PRE-STEAMING REDWOOD
ITS EFFECT ON STAIN CONTROL AND DRYING RATE

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SUMMARY

Tests on pre-steaming redwood lumber prior to conventional drying procedure were initiated in an attempt to reduce or eliminate stain. Preliminary tests revealed that a significant decrease in drying time might also result. Tests are still underway, but results to date indicate that: (1) a partial elimination of stain, and (2) a reduced kiln drying time of approximately three days for 1" heavy green redwood.

INTRODUCTION

Chemical stain in California redwood has been, and still is, a factor affecting the quality of the kiln dried and finished product.

The stain appears as dark brown or black areas at the surface of the wood. Although not readily apparent on the rough board, the stain becomes quite evident after surfacing. The staining is associated with migration to the surface zone and simultaneous chemical changes of extractives in the wood. The extractives remain in the surface zone as the water evaporates. The dark color is caused by the heavy concentration of extractives in a relatively thin layer of wood and by the fact that the extractives are further darkened by oxidation from contact with the air.

The most important factor determining the extent of stain is the extractive content of the wood. The extractive content in turn appears to be related to green moisture content of the wood. In general, a total extractive content of approximately 15% (based on the oven dry weight of the wood) or greater will result in stain.[1] Redwood extractives may constitute from 8 to 40 percent of the dry weight of the redwood heartwood. This can range to as high as 60 percent in the surface zones of dry redwood.[2] The greater portion of this extract is water soluble and the water insolubles are largely soluble in hot alcohol. Table A of the appendix shows a breakdown of redwood extractives into fractions.

Stain may be particularly pronounced on each side of the sticker, with the area which was under the sticker being free of stain. Since evaporation cannot take place under the sticker, the moisture migrates to either side of the sticker carrying the extractives with it.

1. From reports of the California Forest Products Laboratory.
2. Ibid.

Stain is likely to be accentuated by any condition or combination of conditions which allow the moisture in the wood to dissolve large quantities of extractives. Thus stain can be held to a minimum by proper drying techniques. Some of the steps currently being taken to reduce stain degrade are:

1. Hot logging and reduced time of cold decking logs.
2. Sticking lumber as soon as possible.
3. Drying as rapidly as possible consistent with quality.
4. Use of wide pile spacing, high pile foundation, slanted piles and clean yard surface in air yards.
5. Use of pile roofs to reduce water stains.
6. Kiln drying lumber green from the saw or using low temperature predriers before the kilns.
7. Use of low initial temperatures and humidity in kiln drying.
8. Use of paper wrap and/or water-repellent treatment on kiln dried lumber where the value of lumber permits.

The amount of stain occurring under the best of present handling and drying procedures is still a serious problem.

Research at the University of California Forest Products Laboratory indicated that steaming of green redwood lumber before conventional drying could help prevent stain. Late in 1959, Simpson Timber Company decided to conduct pre-steaming experiments at the mill level. A steam chamber was built which could accommodate an entire unit of lumber up to 18 feet in length. The chamber is capable of steaming lumber at 212°F. and 100% relative humidity.

Preliminary tests at Simpson Timber Company and tests at the University of California Forest Products Laboratory indicated that a significant saving in drying time might result from pre-steaming. Hence, future tests were set up to accurately check drying results. A saving in drying time would be extremely welcome because of the high green moisture content and slow drying characteristics of redwood. A kiln charge of 1" heavy segregation green redwood may average 200% moisture content and require 30 days to dry.

Use of high temperatures and humidity in the steam chamber gave rise to the likelihood of a certain amount of collapse and warp degrade occurring. Consequently, provisions for observation of and tallying for these defects were incorporated in the test procedure.

TEST PROCEDURE

The original program for the experimental treatment of stain by steaming consisted of 6 test series. An additional 12 series were later added. Each test series was designed to test different variables or combinations of variables, such as: steaming time, length of time between green chain and sticking, and drying in the kiln green or after air drying.

Test Procedure for Series 1-6: Each of these series consisted of an entire kiln charge. Control and test units were resawn from 2 X R/W Heavy Clear and Aye Vertical Grain redwood. As the stock was resawn, one 1" board was placed in a unit to be steamed while its mate was placed in a control unit. These matched units were designated "A" for control unit and "B" for steaming unit. Each matched pair of units was numbered one through eighteen.

