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CAUSES AND CURES FOR STAINS IN DRIED LUMBER: Sticker Stain, Chemical Stain, Iron Stain and Blue Stain

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STICKER STAIN

One of the more common drying problems today is a dark area noted on dried, planed lumber. This discolored or stained area runs across the width of a piece of lumber and is at the same location where a sticker was located during drying. Typically, the stain is not seen in rough lumber; it is only evident after planing. The defect is called sticker stain or sticker shadow. ("Shadow" is often preferred by lumber graders, as the word "stain," according to the NHLA definition, means the early evidences of decay. However, tradition has resulted in widespread use of the term "sticker stain.")

Sticker stain seems to have been more severe and more common in 1990-92 than during the past 15 years, although there have been outbreaks of sticker stain from time to time in the 1950's and 60's. The reason for past outbreaks, and the higher incidence today, is not known, but it may be related to the unusually cool and damp weather we've had recently and the effects of this unusual weather on the trees' chemical makeup.

Several other reasons for the high incidence of sticker stain problems today include the increased use of light-colored finishes, the elimination of bleaching from the finishing process, and the general surplus of the "white" woods in the marketplace (customers are more choosey when it comes to quality factors of lumber). Perhaps today's antifungal chemical dips and today's composite stickers are also aggravating the stain, but they are certainly not causing it.

Often drying specialists include the lack of knowledge on drying lumber as an important factor in the increased occurrence of stain. It seems that many new drying personnel have forgotten or never learned the basic principles of drying white woods. Further, their equipment is often geared to oak drying, not white wood drying.

Some Basic Principles of White Wood Drying

The basic cause of sticker stain is slow drying (probably under 5% MC loss per day) at warm temperatures (50 to 130°F) when the lumber is above 40% moisture content (MC). These slow drying conditions encourage a chemical reaction to proceed in the wood; this reaction will eventually, as the lumber dries, lead to discoloration. The discoloration itself may, in fact, not show up until much later in drying—that is, the final oxidation and discoloration may actually occur below 15% MC. This final discoloration is accentuated by using temperatures over 150°F during the final steps of the kiln schedule. But it is the initial slow drying, before the discoloration itself occurs, that is the fundamental cause.

Poor handling of the wood before drying begins can also lead to a high incidence of sticker stain. Poor handling includes long log storage in

warm weather and holding freshly sawn lumber in an unstickered bundle for a day or longer before stacking.

It is important to recognize that sticker stain is not a fungal stain. However, the slow drying that results in sticker stain can also result in fungal staining if other conditions for fungal activity are appropriate.

Because sticker stain is actually a result of the oxidation of naturally occurring chemicals within wood (perhaps catalyzed by wood enzymes), there is little opportunity to control stain in freshly cut lumber with chemical dips--including the fungicide dips for blue stain control--or chemical treatments to inhibit the reaction. Some people have attempted to treat the lumber with oxidation-inhibiting chemicals; others have tried using enzyme-inhibiting chemicals. The problem with these chemical treatments has been getting the chemical deep within the wood quickly, rather than just providing a surface treatment.

CONCLUSION: The only practical, 100% cure for sticker stain is to achieve fast drying under the stickers.

Risk Factors for Sticker Stain

There are certain procedures or events that will encourage sticker stain formation (that is, cause or result in slow drying under the stickers, or alter the wood itself in some way). Most of these procedures or events are most serious when the MC of the lumber is over 40% MC. They include

Before sawing

- Using old logs that have been stored during warm weather.
- Storing freshly sawn lumber more than 12 hours in warm weather before stacking.

Stacking and handling

- Using stickers wetter than 10% MC.
- Using stickers wider than 1-1/2 inches or thinner than 3/4 inches.
- Exposing stacked lumber to rain, especially when above 20% MC, and in warm weather.
- Exposing stacked lumber to slow drying conditions.

Kiln equipment and procedures

- Using a kiln load that is over 16 feet-wide with air velocity under 500 feet per minute.
- Using a "snow melting" or "thawing" kiln procedure.
- Developing kiln relative humidities, after the first 6 hours of drying, that exceed the recommendations. For most white woods, a 10°F depression is mandatory for green 4/4 and 5/4 lumber.
- Using kiln temperatures over 160°F, especially when the lumber is above 20% MC.
- Using fan reversal cycles longer than two hours.

