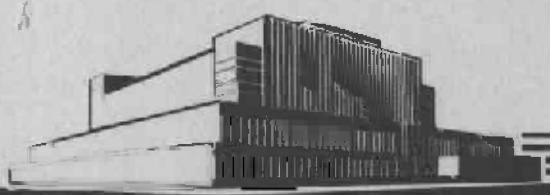
EXUDATION OF PITCH AND OILS IN WOOD

Information Reviewed and Reaffirmed

August 1959

No. 1735



FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

EXUDATION OF PITCH AND OILS IN WOOD[1]

By

F. L. BROWNE, Chemist
and
R. C. RIETZ, Engineer

Forest Products Laboratory,[2] Forest Service
U. S. Department of Agriculture

The tendency of stored lumber and wood products made of some species to exude or bleed resin has been of concern to both producers and consumers. Surfaced stock that has exuded beads of pitch from the resin passages or oozed globules of pitch from pitch pockets while in storage at the producing mills, in the retail yards, or at fabricating factories, has brought inquiries to the Forest Products Laboratory as to the cause and requests for practical remedies. Exudation of pitch through the finish on millwork and painted exteriors has also brought inquiries as to coatings that will inhibit these exudations, but, unfortunately, no such coating is known.

Woods like Eastern redcedar, incense-cedar, and Port Orford cedar (but not Western redcedar) not infrequently exude an oil that discolors paint and finishing films, sometimes retards drying of the coatings or leaves them sticky, and may even cause blistering and early disintegration. In Spanish cedar, an exotic wood, a viscous liquid is exuded that, when its volatile oils are evaporated, leaves a gummy residue that also mars finishing coatings.

Paint and enamel finishes on the white pines and on ponderosa pine sometimes acquire a yellow or brown discoloration over the heartwood, particularly if the wood is damp when the painting is done or soon thereafter. As a rule, the discoloration begins immediately over the resin passages, but later may become generally diffused throughout the coating over the heartwood, while leaving the coating over sapwood unaffected. The discoloration is not an

---

[1] Original report published March 1949.

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

exudation of pitch, but rather a diffusion into the paint of colored substances present in the resin in the heartwood but not in the sapwood of the pines.

Nature of Pitch and Oils in Wood

The pitch in most pines and in Douglas-fir is a mixture chiefly of rosin and turpentine (Jeffrey pine contains heptane instead of turpentine). Rosin is a hard, brittle solid at any temperature to which wood is likely to be subjected in normal service. Turpentine is a volatile substance that is given off along with the water in the wood when lumber is being dried, but the turpentine comes off less rapidly than does the water, and much of it may, under certain drying conditions, be left in the resin after the lumber has been dried to the correct moisture content. When the resin left in the wood contains much turpentine, it melts at a much lower temperature than pure rosin, and, consequently, the more turpentine there is left in the resin in the wood, the more is the likelihood of resin exudation occurring. Green lumber exudes pitch freely even at ordinary temperatures, but, as the turpentine evaporates, the wood must be warmed to higher and higher temperatures before the resin becomes fluid enough to move through wood. When fluid resin does move through wood, it does so in response to pressure exerted upon it by expansion and contraction of air in the wood when the temperature changes.

The oils in the cedars are mixtures of liquids or solids that crystallize with difficulty. Some of these oils have high boiling points and evaporate only very slowly even at the temperatures used in kiln drying wood.

Movement of Pitch

Typical paint failures caused by the movement of pitch in pine woodwork are shown in figure 1. The resin often collects in tearlike globules that blister the paint film, and finally breaks through the film and oozes out. On finished interior millwork the resin often collects in the form of beads, as the resin exudes from the resin passages through the coatings, and sparkles under favorable conditions of light.

Under otherwise similar conditions, the exudation of pitch occurs most seriously where the wood gets warmest. On exterior woodwork, for example, it is usually worst on those parts of the house where there is most sunshine, and on interior woodwork, on those parts nearest radiators, hot air outlets, or other sources of heat. As a rule, exudation is a slow process that requires many cycles of heating and cooling to bring the resin to the surface. The only thing that the user of lumber can do to prevent it, is to keep the woodwork at as even a temperature as practicable and, if possible, to avoid letting the wood become

heated. Nothing can be done in the way of preventive finishing, because exuding resin will come through any paint or other coating available for use on wood.

