THE ELIMINATION OF SUGAR PINE BROWN STAIN

By Edwin Knight, Western Pine Association

We take great pleasure in being able to state that there is now a successful means of eliminating Sugar Pine brown stain. This has been more than 30 years in coming after considerable effort by many people. Research was done on a national level by the U. S. Forest Products Laboratory, on a regional level by the Western Pine Association Laboratory with cooperating mills and by many others. Some of you are partially familiar with the final phases of the work through your assistance in the testing program.

HISTORY

Our first directed research was in the year 1937. At that time an initial survey of the problem prompted a meeting of those interested in the elimination of Sugar Pine brown stain. Those present told their experiences and observations as the first step toward bringing definite planning into this research.

The factor studied first by the Western Pine Laboratory was log storage. Rapid handling was established as an important factor. The time from felling to sawing was found to influence the amount of stain in the lumber. However, 4% of stain unaccounted for in fresh logs showed that other factors were important. Some years later our further study established proof that the greatest single influence on the amount of stain occurring from fresh logs was the time in storage from sawing to stickering for kiln drying. Still there were other troublesome problems. It was not always feasible to sticker the Sugar Pine for kiln drying as fast as it accumulated. If the lumber was wet by fog or rain before kiln drying, the stain was found to develop in the wetted areas. Kiln drying partially air dried Sugar Pine was particularly troublesome. The reason was not known. But the observation of the pattern of the stain development caused kiln operators to avoid any kiln drying condition that caused wetting the lumber. This practice led to the use of very low starting kiln temperatures in order to avoid wetting by condensation. This prolonged the drying time and in spite of these precautions stain continued to be troublesome at times.

IMPORTANCE OF THE PROBLEM

In this day of increasing competition among building materials, it is very important for lumber to have an attractive appearance if it is to hold its markets. Wood is often preferred as a building material because of its characteristic beauty. Stain discolorations are not a part of this preference. There is a growing demand for color in products today, but the customer wants to choose his own color scheme, not the motley array of tones of stain that chance handling and seasoning may produce. These stains are not natural characteristics. The are seasoning defects and as such should not be tolerated. Now we no longer have to do so.

We have a number of good dips for the prevention of blue stain. Out of our efforts to prevent decay in wood by the use of "Penta" (sodium pentachlorophenate) has developed the use of the water borne salt of this chemical compound now in common use for blue stain control along with "Lignasan" (mercury ethyl phospate) for this use. Our current research has now proved the effectiveness of another product, the sodium azide dip, for the elimination of brown stain in Sugar Pine. We still need a good control for the brown sap stain of sour logs. Work is being done on this problem.

CURRENT RESEARCH

It was the lack of a practical remedy for the elimination of Sugar Pine brown stain that led to the recent research on which we are now reporting. The current work, begun in 1957, first reviewed the previous efforts along this line. The logical approach appeared to be in the field of the bio-chemist. This was the route used in attacking the problem. The first step was to determine the manner in which the brown stain developed in the seasoning process. The stain was produced experimentally. The cause was classified and the inhibitor response to various reagents determined. Freshly cut lumber from fresh logs was held chemically dormant by freezing until the effect of each factor could be tested in the laboratory. The tests showed that the stain forming system had all of the characteristics of a specific plant enzyme. Examples of this group of enzymes are the ones which discolor peaches, apples and potatoes when they are left open to the air. In Sugar Pine there is no visable discoloration of the wood until the temperature is raised during the drying process. Although the first stage of the reaction is begun as soon as the wood is exposed to the air, it may not be seen as a discoloration if the wood is dried at a low enough temperature as in the air drying yard. However, a secondary air activated reaction sometimes slowly darkens the wood. This can often be seen in air seasoned Sugar Pine paneling.

It is not very practical to try to simulate air drying humidities and temperatures in the dry kiln although that is part of the purpose in schedules which call for running the fans without turning heat into the chamber during the initial phases of the drying. This slows down the drying and is not fully successful in preventing brown stain. Further, the use of temperatures within these low ranges are actually close to the ideal incubation temperatures of the enzymatic reaction. More realistic schedules will be possible with the use of the inhibitor.