Practical Cures

The cures for sticker stain involve drying the lumber under the stickers as quickly as possible while avoiding wet stickers, avoiding high kiln temperatures, and using good schedules and controls. Specifically,

Before sawing

- Use fresh logs that have been stored less than 2 weeks during warm weather.
- In warm weather, stack freshly sawn lumber within 12 hours.

Stacking and Handling

- Use stickers between 8% and 10% MC; get stickers from the unstacker rather than from storage.
- After one week of drying, unstack and resticker the lumber using new, dry stickers placed in a new location on the lumber.
- Use stickers 1-1/4-inches wide by 3/4- or 7/8-inches thick.
- Use a grooved sticker for extra advantage.

- Keep stacked lumber out of the rain, especially at high MCs in warm weather.

- After stacking, if not loaded directly into the kiln, place lumber in fast-drying locations, like fan-sheds or blow boxes.

Kiln Equipment and Procedures

- Use a kiln load narrower than 16 feet, with an air velocity greater than 500 fpm.

- Do not use a "snow melting" or "thawing" kiln procedure. Avoid kiln conditions that would re-wet partially dried lumber.

- Reverse fans every two hours.

- Use correct kiln sampling procedures.

- Develop kiln relative humidities, within the first 6 hours of drying, that are at least equivalent to a 10°F depression. Larger depressions may be required if recommended in the schedule. In humid weather, kiln temperatures may have to be raised slightly to achieve the low humidities required.

- Do not over-condition the lumber.

- Use low kiln temperatures, never exceeding 160°F, except during equalizing and conditioning.

- Load the kiln with only two rows of lumber, rather than 3 or 4, for the first 12 to 24 hours to achieve the required humidity.

- If lumber has been air-dried or mishandled, use a kiln schedule that operates at very low temperatures (Schedule CS2 in Drying Eastern Hardwood Lumber).

Summary

Sticker stain is a common problem when drying white-colored hardwoods. Stain results because of slow drying under stickers when temperatures are warm. There are many practical techniques and procedures that can be used to develop fast drying under the stickers and prevent staining, provided the lumber was not damaged prior to receipt at the drying operation. Of all procedures discussed, dry stickers and control of relative humidities in the dryer when the lumber is over 40% MC are most important.

OTHER CHEMICAL STAINS AND IRON STAINS

Chemical stains include a variety of discolorations that occur in wood during drying but are usually first noticed after drying is complete. In addition to sticker stain, other chemical stains include

- Interior graying, which is noted especially in southern oak, hackberry, maple, and ash, but can be seen in many species;

- Brown stain (often called coffee stain), which is prevalent in white pine and thick pieces of most pine species; and

- Pinking and browning in the interior of light-colored woods, such as hard maple.

Iron tannate stain, which is dark blue or black in color, is seen primarily in oak. Iron tannate stain is of a different origin and has a different cure than the chemical stains; it is discussed at the end of this section.

Chemical Stains

Chemical stains develop when naturally occurring chemicals in wood react with air (an enzymatic oxidation reaction) to form a new chemical that is typically dark in color. A key point in the formation of these stains is that the chemical precursors, which develop in the wood and will eventually lead to discoloration, are developed above 40% MC. Once the precursors develop, staining is probably inevitable. Stain control must be initiated, therefore, at high MCs.

Further, it is difficult, or impossible, to detect when the precursors have formed. Inspection of air-dried lumber may show no hint of discoloration; yet, after kiln drying, the stain is present. Stain in air-dried lumber is seldom the kiln operator's fault.

In other cases, the surface of the lumber may already be below 40% MC when the precursors are developed. In this case, the stain will develop

only in the interior of the piece of lumber and will not be seen until the lumber is planed or ripped. (Certain woods, such as walnut and teak, may develop a discolored core after drying. This discoloration is only temporary and will disappear with light and time.)

If there is any doubt as to whether the stain is a chemical stain or fungal stain, the stain can be treated with a drop or two of concentrated oxalic acid. The acid will bleach chemical and iron tannate stains, but will not change fungal stains.