The prevention of exudation of pitch is essentially a problem of lumber drying. Air-dried pine lumber usually gives more difficulty than kiln-dried pine lumber. Southern yellow pine, when kiln dried, apparently gives less trouble from subsequent exudation than kiln-dried white pine or ponderosa pine, presumably because relatively high kiln temperatures are commonly used for southern yellow pine, which will withstand such temperatures. With the woods of the white pine group and ponderosa pine, however, relatively low temperatures are favored in kiln drying because of the danger of developing brown stain when those woods are dried at higher temperatures. In the United States most Douglas-fir lumber that is painted has been kiln dried and gives very little trouble with exudation of pitch, but in England Douglas-fir is imported in the green condition. Most of it appears to be air-seasoned before use, and much trouble with such exudation through paint is reported.

The prevention of pitch exudation is most successfully accomplished by heat treatment at a high temperature of sufficiently long duration to volatilize the turpentine and "set" the pitch; that is, to leave it with so small a proportion of turpentine that it will remain hard and immovable at any temperature to which the wood may be subjected in service. Submersion of green pine in water has been reported to be effective in reducing the tendency of stock to bleed. Experiments were conducted by the Forest Products Laboratory of Canada to determine the influence of water storage of white and red pine logs on subsequent bleeding of pitch from lumber cut from them. No particular difference was noted in the length of time required for yellowish stains to discolor the paint, that would indicate any superiority for water-stored material over that sawed without storage in water, nor was there any apparent benefit in this respect obtained by kiln drying as compared with adequate air seasoning.

Solvent Seasoning

A lumber-drying method involving the use of a solvent has been developed for western pines. This method is called solvent seasoning.[3] It removes a large percentage of the pitch from the sapwood of pine at the same time as the wood is dried. The amount of pitch removed from heartwood by this process is not very great, but the pitch in the surface layers is removed. Use of such a drying procedure probably would eliminate the problem of pitch exudation in subsequent use. The process is, however, more expensive than kiln drying.

---

[3] Solvent Seasoning. The Timberman (p. 94) Nov. 1944.

Whether solvent-seasoning methods will eventually replace kiln drying for pine and other kinds of wood, will depend on the value of the extractives recovered in the process and other economic factors. Since, under any circumstances, the bulk of lumber will continue for some time to come to market without the benefit of solvent-seasoning methods, this report has been prepared to show measures that can be taken during ordinary kiln drying or finishing to avoid or overcome pitch-exudation problems.

Kiln Drying

The distillation of the volatile materials in the resin, such as turpentine, is best accomplished at high relative humidities and high temperatures when the wood is green. This treatment can be made without damage in the southern pines, although the usual drying schedules in these species have sufficiently high temperatures to set the pitch adequately. Ponderosa pine, however, is subject to brown stain, which is aggravated by high-temperature treatments, particularly when the stock is green, and this is the principal reason for the present popularity of the low-temperature low-relative-humidity kiln-drying schedules.

The kiln-drying schedule given in table 1 for ponderosa pine up to 6/4 inches thick has been reported as being effective in reducing pitch exudation with a minimum of brown stain developing.

Commercial schedules for kiln drying ponderosa pine of various grades and in thicknesses up to 6/4 inches sometimes have been found to differ considerably from this recommended schedule. Generally speaking, however, a rather definite schedule pattern has been noted. For example, the initial wet-bulb temperature is kept as low as circumstances will permit and rarely exceeds 120° F. The initial dry-bulb temperature is maintained at a level at which the relative humidity will not exceed 40 percent. After the stock attains a moisture content of 25 percent, emphasis is placed on the use of high dry-bulb temperatures. This type of kiln-drying schedule, particularly if final temperatures as high as 170° F. are used, should go a long way toward reducing both brown stain and pitch exudation. [4]

Common grades of Douglas-fir are often kiln dried at temperatures lower than those used for the upper grades. This is done to prevent the hardening of the pitch holding the knots and to reduce the tendency for them to pull out in subsequent machining. As a result, the pitch in the resin ducts is not completely

---

[4] Kiln Drying to Prevent Bleeding of Pitch. Laboratory Note No. 2 Western Pine Association, Portland, Oregon.

set, and when common grades of lumber are used in places where the clearer grades were formerly used, trouble with pitch exudation might be experienced.

Discoloration of Paint Over Heartwood

The resin in the heartwood of the woods of the white pine group and sometimes in ponderosa pine contains a substance that occasionally dissolves in paint films to result in a spotted paint discoloration often mistaken for pitch exudation. In extreme cases the entire coating over the heartwood becomes discolored. This peculiar type of paint defect is shown in figure 2.