The "B" units were steamed at 212°F. and 100% relative humidity for various lengths of time, as shown in the series descriptions below. The "A" or control units were subjected to conventional drying methods. These series were all to be air seasoned before kiln drying.

Description of Series 1-6:

Series 1--Resawn from 2" fresh from the mill and "B" units steamed 5 hours.
Series 2--Resawn, then bulk piled 30/45 days and "B" units steamed 5 hours.
Series 3--Resawn fresh from the mill and steamed 2 hours.
Series 4--Resawn and bulk piled 90 days, then steamed 2 hours.
Series 5--Resawn fresh from the mill and steamed 1 hour.
Series 6--Resawn and bulk piled 90 days, then steamed 1 hour.

Test Procedure for Series 7-18: The test procedure for series 7-18 differs from series 1-6 in the following manner:

1. Stock was checked only after surfacing to finished product dimensions.
2. Each series consisted of one control unit and one test unit instead of a half kiln charge each.
3. All units were 1" x 8" instead of random width.
4. All units were 10' - 14'.
5. Each board, as well as each unit, was marked for identification.
6. Since tests at the University of California Forest Products Laboratory indicated that the additional hour of steaming was of little value, the longest period of steaming was 4 instead of 5 hours.
7. For series 13-18, units are being weighed periodically in the yard to compare air drying rates of the control and steamed units.

Description of Series 7-12(stock in this series was kiln dried).

Series 7--Resawn from 2" fresh from the mill and steamed 4 hours.
Series 8--Resawn from 2" fresh from the mill and steamed 2 hours.
Series 9--Resawn, then bulk piled 45 days and steamed 4 hours.
Series 10-Resawn, then bulk piled 45 days and steamed 2 hours.
Series 11-Resawn, then bulk piled 90 days and steamed 4 hours.
Series 12-Resawn, then bulk piled 90 days and steamed 2 hours.

Description of Series 13-18(all stock was air seasoned before kiln drying):

Series 13-Resawn from 2" fresh from the mill and steamed 4 hours.
Series 14-Resawn from 2" fresh from the mill and steamed 2 hours.
Series 15-Resawn, then bulk piled 45 days and steamed 4 hours.
Series 16-Resawn, then bulk piled 45 days and steamed 2 hours.
Series 17-Resawn, then bulk piled 90 days and steamed 4 hours.
Series 18-Resawn, then bulk piled 90 days and steamed 2 hours.

The test stock was tallied for degree of stain and warp at time of surfacing. Boards were recorded in one of the following categories:

1. Stain which occurs generally or in patches over the surface of the board with or without sticker marks. Stain not severe enough to downgrade the piece.
2. Stain as in category 1, but severe enough to downgrade the piece.
3. Sticker stain apparent only--the non-stickered areas being relatively free from stain.
4. No stain.

Series 7-18 were designed to check drying rates as well as stain. In addition to these tests, special tests were set up to determine drying rates only. These tests were conducted on stock kiln dried green from the saw. Matched pairs of 1" x 8" Clear and Aye Mixed Grain Heavy redwood test pieces were used. Ten matched pairs were to be placed in each of four regular kiln charges of heavy 1" green uppers. The steamed board of each pair was steamed 2 hours immediately before placement in the kiln.

RESULTS AND DISCUSSION OF TESTS TO DATE

The test series are presently in various stages of completion. Results which have been found to date will be presented here.

Stain Results and Discussion

Test Series 1 and 3: Test series #1 was mainly exploratory. Valuable information and techniques for setting up future tests and for evaluating stain were gained. The entire kiln charge was inspected for stain after being blanked to 29/32". In addition, 8000 bd. ft. were checked for stain after being run to 5/8" X 8" and 10" siding, and 36 matched pairs of 1" x 6" stock were inspected after being surfaced four sides. Stain evaluation for Series #1 was broken down into three categories. These were: (1) no stain, (2) stain, and (3) stain that would degrade from Clear to Aye. Stain in all test series after this was broken down into the categories described in the "Procedure" section of this report.

