately high initial extensibility, and good retention of tensile properties, been used for over-all wall areas in North America. Alkyds have, however, been used successfully for this purpose in other countries. Most of the alkyd finishes sold on this continent for use on siding are really alkyd-modified oil paints. The work previously cited showed that these gave little improvements over straight oil paints. One property of alkyd finishes that has probably deterred their use in North America is their incompatibility with previous coats of oil paints, which generally contain zinc and, often,

lead. The alkyd vehicle reacts with these pigments to form a highly impermeable layer that results in peeling and blistering if any moisture is present. It may be that this possibility has prevented the promotion of such finishes. Where these coatings are to be used for repainting, the existing coatings should first be completely removed.

*Latex Paints.* To provide resistance to blistering, coatings with low wet adhesion and high permeability (such as latex paints) have generally been adopted on this continent. When latex topcoats were introduced, they were applied over conventional oil primers. In Europe, by contrast, latex was often considered suitable for exterior use only as a primer under alkyd topcoats.

Latex binder, because of the manner of film formation, has to be inherently highly extensible. Whether this also becomes a property of the pigmented film depends upon the formulation of the paint. Some commercial materials of this type have been found to have less elongation than alkyds. Permeability of latex paints to water vapour is generally, although not universally, high. Perhaps their good application properties - easy brushability, rapid drying and applicability to damp surfaces - have contributed the most to their popularity.

Latex paints, unless highly modified with water-soluble solvents, are sensitive to low temperatures at time of application. They can only form a coherent film if the resin flows as the water in which it is dispersed evaporates. At low temperatures a powdery deposit of resin particles and unbound pigment results.

*Primers.* For many years oil paints were used with additional oil and thinner to serve as primers and intermediate coats in a three-coat system. Research showed that equivalent results could be obtained with a special oil primer and a single oil paint topcoat. As labour costs increased this system was generally adopted in North America. It was also found that aluminum pigmented primers gave superior results with oil paints, but unfortunately two coats of white are required to hide the grey colour completely and this has militated against their use.

As was discussed in [CBD 78](#), the problems of high viscosity of high polymers can be overcome by using them in the form of a latex - that is, a dispersion, not a solution, of the resin in water. The large molecules, however, cannot penetrate the powdery layer on chalking surfaces. The original latex paints, therefore, required a special primer. The use of slow-drying oil primers obviously detracted from the desirable application properties of latex paint as well as markedly reducing permeability. Much development work has taken place and self-priming paints or water-based primers have been introduced. Some of the primers are made with latex also while others contain emulsified or water-soluble binders. It has not been possible in all cases to keep water-soluble stains in red cedar and redwood from bleeding through the topcoat. Some manufacturers, therefore, still recommend oil primers while others prefer alkyd primers under latex topcoats. The individual manufacturer's instructions on primers should be carefully followed because he has formulated his coating to perform best when used in that way.

The finish coat should be applied to primers, including those on preprimed siding, as soon as possible, consistent with suitable weather conditions. Autumn applications of primer alone to protect new wood over the winter, with topcoat to be applied the following spring, is not recommended. This practice has frequently resulted in peeling from the primer, and if primer is allowed to weather for some time, sanding or repriming will be required before the finish coat can be applied.

*Clear Finishes.* There are no really satisfactory clear coatings for exterior wood in spite of the large amount of time and effort that has been devoted to their development. Studies at DBR/NRC over several years have shown that clear finishes fail in either of two ways. Some protect the underlying wood, but in so doing degrade in a manner that is not conducive to easy recoating. Others do not fail within the film but transmit considerable ultra-violet light, which, in combination with moisture, degrades the top layer of wood. Failure then occurs by peeling over large areas (delamination). The amount of ultra-violet light absorber that must be added to inherently durable binders to stop wood degradation generally appears to be uneconomical.

The most durable clear coating in the DBR/NRC tests<sup>2</sup> was a tung oil-paraphenylphenolic varnish. Materials complying with Canadian Government Specifications Board 1-GP-99 should have similar durability because they are required to contain the same resin, although the type of oil is not controlled. Accelerated tests indicate that additional weathering resistance is obtained by applying the above varnish to wood and topcoating with a clear alkyd.