The colored substances appear to diffuse through the vehicles of many kinds of paints, varnishes, and lacquers soon after the coatings have been applied, although not necessarily before they have reached the stage of hardness ordinarily considered dry. It would seem, therefore, that the colored substances are soluble in drying oils and lacquer solvents commonly used in coatings. Nevertheless, there is unmistakable evidence that excessive moisture in the wood at the time of painting or not long afterward greatly stimulates the discoloration and, in practice, often determines whether or not it will appear. The colored substances may therefore be water-soluble materials that are readily emulsified in paint vehicles in much the same way that water becomes emulsified in fresh coatings of some varnishes and turns them white.

The connection between excessive moisture in wood and the appearance of heartwood discoloration of coatings was first noticed by one of the authors and M. W. Baker of Curtis Companies, Inc., when they found that houses in which serious trouble was found with discoloration of paint over pine heartwood, were usually houses in which there was reason to believe that the discolored woodwork had been damp when painted or became damp soon after painting. Discolored paint on interior trim, for example, was often associated with blistering and peeling of paint on exterior woodwork traceable to condensation in side walls.[5] Heartwood discoloration was found particularly common in newly erected houses in which plastering had been done during cold weather, and in which painting had been started soon after plastering.

Following this lead, Mr. Baker experimented in the laboratory of the Curtis Companies with matched specimens of ponderosa pine heartwood brought to different moisture content values before painting or soon after painting. On susceptible boards there was abundant discoloration on pieces brought to fiber-saturation point before or soon after painting, much discoloration on boards brought to 20 percent moisture content, slight discoloration on boards at 16 percent moisture content, and little or no discoloration on boards kept below 10 or 12 percent moisture content.

---

[5] "Condensation Problems in Modern Buildings," by L. V. Teesdale. Forest Products Laboratory Report No. 1196, Jan. 1959.

Although moisture content while paint is drying is a dominant factor in heartwood discoloration, it is not the only factor. Some boards of pine heartwood do not discolor even at fiber-saturation point. A few boards, although apparently a very small proportion in commercial shipments, may become slightly discolored even if kept thoroughly dry. As yet, there is no way of recognizing susceptible boards before they are painted. If the lumber is kept well dried while painting, however, there is seldom any serious discoloration.

The nature of the paint is also a factor of importance in discoloration. The color develops in the vehicle of paint or enamel, that is, in the oils or resins; it does not affect the pigments. Transparent coatings such as clear varnish or lacquer fail to show the discoloration badly because it blends with the color of the wood underneath. The discoloration shows most conspicuously in glossy enamels or paints in which there is a high proportion of vehicle with just enough opaque pigment to provide good hiding power and color. As the proportion of pigment in the coating is increased and that of vehicle decreased, the tendency for the discoloration to show badly diminishes. Semigloss paints, therefore, tend to become less discolored than highly glossy paints, and discoloration is least in flat paints. Nevertheless, the discoloration passes through an undercoating of flat paint to stain a glossy enamel or clear coating applied over it. In one case a table top was examined on which there was a priming coat, a highly pigmented undercoat, and a clear finish coat of pyralin, with the finish badly discolored over those pieces consisting of pyralin, with the finish badly discolored over those pieces consisting of heartwood. When the clear pyralin was stripped off, it was badly stained immediately over the resin passages in the wood, although the discoloration could barely be seen in the highly pigmented undercoat. Of course, paints of a tan color matching that of the discoloration, or paints of color dark enough to mask the discoloration, are less seriously affected, even though they may be glossy, than are white paints or paints of light color.

A few paints are known to be immune to discoloration over pine heartwood. Among them are spirit varnishes or the enamels made from spirit varnishes in which the resin is one that does not dissolve or emulsify the colored substances from the wood resin. One of the oldest of such spirit varnishes is shellac varnish. Cellulose-ester lacquers, however, are often seriously discolored, possibly because of the powerful solvents they contain. The Forest Products Laboratory in 1927 showed that the performance of shellac as a sealer under paint or varnish can be materially improved by plasticizing the shellac with a small proportion of castor oil. Although these findings were later confirmed by the Western New York Paint and Varnish Production Club, plasticized shellac varnish has not been made available in convenient ready-to-use form. More recently, the Western Pine Association has developed a solution in denatured alcohol of a phenolic resin plasticized by a soft polyvinyl butyral resin. The product is made and distributed by a number of paint manufacturers in ready-to-use form.

On interior surfaces not exposed to dampness the spirit varnishes may be used either as sealers under other coatings or as complete finishes, with or without pigments. On exterior surfaces they are useful only as sealers, because they need protection by more weather-resistant topcoats.