Test series #3 was the second one to be kiln dried and examined. In this series all 1" x 6" which developed at the dry sorter was blanked and checked for stain and warp. The first pair of 1" x 8" units which developed were checked for stain after being surfaced four sides.

The results of series 1 and 3 showed that stain present at a blanked thickness of 29/32" is not comparable to stain present at the final product thickness. Consequently, stock in later series was examined for stain after being surfaced to final dimensions.

No actual resultant data will be shown for Series 1 and 3 because of the exploratory nature of these tests. In view of the revisions in evaluating procedures, results of Series 1 and 3 are not comparable to the following series.

Test Series 2, 4 and 5: All 1" x 6" which developed at the dry sorter from the kiln charges in these series was surfaced four sides. The results of the stain tally for these series is shown in Table I. It will be noted that in each series the steamed lumber showed a larger percentage of boards falling in the "no stain" category and a smaller percentage falling in the "downgrade" and "general stain" categories. However, in each series except #5, the steamed boards showed slightly more "sticker" stain. According to California Redwood Association grading rules, sticker stain will not downgrade a board but it is often unsightly on a naturally finished product.

Test Series 7, 8, 9 and 10: Series 7 and 8 were both resawn from 2" fresh from the mill and steamed 4 and 2 hours respectively. The results of the stain evaluation on these two series are shown in Table I. Both steamed and control boards in these series were relatively free of stain; the sticker stain recorded was, in most instances, very light.

Series 9 and 10 were resawn from 2" and then bulk piled 45 days before being placed on stickers. Steaming time was 2 and 4 hours respectively. The stain evaluation results for these two series are also shown in Table I. Again, as in Series 7 and 8, the sticker stain recorded was very light.

The sticker stain which appeared on many of the steamed boards was a "reverse" type of sticker stain. Instead of the stickered area being lighter than the remainder of the board, it was slightly darker. The steaming apparently affected the non-stickered area of the board, but did not affect the area covered by stickers.

This reverse stain condition appears to be the cause of the high percentage of steamed boards in some series showing sticker stain, and the relatively low percentage being free of stain.

The boards which had been placed on stickers fresh from the mill exhibited (1) a much greater percentage free from stain and (2) a considerably smaller percentage downgraded by stain than those boards which had been bulk piled 45 days. The steaming appeared to have a greater effect on the boards which were not bulk piled. However, a substantial reduction in the percentage of boards being downgraded was noted in each case.

The 4 hour steaming period had a greater effect on the percentage of boards downgraded than the 2 hour period.

Exposure Tests

Matched pairs of freshly surfaced steamed and unsteamed boards were selected and exposed to normal atmospheric and high humidity conditions. This was done to determine whether or not the advantages of steaming would continue to prevail. Photographs were taken at various time intervals to detect changes in stain intensity.

To date, only one group of matched boards has been exposed for the entire 31-day period. The steamed and control boards both become darker with exposure, but the steamed boards were considerably lighter and appeared to retain the stain advantage which they had shown immediately after surfacing.

Drying Rate Results and Discussion

Test Series 7, 8, 9 and 10: Drying rate curves for series 7 through 10 are presented in Figures 1 through 4. These curves represent the average moisture content at each time interval for all matched moisture content samples. The steamed board in each pair of moisture content samples exhibited a decrease in drying time. The test series units were placed in kilns with regular charges of green 1" heavy stock. A normal kiln schedule based on moisture content samples from the regular unsteamed stock was followed.

The curves of Figures 1 through 4 indicate that a savings in kiln time of approximately 3 days can be expected from pre-steaming 1" heavy redwood lumber. With respect to drying rate, the 4 hour steaming period showed no particular advantage over the 2 hour period.

Special Drying Rate Test: This tests consists of 4 subgroups. The subgroups are composed of 10 matched pairs. Each subgroup is placed in a kiln of 1" heavy green redwood following a normal green schedule. Test results have been obtained for the first 2 subgroups.

The average drying rate curves for the 20 matched pairs of boards are presented in Figure 5. Two pairs of boards in these groups did not show a definite drying rate advantage for the steamed board. Reexamination of all previous drying rate data from earlier test series indicated a positive advantage for the steamed board in each individual matched pair.

