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THE STAINING AND MOLDING OF LUMBER
AND OTHER WOOD PRODUCTS

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Most of the discolorations or stains producing de-
grade in lumber and other wood products are caused by certain
organisms of the lower forms of plant life known as fungi.
This type of stain is the most important economically and is
very widespread, causing an annual loss which amounts to sev-
eral millions of dollars. The other type of stain believed
to be due to chemical reactions is not so common but never-
theless causes considerable loss due to degrade.

Stains Chemically Produced

There are several brownish to yellowish stains found
in pines and in hardwoods which are apparently produced by
ferments within the wood. Some of these stains appear in logs
stored for a considerable period in the mill pond, while
others develop during kiln drying or air seasoning. The
stains developing in the kiln can in some cases be wholly or
partially prevented by comparatively low kiln temperatures
(120-130° F.) accompanied by low humidities of 60 per cent or
less. Those developing soon after sawing and said to be
caused by ferments can often be prevented by dipping the green
lumber in boiling water to kill the ferment.

The yellowish to brownish stains common in sugar
pine and western yellow pine seem to differ somewhat in these
two woods. In western yellow pine the stain does not pene-
trate deeply in the sapwood and can usually be planed off,
while in the sugar pine the stain penetrates deeply in both

heartwood and sapwood and is most pronounced at the juncture of the two. This "kiln burn" type of stain in western yellow pine should not be confused with a much darker, patchy "brown stain" of the sapwood and heartwood caused by a fungus. Great care is needed in differentiating between stains produced by chemical action and those produced by fungi.

Stains Produced by Fungi

The stains caused by fungi vary in color from yellow, pink, red, brown, blue and green to black. In general these stains are due to the growth within the wood of minute threads of fungi. These fungi are very small plants which secure their nourishment from the wood they inhabit, feeding principally upon the starches, sugars, and other cell contents. As they develop they find means of progressing from one wood cell to another, usually through the thin parts of the cell walls but occasionally boring through the wall of the wood fiber.

The conditions for the rapid development of fungous stains are essentially the same as for the development of true wood-destroying fungi. These stain fungi require an abundant food supply, a comparatively high moisture content of the wood and warm weather. Stains due to fungi are always worse during rainy periods in the warmer seasons of the year, when the air is very humid and the wood dries correspondingly slowly. Very severe staining may occur under such conditions, particularly if the stock is taken fresh from the saw and piled in bulk or without ample ventilation between the boards. Most staining or molding develops at the mill, or in transit when the lumber is close piled in cars or in the hold of ships. Much staining and molding often develops on wet stock placed in storage and not properly piled or ventilated. During the warm humid months stain may appear in logs or in lumber and other products within 24 to 48 hours after cutting, but develops much slower during the cooler months of the year.

Although stain does not materially affect the mechanical properties of wood for general commercial uses, it should not be present in excessive amounts, since the conditions which permit the luxuriant development of mold and stains also offer the opportunity for infection with wood-destroying fungi. Moreover, an undue amount of stain indicates a high percentage of sapwood, which is not desirable, as a rule, in structural timber on account of its low resistance to decay.

Molding and staining do not greatly affect the strength properties of wood but the value of the wood is lowered for use where discolorations are objectionable. Where the wood is to receive a natural finish, fungus stains are obviously objectionable. Bright stock free of stain is always demanded in certain grades of basket and box veneers, cooperage, box boards, veneer, vehicle, lumber, dimension stock and timbers for export, and a long list of other products. Where the discoloration is to be covered up or painted and where the use of sapwood is not objectionable, there is no reason for discriminating against it providing no wood-destroying fungi are associated with the staining organism. Exceptions to this occur in airplane and similar stock requiring maximum strength. Where sapwood is acceptable, and the customer is not prejudiced against stain, a large amount of stained stock can be used in the manufacture of sash, door, millwork, and a great variety of other wood products which are to be covered with paint.