Successful use of sealers to prevent discoloration depends at least as much on skillful application as it does on the nature of the sealer. The usual recommendation is to apply the sealer on the bare wood or after wood stain or wood filler when they are used. The protective coating is then applied over the sealer. If too little sealer is applied, however, it may fail to hold back the discoloration. The amount of sealer needed may vary widely according to the absorptiveness of the wood. On the other hand, too much sealer, that is, enough to form a continuous coating of appreciable thickness over the wood, is likely to prove incompatible with dissimilar topcoats and therefore may alter their performance unfavorably. For greater assurance that the sealer will prevent discoloration, some painters apply a priming coat of the protective paint first, then a thin coat of sealer, and then the topcoats of protective paint. This procedure requires less sealer and is more certain to prevent discoloration, but it also involves more risk of impairing the normal performance of the protective paint. In either method of application good judgment on the part of the painter is needed to gage correctly the amount of sealer to apply to accomplish its purpose without too much sacrifice in other characteristics of the finish.

Aluminum paint does not become discolored because the highly opaque aluminum flakes float on top of the coating and hide any staining of the vehicle. Applied to the bare wood before the regular paint or enamel, a priming coat of aluminum paint will often prevent discoloration and is less objectionable than shellac. Cases have been known, however, in which discoloration appeared in white paint or enamel despite a priming coat of aluminum paint underneath. Aluminum priming paint for use on exterior surfaces under house paint should be made with a vehicle of either bodied drying oil or of a very long-oil spar varnish. Aluminum paint of that kind is commonly sold under the name of "aluminum house paint for wood." On interior surfaces the aluminum priming paint is more effective against discoloration if it is made with a vehicle that is short in oil, such as an architectural varnish or a rubbing varnish. The so-called "heat-resistant" aluminum paints may be used effectively on interior woodwork.

Discoloration of paint over heartwood is less often a cause of compaint on exterior than on interior woodwork. This is probably due to the fact that the stain fades out in sunlight, so that it appears only temporarily on exterior surfaces, unless they are always well shielded from sunlight.

When discoloration appears, it usually does so within a few hours or, at most, a few days after the paint has been applied. If the wood is dry when painted

but becomes wet soon afterward, the appearance of the discoloration may be delayed until shortly after the entrance of the moisture. Once paint is thoroughly dry and has aged for a few months, however, it evidently becomes immune to discoloration. Nevertheless, if paint has once become discolored, a fresh coat of paint applied over it even several years later is likely to show the discoloration again.

Movement of Oils

The aromatic oils in Eastern redcedar, incense-cedar, and Port Orford cedar are soluble in the usual finishing films, and thus often cause softening, wrinkling, and general disintegration of the coatings. A typical paint disintegration caused by oil exudation is shown in figure 3.

In chests or cabinets made of Eastern redcedar the oil seems to diffuse through the wood as a vapor, which condenses or concentrates on the inner walls of the unfinished wood and often stains the contents of the chest. The oil of Eastern redcedar is very slightly volatile, and thus imparts its aromatic odor. Any process used to decrease the quantity of oil present in Eastern redcedar will, of course, reduce the intensity of the favorable odors, and where such odors are particularly desirable, care must be taken in the oil-reduction process not to carry it too far.

Port Orford cedar containing concentrated quantities of oil can often be detected and segregated in any fabrication process. Concentrations of oil seem to run in streaks that result in paint wrinkling, as is shown in figure 3. Although the oil is volatile, it probably does not evaporate so fast as water during the seasoning process, so that the wood often contains considerable quantities of oil after becoming dry. The oil diffuses through the wood and concentrates on the surfaces of the finished articles, such as Venetian-blind slats that are bundled together, where it softens and mars the paint or finishing films. Very often, however, the remaining oil, after the wood has been seasoned, does not diffuse to the outer surfaces unless the finished pieces are heated to a higher temperature than was probably used in the kiln-drying process. Thus Venetian blinds made of Port Orford cedar slats sometimes exude oil when in use, because the exposure to direct sunlight causes heating to higher temperatures at which the oil diffuses through the paint film to cause spotting or discoloration of the paint, and even wrinkling and blistering if sufficient oil is present.

Spanish cedar exudes a gumlike substance containing a volatile aromatic oil that often stains the paper lining of cigar boxes. The evaporation of the oil leaves a sticky residue, difficult to take care of in the finished articles. The aromatic vapor or oil of Spanish cedar is desirable for such uses as cigar boxes, and any treatment or process used to volatilize the oil and to set the

gum so as to prevent subsequent exudation must be used with caution in order to prevent excessive volatilization and loss of these aromatic materials.