Other Effects of Steaming

Collapse: Nine control boards and 16 steamed boards out of series 7-10 were found to have varying degrees of collapse. Generally, when a steamed board showed evidence of collapse, its mate also showed evidence of collapse but to a lesser degree. Collapse was always noted to be in or near areas of abnormal wood.

Bow: Several steamed boards were bowed. The boards bowed between the sticker locations, giving the boards a snakey appearance. Very few of the boards were found to have sufficient bow to downgrade or trim.

Tests at the University of California Forest Products Laboratory revealed that the cause of the bow is thermal expansion of boards containing abnormal wood (compression wood) while restrained by stickers during steaming. The bow in the boards has been found to be reduced or eliminated after the boards have been solid piled for a period of time. Future tests are planned which will evaluate the effect of steaming boards while not restrained.

Due to the plasticity of redwood during the extreme conditions of steaming, it is doubtful that units could be placed on top of one another in a steam chamber because of the crushing at sticker locations which would result from the weight of the units.

CONCLUSIONS

1. Downgrading of redwood from Clear to Aye can be substantially reduced by steaming prior to conventional drying procedures.

2. By pre-steaming, kiln drying time can be reduced approximately three days for 1" heavy redwood.

3. Adverse effects of steaming, such as collapse and warp, were not as severe as expected and do not appear to present an insurmountable problem.

4. A four hour steaming period produces better stain control than a two hour period.

5. There is no significant difference, with respect to increased drying rate, between a two and four hour steaming period.

Table I

RESULTS OF PRESTEAMING ON STAIN CONTROL

Test Series Number	Time Bulk Piled	Time Steamed	Seasoning	Number of Boards Examined	Percent of Boards in Each Category: No Stain	Sticker Stain Only	Stain Generally or in Patches	Stain Which Will Down Grade
2	45 Days	0 (control)	Air Yard and Dry Kilns	776	39.5	24.5	21.9	14.1
		5 hrs.			45.7	28.7	22.2	3.4
4	90	0		458	7.0	16.7	40.3	35.5
		2 hrs.			19.5	23.5	36.1	20.9
5	0	0		322	24.3	22.3	42.6	10.8
		1 hr.			35.8	18.5	39.9	5.8
7	0	0	Kiln-Dried Green	332	43.7	15.6	33.5	7.2
		4 hrs.			60.0	25.5	13.9	0.6
8	0	0		350	35.2	10.8	43.8	10.2
		2 hrs.			28.2	42.5	25.9	3.4
9	45	0		306	22.2	27.5	29.4	20.9
		4 hrs.			20.9	41.9	33.3	3.9
10	45	0		338	17.2	26.0	30.2	26.6
		2 hrs.			18.9	37.9	32.0	11.2

APPENDIX

Table A

REDWOOD EXTRACTIVES

The following breakdown of redwood extractive into fractions has been extracted from reports of the University of California Forest Products Laboratory.

Cold water extract (60% of total extract)
- Dioxane insoluble portion (50% of total water-soluble material)
  - Greyish non-hygroscopic powder
  - Consists of
    - Cyclitols (30% of total water-soluble material)
      - Sequoyitol
      - Pinitol
      - Meso-inositol
    - Sugars (0.5% of total water-soluble material)
      - Glucose
      - Arabinose
      - Rhamnose
    - Polysaccharides (1.5% of total water-soluble material)
      - Yield an hydrolysis of
        - Arabinose
        - Glucose
        - Rhamnose
        - Xylose
        - Galactose
        - A uronic acid
    - Non-tannin polyphenolic (18% of total water-soluble material)
- Dioxane soluble portion (50% of total water-soluble material)
  - Tannin (25% of total water-soluble material)
  - Unstable polyphenolics

Hot ethanol extract (40% of total extract)
- Polymerized tannins
- Phlobaphenes
- Coloring matter

The tannin, on alkaline fusion, yiels protochatechuic acid, pyrogallol and catechol among the reaction products. Methylated tannin produced veratic acid. This and other information suggests that the product of fusion is a phlobatannin built on the catechin model.

Lyophilized extract from air dried lumber is hygroscopic at 75% R.H., 70°F.
Lyophilized extract from green lumber is hygroscopic below 55% R.H., 70°F.