Essential Requirements

What characteristics cause chemical stains to develop? In short, whenever wood dries slowly and temperatures are warm to hot, the enzymatic oxidation reaction will begin to take place. The longer poor drying conditions exist, the more the reaction proceeds inward and the darker the color. The reaction is most active around the zone line dividing the center region of the lumber that is above 30% MC from the outer region that is under 30% MC.

To control chemical staining, attention must be focused on the causes of, and cures for, slow drying, especially at times when wood is above 40% MC.

Slow drying can be caused by various factors:

- High relative humidity in the initial stages of drying
- Slow air velocities and/or long air flow paths (air passes through more than 16 feet of lumber before being reheated)
- Snow melting schedules using high RHs
- Overloaded predryers or kilns (desired relative humidities are not quickly achieved)
- Foggy, or humid, warm air-drying weather

The list here is not exhaustive, but it includes the most common causes. Usually there will be several undesirable conditions that, when combined, result in staining. Individually, the condition may be tolerable. Each of these items is discussed briefly below.

High relative humidity. The most frequent cause of chemical staining is relative humidities in predryers or kilns that are too high. (Note: It is the actual conditions in the dryer that are critical, not the conditions set on the controller.) For most light-colored woods, the initial kiln drying settings are 130°F with a 10°F wet-bulb depression (equivalent to 65% relative humidity). Predryer conditions, which use a lower dry-bulb temperature, must be even lower in humidity. Failure to achieve this initial humidity when the wood is warm will likely lead to staining. If kept at high humidities for very long, the staining will proceed and worsen.

Air flow. The relative humidity may be acceptable when the air enters a load of lumber. Because of slow air velocity and/or long air travel paths before the air is reheated, however, the humidity in the air will rapidly increase. In the interior of the pile, the humidity can be high enough to result in staining.

Snow melting. A "snow or ice melting" schedule, or "lumber thawing" schedule (often 80°F at 100% RH for 24-hours), is ideal for stain development.

Overloaded predryer. A lumber predryer or kiln that is loaded with too much wet lumber, or a drying schedule that requires a low wet-bulb temperature (which cannot be achieved), especially during hot, humid weather, can result in excessively high RHs in the dryer.

Humid weather. Springtime weather often provides very good air-drying. An occasional spell of warm, foggy weather, or rain, however, can provide excellent conditions for stain initiation.

Iron Tannate Stain

Iron tannate stain is a result of a chemical reaction between wood tannins, water and iron. Control is achieved by eliminating the source of iron. Typical iron sources are rusty metal in the kiln (such as roof vents or fan floors). Water condenses on these iron items and then drips on the lumber. Rusty, iron steam spray pipes, with inadequate water draining systems, can also cause iron stain. Spray lines should drain by gravity, should have a small pipe at the end to carry away water, and should have spray holes facing upward (on the top half of the pipe). Occasionally, the source of iron can be metal chains or forks used in handling the lumber. In this latter case, the stain seldom penetrates the lumber surface more than 1/64 of an inch.

SAP STAIN (BLUE STAIN)

When wood is exposed to slow drying conditions, it is likely that the sapwood will become infected with a fungus that results in discoloration of the lumber. This discoloration is called sap stain, or blue stain. The typical coloration is blue, gray or black. The color is actually due to the color of the fungus itself, rather than a color change within the wood cells or chemicals. Although the fungus does not appreciably affect the strength of the wood, it does create color problems for wood that will be finished with light-colored or clear finishes. Prevention and control of blue stain is easily achieved either through better drying or chemical treatments. The following discussion covers prevention and control of sap stain.

Essential Requirements

Sap stain is caused by a fungus. Although lumber can be sterilized before drying begins, the causal fungus is so prevalent in the air that sterilized wood can be reinfected after only a brief exposure to air. Therefore, control of sap stain is achieved only by controlling the environmental conditions necessary for the fungus' survival. In order for the fungus to grow, it has four essential requirements:

1. The temperature must be between 50 and 130°F. Optimum fungal growth occurs between 70 and 90°F. Below 50°F, the fungus is dormant; above 130°F it is killed.

2. There must be sufficient oxygen present. In living trees, or in logs or lumber continuously sprinkled with water, there is not enough oxygen for the fungus to grow. Once drying starts, however, sufficient oxygen is present. Sprinkling after drying begins will not control the fungus.

3. There must be sufficient moisture available. In general, there is sufficient moisture when the wood moisture content is above 22%. In practice, the greatest risk of staining damage exists above 40% average MC.