The effect of air can be seen by the stain around insect holes, shakes and other defects that let in oxygen into the log. In these locations the stain forming reaction has already taken place and no amount of schedule manipulation does any good in preventing the formation of the brown stain when the wood is dried. Unfortunately some stain will still occur in those areas, even when properly dipped with the stain inhibitor. However the degrade is generally small because of the naturally low grade in which these defects are present. One of the early efforts to inhibit the brown stain reaction was through the use of heat. This was successfully accomplished in the laboratory when temperatures were quickly raised to 170 to 180 degrees F. and maintained at this level for an hour. This is not considered practical at the mill because there is not time to do it soon enough or effectively enough within the limitations of mill equipment. Why are not the low temperatures, typically used, fully effective as long as the humidities are sufficiently low to prevent moisture accumulating on the surface of the boards? They ARE effective at the surface of the board as a general rule. But, further into the board conditions are more suitable for the stain formation.

The common explanation for the cause of the stain has been a darkening of the sugars in the wood due to carmelization by heat. These products were thought to be moved toward the surface where they concentrated just below the dry surface zone. but our experiments showed that there is no movement of this type. It was found that the stain develops from the surface of the board; first in the sap wood, next in the heart boundary and progressively with time throughout the heart wood. There it persists while fading in the sap wood. From then on further oxidation further lightens the sap wood, but the heart wood becomes more deeply colored as the phenolic tannin-like pigments undergo still further changes during the kiln drying process.

Why does it not occur the same way in Ponderosa Pine? A similar enzyme can be prepared from Ponderosa, but its presence can only be demonstrated after the natural inhibitors have been removed. The brown stain of Sugar Pine is not the same as that which occurs in the sour sap wood. This stain is a bacterial infection that is not controlled by the enzyme inhibitor of Sugar Pine. This type of infection could be found in the sapwood of most other species.

FIELD TEST PROCEDURES

After the laboratory tests were completed the tests were conducted on a mill scale. The best inhibitor found in the laboratory, sodium azide, was used in four concentrations in the mill study. The first group was used without the addition of any blue stain dip. The second had 10 lbs. of a Penta mixture included over the same concentration range of the azide. The next group used 2 lbs. of Lignasan with lower concentrations. (The addition of this anti-blue stain dip builds up an inhibition to the mixture of azide and Lignasan well in excess of the sum of the individual effects of the two reagents). The dip in each of these groups was made up to a volume of 100 gallons of solution by the addition of water. The test samples consisted of 48 packages of 1-M' each of Sugar Pine Sinker. The only selection of the stock was the exclusion of boards that showed openings to the air through insect holes, shakes, etc. Of the four loads each dip concentration; one group was stickered immediately, one after seven days and one after 14 days in solid pile. Another 6 days elapsed before the lumber was put into the kiln. The fourth load from each group was stickered immediately for the air seasoning portion of the test.

Results:

Table 1 gives the results shown by the tests.

Table 1. **Degrade Loss from Sugar Pine Brown Stain**

(Based on $20/M Average Loss for 3 year period)

Per 100 gal. Dip Solution		Degrade Loss $/M			
		Days Held in Solid Pile After Sawing			
lb. Anti-Blue Stain	lb. Azide *	0	7	14	Air Seasoned
	0	0.75	$14.36	$19.10	$3.90
	0.25	1.82	15.54	9.52	6.08
None	0.5	.00	8.41	4.36	0.32
	1	.00	0.49	0.30	.00
12 lb.	0	.36	9.37	16.70	7.76
Penta-	0.25	.00	0.95	0.55	0.74
chlorophenate**	0.5	.31	0.28	0.15	.00
	1	.00	0.35	.00	0.78
2 lb.	0	.62	6.11	4.34	4.47
Ethyl Mercury	0.05	.00	0.51	2.46	.00
phosphate	0.25	.00	0.82	0.27	0.15
	0.5	.00	0.25	.00	.00

*Buffered with borax

** Permatox 10-S was ued in the field test,
see R. N. no. 2,212 for list of penta preparations.

The last column labeled Air Seasoning shows the results of the series of tests completed in March 1959. In all tests, a stepwise improvement in grade realization is shown as the concentration of the Azide increases. When anti-blue stain chemicals were added to the dip solution, there was an additional suppression of brown stain that is well worth the added cost. A $20/M' degrade figure was used in the calculations as for loss in those pieces containing brown stain. This was based on a three year average loss realization figure found by one company for brown stain degrade. The material used for the air drying portion of the tests was air dried for six months before putting into the dry kiln. It was wet before kiln drying. After kiln drying, the test stock was surfaced and graded for value as based on the fall down due to brown stain. The results of the air drying tests were particularly gratifying because this has been one of the special hazards in drying Sugar Pine, especially when the air dried lumber was wet by rain or fog during the air drying period.