SIMPSON TIMBER COMPANY
May 17, 1961

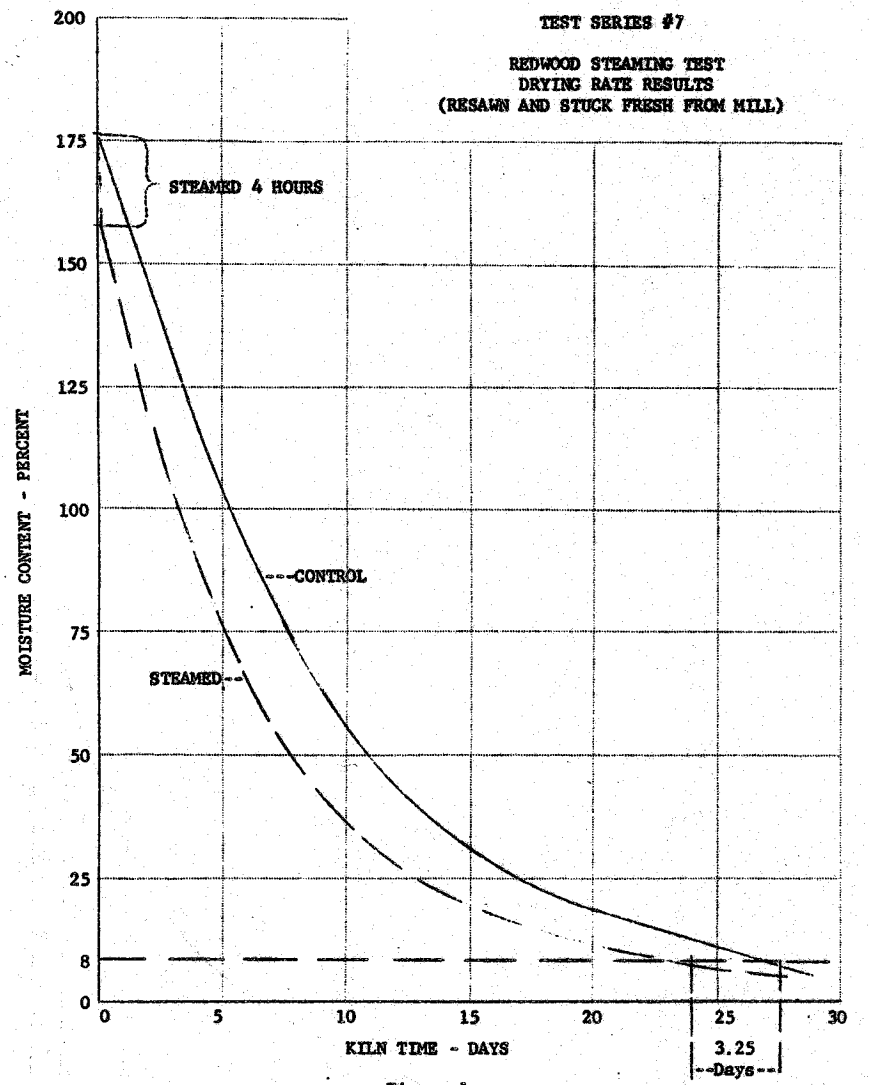

Figure 1

SIMPSON TIMBER COMPANY
May 17, 1961

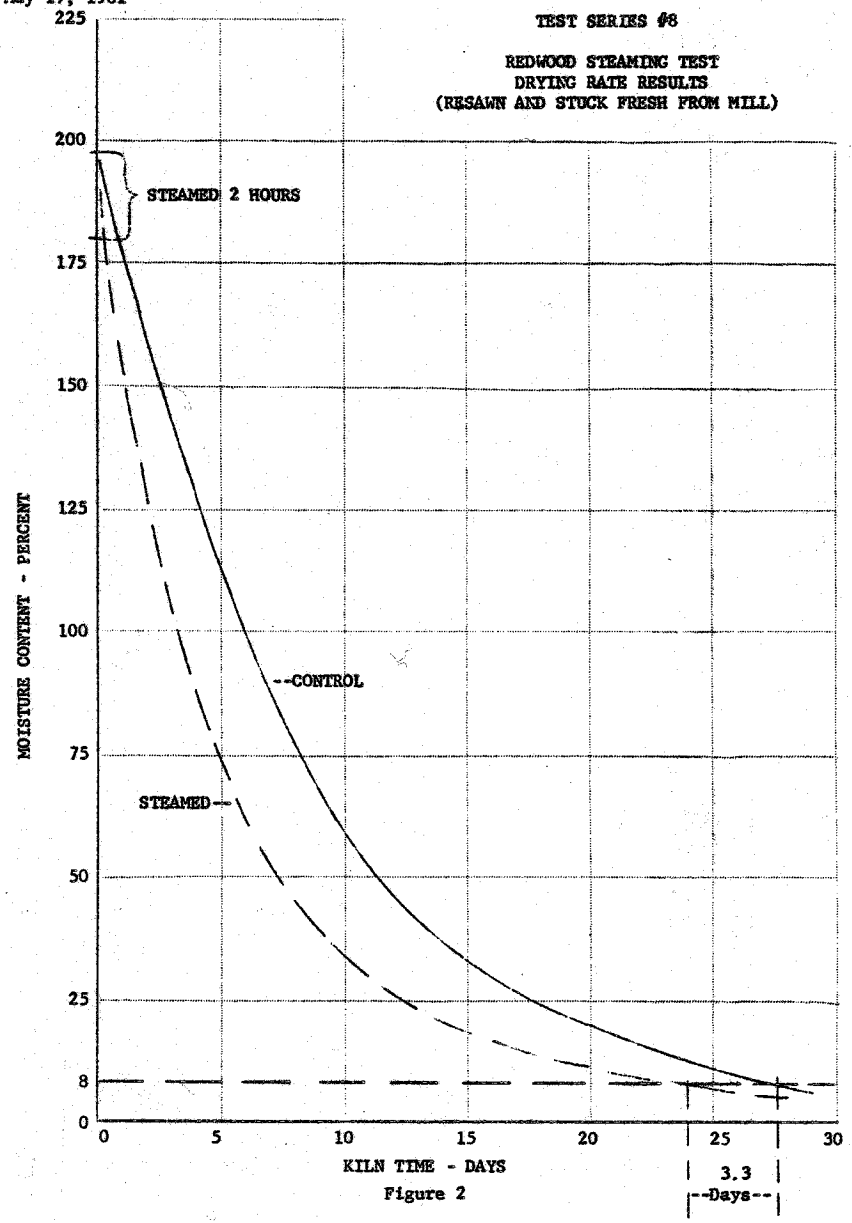