Many of the staining organisms belong to a large group of fungi commonly termed molds. The molds in general produce stains which rarely penetrate deeply into the wood. Such stains as the yellow stain of oaks and other hardwoods and the grayish-olive stain of hardwoods penetrate the wood to a considerable depth, and cannot readily be dressed off. However, there are a large number of the common black, green and pink molds producing superficial stains which are, in most cases, readily planed off the boards. Products from the cooperage, box, veneer, vehicle and other industries suffer greatly in degrade due to the development of molds and stains upon them. Mold stock should not be made a part of wood containers used in transporting perishable foodstuffs on account of the danger of contamination.

The brown stain of white pine and yellow pine.--The brown stain or "scorch" stain has been found to discolor the best grades of sugar pine, eastern white pine and western yellow pine lumber and considerable loss in degrade has resulted.

The "scorched" areas are somewhat irregularly distributed throughout the sapwood and heartwood and the colors of the patches and streaks range from a light yellowish brown to a rich dark brown, sometimes approaching black. The streaks are sometimes narrow, extending some distance along the grain of the wood. The discoloration is due to a fungus present in the wood and is very difficult to distinguish from the chemically produced brown or yellow stains of sugar pine and western yellow pine.

Blue stain.--Blue stain is common in the sapwood of a large number of woods, both of the hardwood and the softwood groups. The fungus causing the stain grows rapidly and stain may appear in a log or board soon after it is cut. The minute threads of the fungus in the wood tissues are responsible for the blue-gray discoloration. When these threads, feeding on the contents of the wood cells and to a slight extent on the cell walls, reach a certain stage in their development, fruiting bodies are produced upon the surface of the wood. These fruiting bodies appear as minute black specks upon the blued wood, and under a magnifying glass are seen to resemble small black hairs or bristles swollen at the base. These black, flask-like bodies contain the minute spores which when ejected are carried about by the wind and other agencies and are capable of germinating and causing new blue-stain infections. Blue stain at first appears in spots or streaks. Later as the fungus develops deep in the wood, the entire sapwood may be discolored. In this stage it cannot be surfaced off.

When there is not sufficient moisture, the blue stain fungus becomes inactive and can remain dormant in the wood for long periods of time. When favorable moisture conditions return it revives and continues its growth. The bearing of this fact on the piling of lumber for air seasoning or for storage is self evident. Boards cut from the sapwood of slightly blued logs should be stored and piled so that further growth of the fungus will be checked by rapid drying. Otherwise the blue stain will spread. It is equally important to keep the stock dry once it has been properly seasoned, for the fungus will revive and continue to spread as long as sufficient moisture is present.

The "souring" or "fermenting" of the sap has often been given as the direct cause of blue stain. The direct cause, however, is the blue-stain fungus present in the wood. This fungus grows best on substances which contain some acid, and the acid or sour sap, particularly in such woods as sap gum, makes conditions very favorable for rapid development. This is the reason alkaline dips are used in the prevention of sap stains for the acid condition is neutralized and the conditions are then no longer favorable for this development.

Prevention of Staining and Molding

There are three possible methods of combating stains and molds on wood, as follows: Air seasoning, kiln drying and treatment with antiseptic solutions.

Since this paper was written, investigations of sap stain and mold have made it possible to improve control treatments. The reader is referred to the following paper, available at the Laboratory on request: Dipping tests for control of sap stain, mold, and decay in southern lumber and logs, by T. C. Scheffer and A. D. Chapman.

Air seasoning.--Air seasoning, when it can be employed effectively, is believed by many to be the cheapest method to use. Climatic conditions strongly influence the effectiveness of this method. Rapid handling from the time the tree is cut until the lumber is properly stacked in the yards will greatly aid in reducing if not preventing these defects which appear in the stacked material. The piling methods used should afford the maximum of air circulation about the boards and about the piles.

Kiln drying.--Kiln drying appears to be an effective method of control, although if low temperatures are used the molding fungi which are more resistant to heat may develop in the kiln.

It has been determined through tests that a temperature of 140° F. maintained for three hours at saturated atmosphere kills the blue stain fungus in 1-inch and 2-inch stock but not in 4-inch stock. In six hours under the above conditions, the fungus was killed in all three sizes. Temperatures and humidities used in several commercial kiln runs have also been found effective in killing this fungus in 1, 2 and 4-inch stock. Ordinary kiln drying should therefore be effective in killing this fungus and preventing its development, providing the stock is kept in a dry, sanitary condition during subsequent storage. In general, steaming the stock at 170° or 180° F. for a period not exceeding an hour will stop the growth of mold. This treatment heats the surface of the stock sufficiently to kill the mold, and at the same time too rapid drying is prevented by the saturated air.