The general remedy or process for the prevention of the exudation of these volatile oils is associated with their evaporation. If sufficient evaporation does not take place during the usual seasoning process, the drying process must be extended or the material be treated under conditions accelerating the oil-evaporation process. The latter implies a heat treatment, the generally recommended procedure for which is to kiln dry the stock by the usual methods to a moisture content of 6 to 8 percent and then heat to treat it at 200° F. for 8 to 17 hours at a relative humidity of 60 percent. The oils and gums will exude to the rough surfaces, which are then removed in the dressing process. For Eastern redcedar and Spanish cedar modifications of the duration of the treatment may have to be resorted to in order to maintain sufficient oil to produce the desired aromatic odor.

Port Orford cedar up to 9/4 inches thick can be kiln dried by the schedule given in table 2.

Drying at the temperatures given in that schedule should evaporate considerable quantities of oil. If oil exudation is still experienced in products such as Venetian-blind slats, higher temperature treatments can be made without injury to the stock, provided the relative humidities are adjusted to prevent overdrying.

Port Orford cedar Venetian-blind slats are sometimes heat-treated by passing them through hot rolls, but at best only evaporation of the surface oils is thereby obtained.

Eastern redcedar is rather difficult to dry, and care must be taken to prevent the shelling off of the streaks of sapwood. A satisfactory schedule for kiln drying 1-inch boards of this species is given in table 3.

Recommendations

For Lumber Producers

To producers of lumber the kiln schedules given in this report are the principal recommendations for minimizing difficulties caused by pitch and oils in wood. They represent the best information available at the Forest Products Laboratory on the subject at the present time, but further investigation might lead to still better procedures and is therefore greatly to be desired. As far as

practicable, the difficulties with pitch and oils in wood should be controlled at the point of production of the lumber, because the lumber increases greatly in value as it is remanufactured into finished articles and rejection of troublesome pieces becomes prohibitively expensive, while satisfactory repair of the damage is often impossible.

For Lumber Users

Millwork plants or other lumber users equipped with dry kilns may find the kiln schedules or after-treatments suggested in this publication useful for reducing trouble from exudation of pitch. Users not so equipped, however, can do very little about it. Maintenance of uniform temperature during storage of the lumber in lumber yards or at the job while it awaits erection, is probably helpful. Since turpentine is given off slowly during the storage of lumber, the lumber that has been in the yard longest is probably less susceptible to exudation, and perhaps also to discoloration, than lumber just received.

Boards in a shipment that already have beads of exuded pitch, may well be culled out and used for concealed construction or other places where further development of exudation will not prove seriously objectionable.

When exudation occurs before woodwork has been painted, the painter should remove it before applying paint. If the exuded pitch has hardened, it can be chipped off fairly easily with a putty knife or be removed by sandpapering; but if it is still soft, such procedures smear it over the surface of the wood. If it is left there, the paint later on is likely to alligator, crack, and fail early over the pitch-coated areas. Exuded pitch that is still soft, should be removed thoroughly by scrubbing with rags wet with denatured alcohol and then be sandpapered after most of the soft resin has been scrubbed off. Any further exudation that occurs before subsequent coats of paint are applied, should be removed by scrubbing with alcohol. There are no paints no painting procedures that can be relied upon to prevent exudation of pitch.

On exterior woodwork, exudation that takes place after painting might best be left alone until it is time to repaint. It should then be scraped off thoroughly before applying new paint. If a few boards in the structure have proved particularly unsightly because of exudation or because of early paint failure, it may be wise to replace them with new lumber before repainting. In extreme cases such boards have been known to keep on exuding pitch for many years. Where it is not practicable to put up with exuded pitch because the woodwork may be handled or may come in contact with clothing, prompt replacement of boards from which pitch begins to exude may be the best way out of the difficulty.

On interior woodwork exuded pitch should, as a rule, be scrubbed off with rags wet with denatured alcohol while the beads of pitch are still soft. On surfaces not too conspicuously exposed to view nor likely to be touched by hands or clothing, it may be more convenient to let the beads of pitch harden, after which they can be scraped off, but care should be taken not to scratch the paint or varnish any more than is necessary. In many cases the exudation will reappear and have to be removed a number of times before it no longer occurs. Repainting should be deferred until all further exudation has ceased, or until repainting has become necessary for other reasons. It should be remembered that exudation is favored by fluctuations in temperature or by warming the wood to high temperatures. Insofar as it is practicable to do so, the woodwork should be kept at uniformly moderate temperature in order to reduce the chances of exudation.