Figure 2

SIMPSON TIMBER COMPANY
June 6, 1961

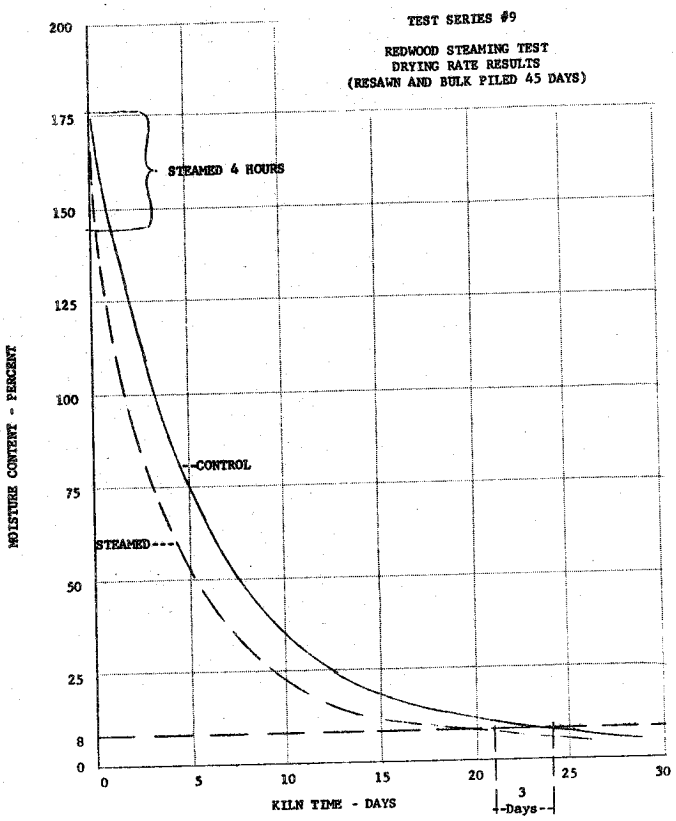

Figure 3

SIMPSON TIMBER COMPANY