The process of steaming lumber followed by air seasoning has in many cases given good results in rapidly seasoning the stock and in preventing, to a considerable extent, the development of stains and molds. However, under unfavorable weather conditions and improper steaming the stock often stains and molds during air seasoning. The blue-stain fungus is killed when present in 4/4 gum boards steamed under pressure of 30 pounds for 40 minutes.

Antiseptic treatment.--The antiseptic treatment of wood with solutions to prevent staining and molding has been practiced for some time with varying degrees of success. Sodium carbonate (soda ash) and sodium bicarbonate (baking soda) are the chemicals most commonly used in this method of control, which consists in chemical or hand dipping the stock as it comes from the saw in a heated chemical solution.

Neither of the two chemicals mentioned is a perfect preventative under severe conditions, such as continuous rainy periods during the warmer months, but either will go far toward keeping the stock clean. In rainy seasons an 8 per cent solution of sodium carbonate is desirable. In drier weather half this should suffice. A high grade of soda ash should contain about 58-1/2 per cent alkali and every effort should be made to conform to this standard of purity. When sodium bicarbonate is used, an 11 per cent solution should be employed in wet weather and 5 to 6 per cent in dry weather. This chemical, when dry and pure, should contain about 37 per cent alkali.

There are other chemical dips which have been employed under semi-commercial conditions, the most promising being mercuric chloride (corrosive sublimate) and sodium fluoride. The former gave excellent experimental results in a 0.1 per cent solution but on account of its highly poisonous character its general use is not recommended. Sodium fluoride in a 3 per cent solution can be used successfully against blue stain but has not given completely satisfactory results, under severe conditions, against molds.

In the use of these chemical dips, the following points should be kept in mind: (1) The solutions should be carefully mixed and the concentrations in the dipping tanks should be kept uniform by means of a hydrometer. (2) The solutions should be heated when applied, the bicarbonate solution not above 120° F., however, because it is broken down into the carbonate by excessive heating. (3) The stock should be dipped as it comes from the saw. (4) After dipping it should be carefully piled so as to insure ample ventilation. Narrow, chemically-treated cross strips are preferable to the wide untreated strips commonly employed, since treated crossers tend to eliminate stain at the point of contact.

It is evident that the conditions under which the stock is stored after treatment are highly important factors in the control of stain. Proper methods of piling and protection of stored material against moisture are vital points to be considered in preventing stain.

The cost of mechanical dipping of lumber should not exceed 10 to 12 cents per M board feet at the 1922 prices of chemicals.

There is at present no perfect method for controlling the staining and molding of wood. However, experiments are in progress aiming at finding better methods of prevention.

SUMMARY

There are two types of wood stains: (1) those due to purely chemical reactions in sound wood; (2) those produced by fungi.

The latter are by far the most important and affect a large number of different woods, hardwoods as well as conifers.

Most of the mold stains are superficial and readily surface off, but the "blue stain" often discolors the entire sapwood and is hence the most conspicuous on dressed lumber.

Sap-stained wood can be used for ordinary commercial use when its appearance is not objectionable, where it is to be covered up or painted over or where durability in respect to decay or where strength is not of prime importance.

The chemical stains are limited to a comparatively few kinds of timber and usually penetrate deeply both the sapwood and heartwood.

Neither fungus stains nor chemical stains weaken the timber to any appreciable extent. However, a luxuriant development of fungus stain implies that the timber has been piled in a moist, poorly ventilated condition which also favors infection with true wood-rotting fungi.

Fungus stain can be prevented by kiln drying or can be largely controlled by open piling in air drying, or better, by dipping the fresh stock in antiseptic solutions and then piling properly.

Chemical stains can be largely prevented by maintaining low temperatures and low humidities in the dry kiln during the conditioning process. In air-seasoned stock, the ferments causing stain may be killed by dipping in boiling water.