Specific instructions for the use of the dip can be secured from the Laboratory Research Note No. 4.5114. The suppliers of the dip can also furnish this information.

BENEFITS OF KILN DRYING

The proper use of the dip will make it possible for the kiln operator to use of the most rapid drying schedule consistent within the limitations of the stock to resist seasoning defects. No one schedule can be devised that will fit all situations. Equipment variations, the heating capacity of the dry kiln, its venting capacity, insulating efficiency, lumber segregation, initial moisture content and drying rate all affect the schedule that is used. However, certain principles control the general application of the temperatures and humidities. For one thing Sugar Pine does not season check easily; in spite of the fact that it is a White Pine and has a low transfusion rate. The relatively low shrinkage factor may be partly accountable. But what ever the cause, fairly fast schedules can be applied to this species even in the early stages of the drying. Had it not been for the danger of excessive brown stain it would have been logical to use higher than average initial temperatures on this species in order to increase the transfusion rate. Now that an inhibiting dip removes this danger, it is no longer logical to use low temperatures at the early stages of the drying.

The same holds true of low relative humidity. With higher temperatures it is possible to maintain a fairly rapid drying rate even with normal humidities. Consider the fact that a 20 degree depression will provide an E.M.C. of around 8%. That is sufficiently low to maintain a fast drying rate for 4/4 segregations of most species if the temperature level is correct. For other thicker sizes a higher starting E.M.C. is often advisable. But the correct temperature depends upon the transfusion rate of the species. In Ponderosa Pine it is sufficiently rapid that a high initial temperature is not needed. A moderate temperature will move the moisture to the surface as fast as many kilns are designed for venting during the initial stages of the drying. The auxiliary vents so often put on kilns are designed for Sugar Pine are there to bring the wet bulb to very low levels. They will be no longer needed for Sugar Pine with the proper application of the inhibiting dip.

Another practice used for the drying of Sugar Pine that can be changed with the advent of the dip is the use of excessively large wet bulb depressions at the end of the schedule. This is poor practice with any species and especially so with Sugar Pine because it leads to excessive moisture content variations that are a major cause for degrade. The result is warp and twist in all grades of Sugar Pine lumber. Roller split is excessive. When a light textured species such as Sugar Pine is shown to roller split, even in the wide lumber, one can be sure that the final moisture content of the stock is very low. A much higher quality of product could be assured if a more moderate relative humidity were used in the schedule. It would not need to be low to maintain a fast drying rate if the temperature were carried at a higher level from the start.

The dip should now make possible the use of final conditioning treatments at the end of the drying schedule to relieve casehardening. Sugar Pine will caseharden much the same as other species. The fear of brown stain has been the main reason for omitting this desirable seasoning practice from Sugar Pine schedules. Some have practiced a measure of conditioning by the use of approximately 15 degree wet bulb depressions at the end of the drying. But this is not very effective unless the lumber is very dry. Even then, the time required to do the job adequately will be long. Now this practice can be safely modified by the use of higher temperatures and humidity. This is suggested as another schedule improvement.

Kiln drying can now be practiced on pre-air dried Sugar Pine Lumber without the fear of the excessive stain that has often followed this practice. Moreover the stock can be brought in before it has reached the fibre saturation point if it is necessary. We make this prediction on the basis of the pre-air drying results to date.

Some of you may have been more fortunate than others in keeping stain losses in Sugar Pine low. This has generally been done by fast handling and careful scheduling but there are gains to be made by the use of the dip by all who kiln dry Sugar Pine. The increased drying production and other grade improvements that result from better moisture uniformity are worth considering. The control dip will make possible the practical revision of Sugar Pine schedules.

1 Presented at Forest Products Research Society, Milwaukee, Wis., June, 1952, by Millett

2 Western Pine Association Laboratory Research Note No. 4.5111

3 Western Pine Association Laboratory Research Note No. 4.5112

4 Western Pine Association Laboratory Research Note No. 4.5113

5 Western Pine Association Laboratory Research Note No. 4.5114