Collection of oil on the inside surfaces or on the hardware of cedar chests, or on fabrics kept in them, usually comes from condensation of the vapors evaporated from the wood rather than from exudation. While the chests are in the dealer's hands or when not in use, condensation of vapor within them can usually be prevented by keeping the lids partly open or by removing the lids to permit circulation of fresh air to carry off the vapors as they escape from the wood. While in use the chests must, of course, be kept tightly shut to hold in the vapors, because the vapors provide protection against moths. The fabrics placed in them can be wrapped in paper to retard their absorption of the vapors. Any articles to be left in the chests more than 6 months might well be removed and thoroughly aired twice a year. The interior surfaces of some cedar chests are given a thin coating of varnish or lacquer to retard evaporation of the vapors, but since all evaporation cannot be cut off without destroying its effectiveness against moths, much the same precautions should be taken with both coated and uncoated cedar chests.

Discoloration of paint over the heartwood of pine lumber is exceedingly difficult to do much about once the job has been completed. It usually occurs as a result of allowing the wood to become too damp just before or soon after painting. It is seldom serious on wood that is properly dried and kept dry until the paint has hardened and begins to age. Whenever discoloration does occur and is not too unsightly, the best course is usually to put up with it and to make no attempt to overcome it. On exterior woodwork, the discoloration is generally temporary because it bleaches out in strong light. Once it has appeared on interior surfaces, however, it may persist for years and reappear each time the woodwork is repainted.

In the manufacture of furniture and cabinets it may be possible to select only sapwood for prominent surfaces on which discoloration would be very objectionable, and to use the heartwood for less important parts or for concealed construction.

A priming coat of shellac on the bare wood before painting has long been recommended for preventing discoloration by bleeding of substances soluble in paint vehicles. It is not always successful in preventing discoloration over the heartwood of the pines, possibly because it is sometimes applied too sparingly or unskillfully. It seems to be more successful when applied after the usual paint priming coat has been put on and has dried. The use of shellac in this way, however, is objectionable because it makes the coating more brittle and easier to scratch or chip off, and, in some cases, may cause alligatoring or other early failure of the coating. A priming coat of aluminum paint is likewise recommended for preventing discoloration of this kind. It has the advantage over shellac of not making the coating brittle nor subject to early failure; but, on the other hand, its dark color is hard to hide with white or light-colored paints, so that more paint may have to be applied than would otherwise be the case. The vehicle for aluminum paint for interior woodwork to stop discoloration is not the same as the vehicle preferred for aluminum paint for priming exterior woodwork. For stopping bleeding the vehicle should be a relatively short-oil varnish, such as the kind of varnish commonly used for varnish finishes on interior trim. Two pounds of paste aluminum to 1 gallon of such varnish should be satisfactory.

It has already been pointed out that finish coats of flat paint apparently are less subject to discoloration than finish coats of semigloss paint, and semigloss paint less so than gloss paint or enamel. Application of clear varnish over undercoats of paint is particularly bad from the point of view of discoloration. If the paint is of a color similar to that of the yellow discoloration, the defect will be less objectionable than it is on white paint or paint of a strongly contrasting color.

Since discoloration seldom appears on pine woodwork that is well dried before painting, none of the above suggestions should be taken as general recommendations for painting pine woodwork unless there is some reason to believe that without such precautions the discoloration will appear.

Table 1. --Special kiln-drying schedule for ponderosa pine

Moisture content at which changes should be made	Dry-bulb temperature	Wet-bulb temperature	Relative humidity
Percent	°F.	°F.	Percent
85 or more	120	103	55
80	130	108	48
50	140	112	41
30	150	114	33
20	160	114	24

Table 2. --Schedule for kiln drying Port Orford cedar up to 9/4 inches thick

Moisture content at which changes should be made	Dry-bulb temperature	Wet-bulb temperature	Relative humidity
Percent	°F.	°F.	Percent
30 or more	160	146	70
25	170	144	50
13	180	135	30

Table 3. --Special kiln-drying schedule for 1-inch Eastern redcedar

Moisture content of heartwood samples at which changes should be made	Dry-bulb temperature	Wet-bulb temperature	Relative humidity
Percent	°F.	°F.	Percent
25 or more	140	128	70
20	150	127	50
15	155	124	40
10 to final	160	115	25

