SOME COMMON STAINS OF SOFTWOOD LUMBER

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Lumber Grading Rules generally define stain as a discoloration that is different than the "natural color" of the rest of the board. It may be graded as light, medium or heavy stain according to the intensity of discoloration. Light stain may be barely perceptible and does not materially affect a natural finish. At the other extreme, heavy stain may obscure the wood grain and is unacceptable for a clear finish, but is suitable for painting.

The Rules may differentiate between heartwood stain and sapwood stain. They also may note that where stain is permitted it does not affect the intended use of the piece. That is, stain degrades the appearance of the wood, but otherwise has no practical effect on its strength or utility.

The most common and troublesome stains are the bluish-gray sap stains, and, to a lesser degree, the brown stains. The blue-gray sap stains are usually caused by wood-staining fungi growing in moist sapwood. Brown stains often are of nonfungal origin and may result from the darkening of materials which occur naturally in the wood. They generally are called "chemical" brown stains.

Other less prevalent discolorations (pink, purplish, yellowing and tans), may occur in heartwood of living trees, or in old logs. They are likely to be an incipient stage of rot; i.e. "Firm Red Heart" is the incipient stage of red ring rot caused by the fungus F. pini. Occasionally we see samples of unusual staining which we can't identify. They often are nonfungal and the suggested causes might be anything from freakish weather to Mt. St. Helens. (May be some truth there in some cases).

I'll talk first about fungal stains in sapwood, and later discuss some common examples of chemical brown stain.

Fungal stains

What are these fungi; how do they cause stain and decay in wood, and how can we control them? The kinds of fungi that damage wood are:

1) Mold fungi which generally discolor only the surface and do not weaken the wood. The color usually can be removed by planing.
2) Sapstain fungi cause a deeper discoloration of sapwood (some Grading Rules define stain as a discoloration that "penetrates the wood fiber"). For most practical purposes, these fungi don't weaken the wood.

3) Decay fungi - may develop in heartwood as well as in sapwood. They weaken the wood by feeding on the cell walls.

Mold, sapstain and decay fungi are plants and have plant-like requirements for growth. But unlike green plants which need sunlight and are able to manufacture their food, these fungi use some portion of the wood for food and can grow in the dark. Contents of ray cells are food for mold and sap-stain fungi, whereas decay fungi feed also on woody cell walls which they perforate, erode, and eventually break down. Damp conditions favor fungal growth, but most cannot flourish in wood that is too wet, (not enough oxygen), nor can they grow in wood dried to $\leq$ 20% MC. Oxygen is necessary for their growth and may become a limiting factor when excluded by immersing wood in water, (like underside of a ponded long), or by keeping it saturated by sprinkling. Mild temperatures cause fungi to flourish. Freezing emperatures prevent their growth, but are not fatal. High temperatures are fatal. In green wood, a temperature of 150 degrees Fahrenheit for one hour will kill most fungi. (see Kiln Operators Manual, sterilizing treatments).

Fungi invade wood by direct contact with infected pieces, or by germinating from microscopic seed-like spores which float unseen in the air and may be carried about by wind, insects, contaminated equipment, etc. The spores do not germinate very well until EMC conditions rise about 20%, or wood surfaces become wetted. High humidity conditions (>90% RH) not only increases the percentage of spores able to germinate, but also allow spores to germinate sooner. Germinating spores send out microscopic root-like strands called hyphae which penetrate below the surface and develop into an extensive branching system within the wood. The hyphae secrete enzymes which dissolve and convert woody materials into food that can be used by the fungus.

Young hyphae are fine, colorless and difficult to see even under the microscope; they do not discolor the wood. The hyphae of blue-staining fungi become large and dark colored as they mature. It is the dark hyphae which impart the characteristic bluish-gray color to stained sapwood (wood infected by immature hyphae would not yet show stain). The young hyphae will mature and darken most rapidly when growth conditions are good ($\sim 80^{\circ}$F and MC above FSP). The speed of darkening can vary among different strains of fungus, but can occur within ten days. Visible staining is not likely in wood below FSP. This may be a good time to mention something about how long some fungi may survive in very dry or in very wet wood:

Generally, the wood-rotting fungi survive longer than the wood-stainers in dry wood. Most of the fungi tested were able to survive indoors in dry wood (MC - 6-9%), for at least two years; some fungi capable of rotting wood lived about twice as long -- one species lasted 11 years!