Even the varnish with the best durability needed repair of small defects as they occurred to prevent their spreading to larger areas. As this touch-up needs to be carried out after every second summer, the film thickness becomes excessive and leads to cracking so that eventually the whole system has to be removed. If a clear coating is allowed to deteriorate to the point where the wood starts to weather, any subsequent clear coating will fail rapidly.

*Stains.* Stains are used where it is desired to see some of the natural wood grain yet obtain more protection than clear finishes can provide. Only stains made with pigment are durable under exterior conditions. Dyes are not sufficiently lightfast and, being transparent, transmit light with resulting degradation of the wood surface. If the pigment content is high, the grain may be completely obscured. Stains, therefore, are a compromise between the desired appearance and the required protection, with most commercial materials tending to emphasize the latter property. They contain either large amounts of solvent or a low viscosity binder so that a thick film is not left on the surface. They fail by erosion, thus leaving a good surface for refinishing.

The best results in DBR/NRC exposure studies were obtained with the stain formula developed by the U.S. Forest Products Laboratory in Madison, Wisconsin. The dark colour probably accounts for much of its good durability. This colour can be varied, but lighter colours will be less durable. In the same tests, alkyd-based stains were somewhat less durable and a creosote stain was markedly inferior. Although properly formulated stains are more durable than the best clear finishes, they should not be expected to last as long as fully pigmented coatings.

### **General Recommendations for Wood**

*New Work.* A clear coating should not normally be considered a good alternative to painting or even to staining. Clear coatings should only be specified for exterior wood when there is a strong preference for them that outweighs other considerations such as their short life and need for excessive maintenance. To date, the most durable clear system consists of two coats of the phenolic varnish described above and two coats of a clear alkyd topcoat. For stains, the Madison formula is recommended, although allowance must be made for shorter durability with lighter colours.

For completely pigmented materials, the choice lies between latex paints and alkyd finishes, unless oil paints have performed satisfactorily on similar structures in comparable locations. Latex is more readily available in a full range of colours and application costs are probably lower than with alkyds. Nevertheless, it is believed that use of alkyds on new wood should receive more consideration than it has in the past.

After a decision has been reached on the topcoat to be used, an appropriate primer must be specified. The manufacturers' recommendations should be carefully considered in making this selection. Oil primers can be used under any of the three types of topcoats, but may not be best with a particular formulation. Alkyd primers have proved to be better than oil primers for use under some alkyd finishes. As discussed above, the selection of a proper primer for use under a latex finish may be critical.

*Recoat Work.* Oil paint originally applied on new homes frequently fails by peeling, not because of moisture migration but because of conditions during application that prevented development of proper adhesion. If the surface is properly prepared, subsequent application of oil paint will generally give satisfactory service. It is necessary, however, to remove as much as possible of the old material, especially in areas adjacent to the peeling; although adhesion was good enough to prevent peeling in the first place, it may not be sufficient to resist the forces exerted by additional coats of paint.

If several applications of oil paint have failed by moderate blistering not evidently associated with structural defects, latex should be considered. Again, it is necessary to remove more than just the blistered spots because adhesion in adjacent areas has been weakened and will fail when recoated. Where a latex system applied to bare wood has performed successfully, apparently because of its ability to transmit moisture, it should be recognized that additional coats applied in repainting will reduce the over-all permeability.

Alkyds should only be used for repainting if the previous coating is known to be compatible or if it has been removed completely. Application of alkyd over oil paint is not the only cause of intercoat failures. Because of local conditions there may be a high rate of dirt collection. This dirt must be removed before repainting can be successful. Areas under the eaves are particularly susceptible to soot and oil deposits. In sheltered areas the gloss will have been retained, so that, after washing, sanding will be required to improve adhesion between the new and old coatings.

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2. Ashton, H. E. Clear Finishes for Exterior Wood, Field Exposure Tests. J. of Paint Technology, Vol. 39, No. 507, April 1967, p. 212-224.