

REDWOOD DRYING TEST USING THE THERMODRI PROCESS
CONDUCTED FOR THE CALIFORNIA REDWOOD ASSOCIATION

THERMODRI Presented By
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INTRODUCTION

In November, 1967, an agreement was reached between the California Redwood Association and Messrs. D. Shiells and E. Merwin representing THERMODRI, whereby a joint test would be carried out to test the feasibility of the THERMODRI process for seasoning redwood.

This initial test was carried out in February, 1968, and this report summarizes the results of the work performed.

Technically and operationally the test was successful and yielded a substantial amount of data. It also disclosed potential problem areas and these are discussed in the report.

It is important to note that the test reported herein is the first test carried out on a fairly large scale with redwood using the THERMODRI process and that it would be presumptuous to expect that such a test would provide complete and entirely satisfactory results in all respects.

DISCUSSION

Process Description

In the THERMODRI Process moisture is removed from green wood under vacuum conditions. Heat required to evaporate the moisture in the wood is provided by a heat transporting solvent in which the green lumber is immersed. The wood temperature is controlled at a level well below that which could cause damage to the wood.

Rapid drying results from the heat transfer which takes place between the wood and the heated solvent. The solvent is rapidly recirculated through units of lumber and the heat supplied to the wood is evenly applied to all of the surface.

A vapor barrier formed at the surface of the wood inhibits back diffusion of the solvent into the wood and controls surface temperature.

The solvent and moisture are immiscible and the vapors removed can be condensed and separated from the solvent.

The entire process can be automated and provides for gradual preheating of the wood, a drying cycle and finally, a period of post-steaming. The post-steaming period relieves stresses and provides for moisture equalization.

Plant Description

A large prototypical THERMODRI process plant was built and placed in service in South San Francisco to demonstrate this process on a scale large enough to demonstrate its feasibility as applied to commercial wood seasoning plants.

This plant is designed to serve a dual purpose: it functions as a research and development unit, and it is operated as a prototype of a commercial unit. This plant has a capacity of 5500 BF per day.

The plant is fully automatic and is operated and controlled from a single, central control panel. The panel contains the programmer, timers, control switches, controllers, alarms, and recorders required for the process.

Test Description

The lumber for this test consisted of about 2000 BF of clear and aye grade rough green medium segregation 1" x 8" redwood. The initial moisture content was measured December 8, 1967, and again just prior to the test on February 2, 1968. Ten moisture content sample boards which were identified by means of metal tags attached to one end were used. The M. C. ranged from 193.3% to 80.6% with an average of 117% just prior to the test (see Table I).

The redwood was stuck in two units, each about four-feet high with the moisture content sample boards located randomly throughout the two units.

After stickering, the two units were rolled into the autoclave and secured. The door was closed and sealed after which the THERMODRI process was started by means of a single pushbutton.

The entire run was programmed and set to run automatically.

No problems were experienced at any time during the program due to mechanical or electrical causes, however, initial controller settings were not completely correct for the redwood and thus, these were revised manually early in the test period.

THERMODRI TEST
REDWOOD 1856 B F (APPROX)

TEMPERATURE °F

VACUUM, IN. Hg.

INITIAL SOLVENT TEMP 160 F.