June 6, 1961

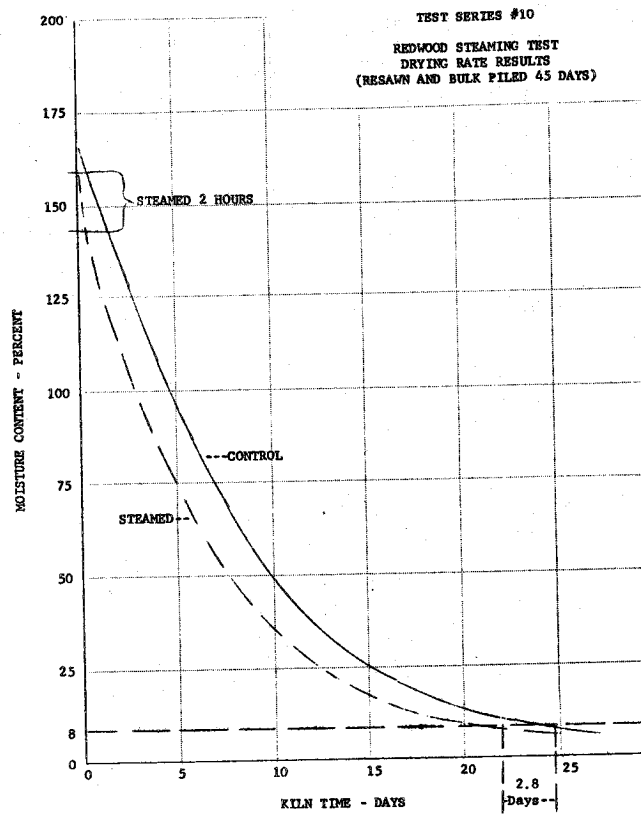

Figure 4

SIMPSON TIMBER COMPANY
June 7, 1961

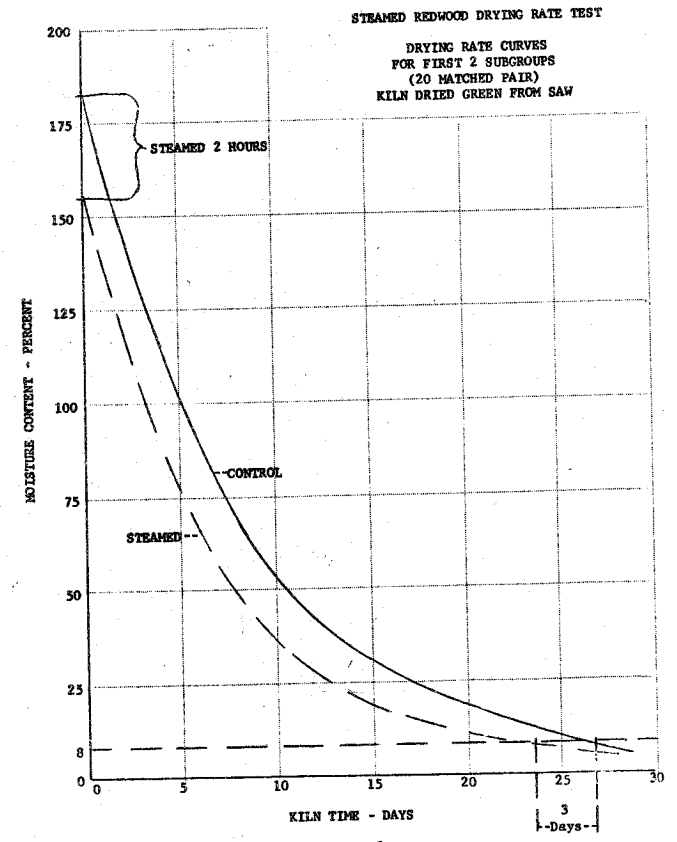

Figure 5