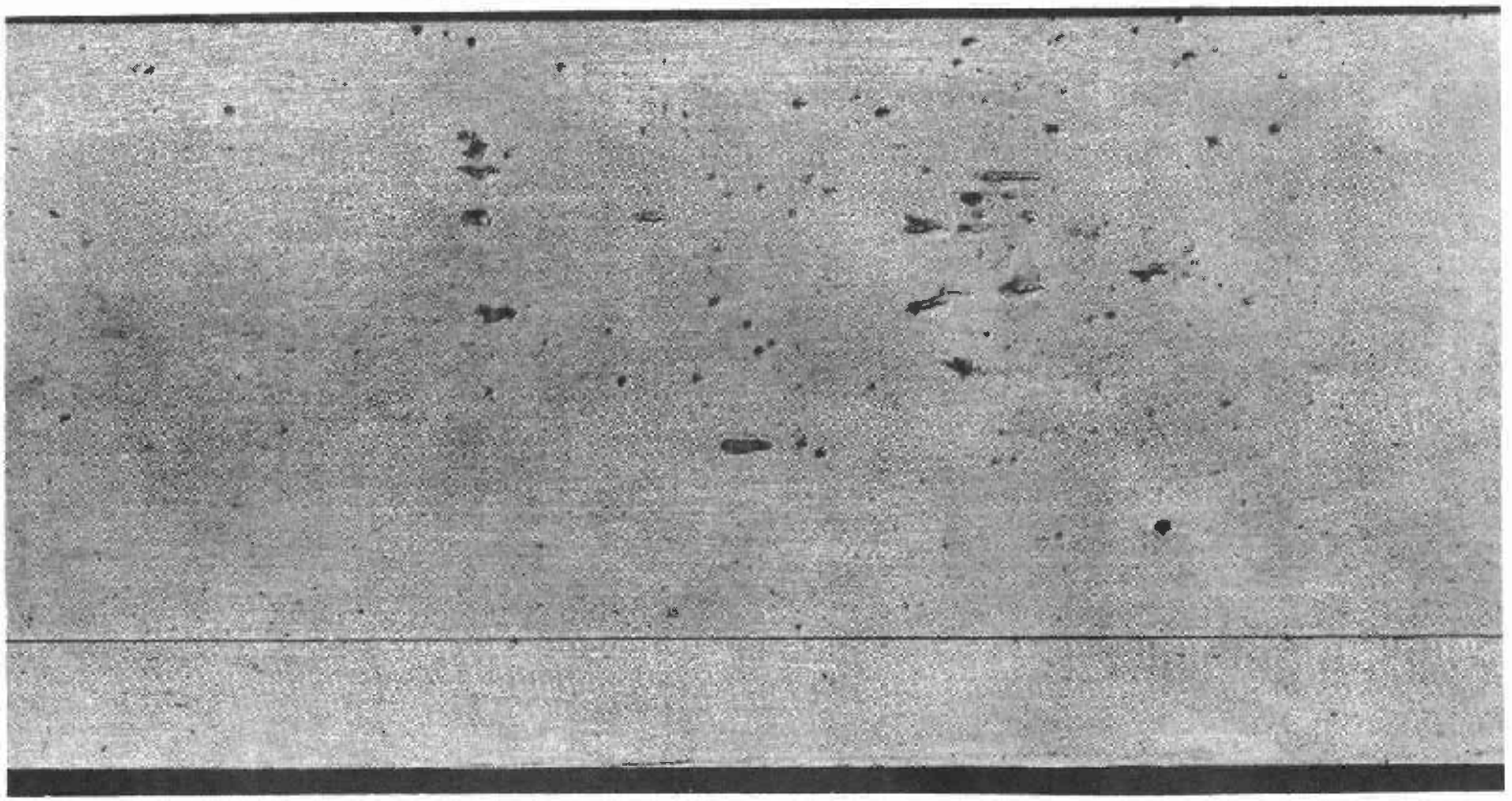


Figure 1.--Exudation of pitch in corner boards. Globules of pitch collecting underneath the paint film cause blistering.