If infected wood is rewetted so its MC increases to ∿ FSP, the dormant fungus can resume growth. High humidity (90% RH) alone is not enough to restart active fungal growth in wood (EMC = ∿22%), unless condensation occurs to put liquid water on cool surfaces, (mold may grow on the wood surface).

In saturated wood the fungus does not lack moisture, but if the cell lumens are filled with water there may not be enough air space to provide adequate oxygen. Oxygen requirements of wood inhabiting fungi are generally very low and some common wood-rotters have easily survived for nine months in completely saturated sapwood. Hence, ponding and sprinkling can help to control growth of stain and rot in logs, but ordinarily do not kill the fungus.

Nonfungal or "chemical" stains

These stains seem to be caused by substances already in the tree -- probably in the sap (not an infection like fungal stain). They tend to develop at or just beneath the surface of drying lumber but some may penetrate deeply. Some kinds appear on drying log ends and stumps as well as on lumber. A common theory is that soluble staining substances may be carried along toward the drying surface and become concentrated there. Darkening of the concentrate may be an oxidation process brought on by exposure to the atmosphere and more available oxygen -- (like browning of a cut apple).

Brown stain of hemlock, seen most frequently on ends of lumber, is caused by the movement of extractives (mostly catechin) to the wood surface where they oxidize, forming the brown color. Alkaline conditions as with some dips used to control blue stain, may intensify the brown color. Most of the research on hemlock brown stain has been done in Canada. Chemicals tested there reduced staining in laboratory screening tests, but were not long-lasting enought to protect green hemlock lumber during the drying process.

White pine may be subject to an enzymatic brown stain in the heartwood or sapwood. Prompt removal and processing of logs and dipping freshly sawn lumber in solutions of sodium azide or sodium fluoride have reduced or prevented this kind of stain. Less toxic solutions of ammoniacal zinc oxide, sodium carbonate, or phosphoric acid have been effective in small-scale trials.

Brown stain sometimes develops in the sapwood of Douglas-fir where it has been especially troublesome to exporters supplying clears to the Italian market. Its appearance often resembles the brown stain seen on hemlock, but colors vary from pale yellowish tan, through shades of brown to reddish brown. Dip treatments that controlled or recuded brown stain on pine and hemlock did not control brown stain on Douglas-fir, but steaming to raise the temperature of the green sapwood to ∿212°F for ∿ 2 hours prevented later development of the stain.

A different kind of brown discoloration sometimes occurs in ponderosa pine sapwood during kiln drying of lumber from pond-stored logs. The ponds have been found to contain bacteria that infested the sapwood causing a "sourlog" smell and producing chemicals that reacted with air and heat to cause the brown stain. Storing logs in sprinkled decks rather than in stagnant ponds has helped to reduce the problem.

Control of fungal stains

Stains may be of fungal or non-fungal origin. A first step in their control is to identify the kind of stain and then select an appropriate control procedure.

Fungal staining can be prevented or reduced by prompt removal of logs from the woods and conversion into dry lumber or by storage in ponds. Sprinkling cold decks with water prevents fungal attack if surfaces of the logs can be kept well wetted. Sprinkling also prevents drying and checking and reduces insect attack. (Also provides fire protection).

Fungal stain also can be prevented by protective chemical treatments. Dips and sprays are surface treatments, they won't stop fungus that has already penetrated into the wood. During warm weather you should dip as soon as possible - not more than one day delay. Tests have shown that, if conditions are favorable for 48 hours, the fungal hyphae can penetrate into the wood beyond the depth reached by dip or spray treatment. Of course, delays are safer during cool weather when fungal growth is slowed. Recent emphasis is to find treatments that are safer to use and still effective.

If you dip to control fungal (and some chemical) stains:

- follow the manufacturer's recommendations closely
- maintain proper solution concentration
- get full coverage

Control of chemical (brown) stains

Generally, get logs out of the woods and through the mill and kiln as soon as possible. Avoid sour pond conditions and, if necessary, use kiln schedules recommended for control of brown stain. Effective dip treatments for chemical stain are presently limited to controlling enzymatic brown stains in white and sugar pines. Steam treatments prevented the development of brown stain in coast Douglas-fir, but in practice there is no effective control being used on either Douglas-fir or hemlock.

In closing, I wish to commend Charlie for his unflagging efforts in putting this meeting together, and for his selection of Harrah's as our host where freebie bar coupons have finally brought Watneys within my grasp.