4. There must be food available, in the form of sugars. There is usually an inadequate food supply in the heartwood, so the fungus is found only in the sapwood. The sugar content does not vary appreciably throughout the year, so there is always a risk of sap stain whenever the other conditions are favorable.

Control

In order to control the fungus, at least one of these four requirements for growth must be eliminated. Let's look at each of these four in a little more detail.

Temperature. Temperature can seldom be controlled well enough in drying to control the fungus. In the winter, there is little risk to lumber stored outdoors. However, when the lumber is brought into a predryer or kiln and temperatures are favorable, the staining process can begin or continue.

Oxygen. Oxygen levels are difficult to control, as oxygen is present everywhere. Sprinkling of freshly sawn lumber is one possible control technique, but water may present chemical staining problems.

Water. The easiest of the four requirements to eliminate is moisture. Rapid drying (relative humidities under 92%) will control the blue stain fungus. (It is important to understand that the recorded conditions represent the relative humidity of the air entering a pile of lumber. With poor air flow or long air travel paths, the relative humidity of the air can increase enough to establish favorable staining conditions within the lumber pile.)

Food. When drying will not be rapid, the only viable alternative when temperatures are above 50°F is to poison the food supply for the fungus. Typically, the lumber is dipped in a preservative chemical, treating (or poisoning) the wood fibers at the outer surface. This barrier of poisoned wood prevents the fungus from entering the wood as well as prevents its growth on the surface. (If the wood is already infected before treating or if a split or crack develops exposing untreated wood, then the fungus can develop.)

Chemical Treatments

As with all noxious chemicals, care must be exercised in the application of blue stain-preventative chemicals to avoid both human and environmental risks. A license is required for the application of some chemicals. Licensing requires knowledge of the risks of handling many different chemicals, and is encouraged before the use of any sap stain preventative.

Generally, the chemical should be applied whenever temperatures are expected to exceed 70°F. With expensive woods, where a little stain is serious, dipping at temperatures above 50°F is safer than trusting the weather forecast. As a rule of thumb, at temperatures of 70°F, lumber should be dipped within two days of sawing; at 80°F, within one day.

KILN DRYING SCHEDULES FOR LIGHT-COLORED WOODS

The following two sets of schedule recommendations, the standard schedule and the new white wood schedule, are based on the schedule designations of the USDA Forest Service's Forest Products Laboratory. The standard schedules have been the recommendation for over 40 years. In light of today's special color requirements and different wood characteristics, the white wood schedules were developed to provide excellent color control. In order to use any kiln schedule, and achieve the color control desired, the following six procedures must be followed exactly:

1. Never exceed 160°F, except during equalizing and conditioning. (Dry-bulb temperatures in the schedules are maximum temperatures.)

2. Use dry-bulb temperatures below 130°F when above 25% MC (or above 20% MC for better protection) if the lumber has been previously mistreated.

3. Never exceed a 45°F depression.

4. Never use less than a 10°F depression, especially when first starting the schedule. Remember, it is "what you get and not what you set" that is important.

5. Use correct sampling.

6. Air velocity must be brisk throughout the load of lumber.

Species	Standard Schedule 4/4 - 6/4	Standard Schedule 8/4	White Wood Schedule* 4/4 - 6/4	White Wood Schedule* 8/4
Ash, green & white	T8-C3	T5-C2	T5-B5	T2-B4
Ash, black	T8-D4	T5-D3	T5-D5	T2-D4
Basswood	T12-E7	T10-E6	T9-E7	T7-E6
Hackberry	T8-C4	T6-C3	T5-C5	T2-C4
Maple, hard	T8-C3	T5-C2	T3-C5 T1-C5 CS-2***	**
Maple, soft	T8-D4	T6-C3	T5-D5	T3-C4

* It may not be possible to achieve the low wet-bulb depression and wet-bulb temperatures specified during the summer. Raise the dry-bulb temperature slightly to achieve the correct wet-bulb depression or else don't dry white woods green-from-the saw in warm, humid weather--wait until the outside conditions are drier.

** T1-C4 will often work well, but careful attention to checking is required, as well as proper operation and calibration of equipment.

*** See Drying Eastern Hardwood Lumber.

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