Z M 80307 F

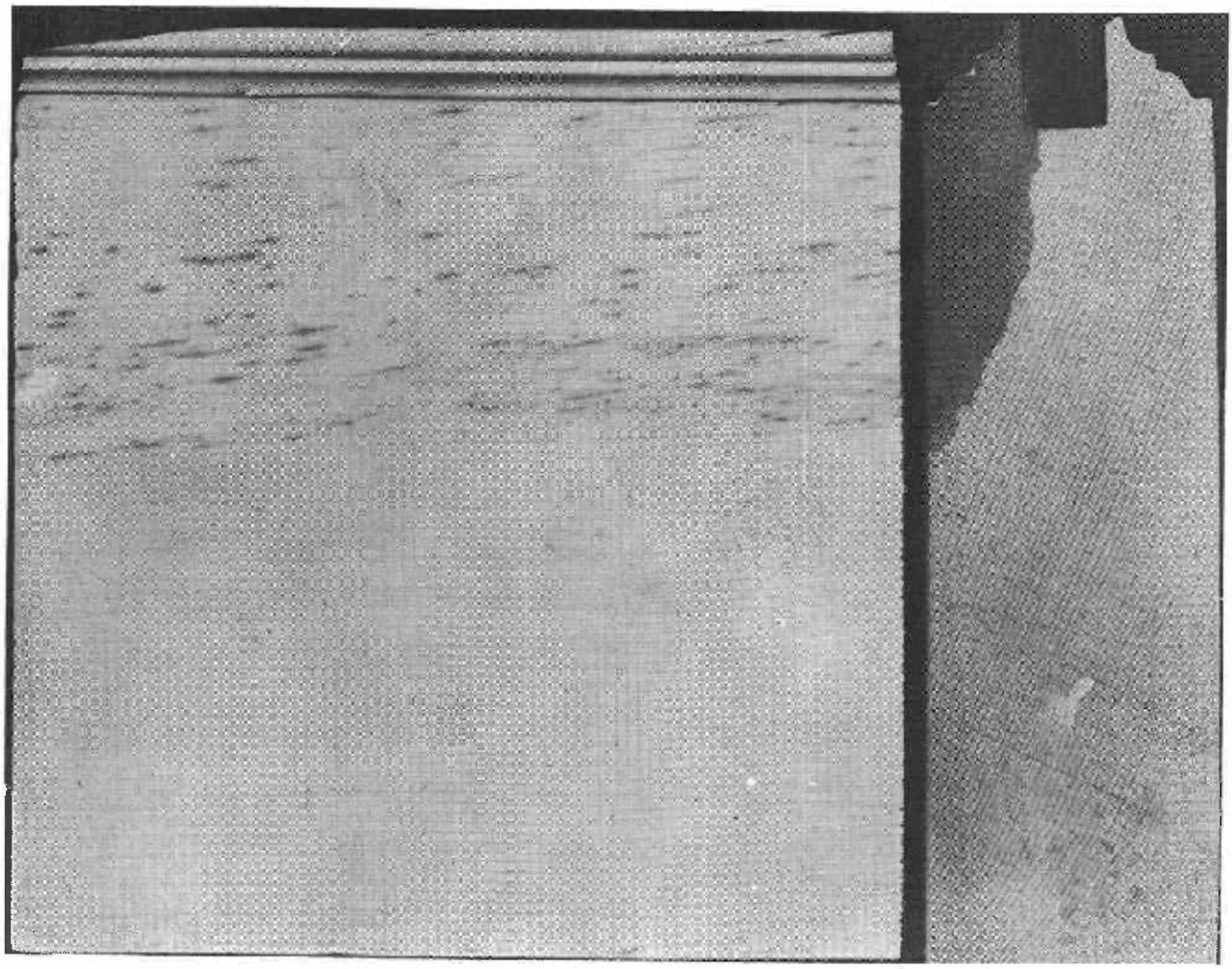


Figure 2.--Paint discoloration over heartwood of wood of the white pine group.

Z M 80308 F

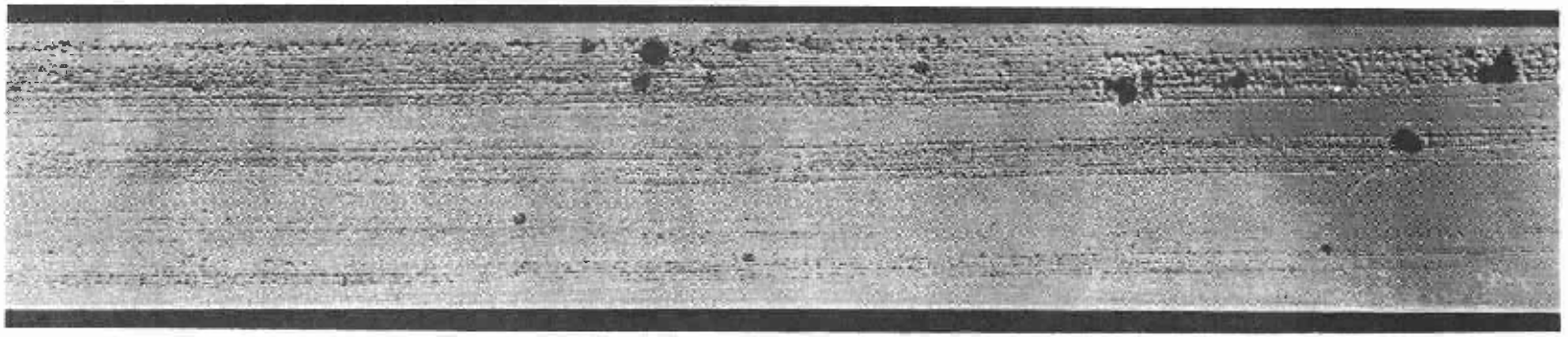


Figure 3.--Exudation of oil in Port Orford cedar, causing wrinkling and blistering of paint films.

Z M 80309 F