SOLVENT TEMP. □ LVG AUTOCLAVE

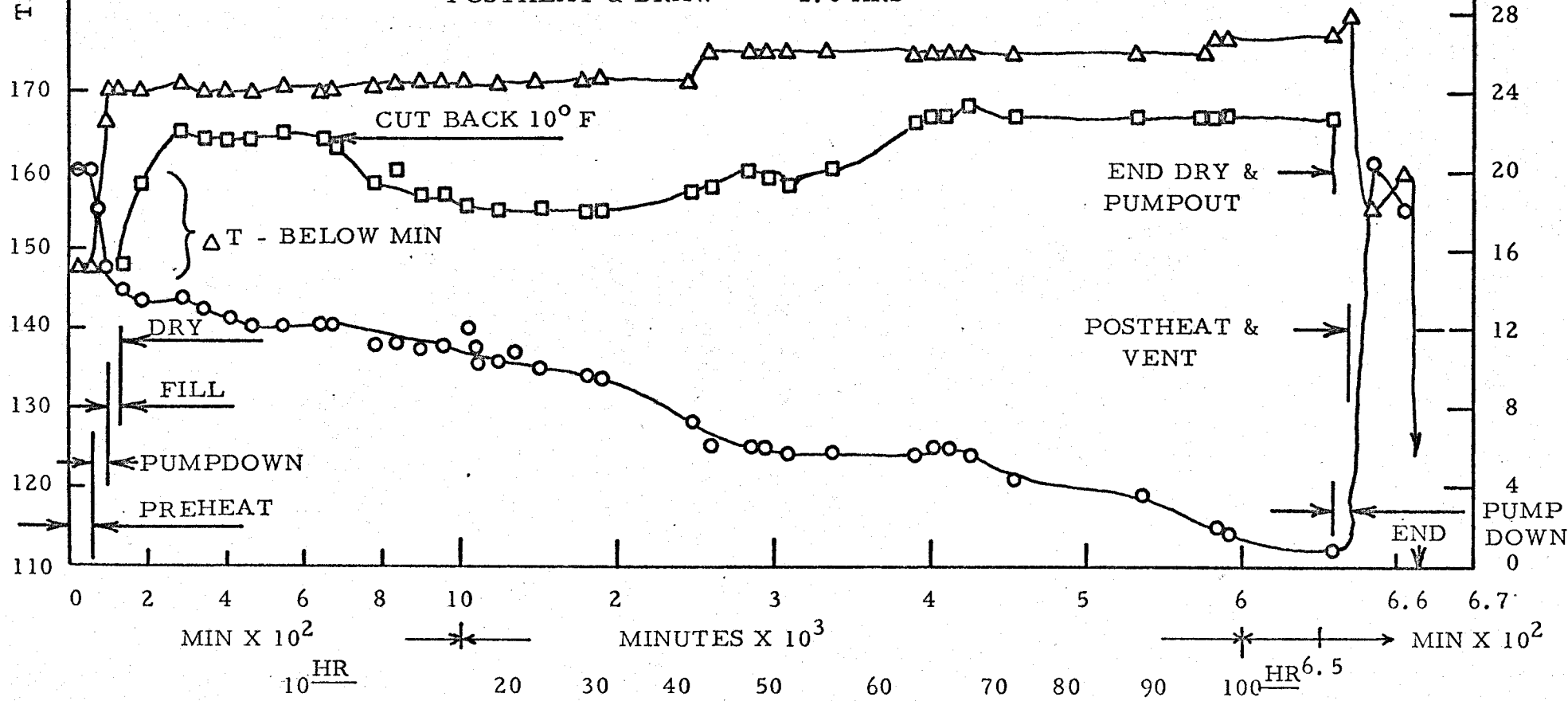
VAPOR TEMP. ○ " "

AUTOCLAVE VAC △ CYCLE PERIOD

PREHEAT & FILL 2.0 HRS

DRYING 106.5 HRS

POSTHEAT & DRAW 2.0 HRS



Test Results and Analysis

Initial settings were selected to provide a low temperature difference between the wood and the solvent. Due to the long filling time required (the autoclave was not loaded to capacity) the solvent cooled excessively and its temperature fell to nearly that of the vapor temperature of the moisture in the wood. It was during this period, between 100 and 300 minutes, that excessive solvent absorption in the wood probably took place. Under the conditions present during this period the vapor leaving the wood was not able to adequately inhibit penetration by the solvent.

Since the solvent is used as a heat exchange medium there are a number of candidate materials which might be employed and a more detailed investigation into this area may disclose additives such as paraffin based solutions which will effectively reduce back diffusion of the solvent into the wood.

The total water removal rate was not measured until after the first 10 hours and in addition the starting point was not precisely determined. Water rate was calculated by periodically measuring the increase in height of a rectangular hold-up tank since the total rate was below the capacity of a flow meter and controller provided for the purpose. The tank sides were observed to be bulged at one point and this also accounts for part of the discrepancy.

More precise measurements are indicated in future tests to obtain closer agreement between measured water removal and initial and final moisture content.

SUMMARY

When the lumber was removed following completion of the test on Thursday morning, February 8, 1968, a visual inspection was made. It was darker than when loaded but otherwise, the stacks appeared to have the same appearance as when originally loaded, that is, no excessive warpage or twisting of the lumber. It was noted that the boards darkened somewhat in the first hours following exposure to air possibly as a result of surface oxidation.

The process ran for a total of 110.5 hours, or about 4 1/2 days, of which 106.5 hours were used in actually removing moisture from the redwood. The balance of the cycle included pre-heating and post-steaming operations.

About 1000 BF of 1" x 8" redwood dried in this test was surfaced within 5 hours of the termination of the test. No problems were experienced in planing off the solvent soaked layer even though it was rather severely impregnated.

Birdseyes were popped in the dried wood, however, cellular collapse was not excessive in any of the dried wood.

It is probable, however, that collapse did occur and would be detectible by means of a more detailed check than was given this lumber. Again, additional work is indicated to determine optimum drying cycles and their effect on structural degradation of the dried redwood.

The initial moisture content of the ten samples was 117 and ranged from 193% to 80% and the final moisture content averaged 9.46%, with the majority of the samples falling in the range between 12% and 5%.

The average solvent content in the redwood was 17.4%, ranging from 29% to 6%. This value is higher than that determined in previous tests by a factor of about five.

The final moisture content and oil content were determined by the distillation method, using toluene as the solvent. Moisture and oil content were determined for both the shell and the core (see Table 2 attached at the end of the report).

The reason for the extremely high solvent content was determined to be the result of having too low a temperature gradient between the vapor pressure of the moisture in the wood and the bulk solvent. This low gradient resulted from an effort to maintain a low gradient during the cycle combined with over-cooling of the solvent during the period when it was being admitted to the Autoclave.

Solvent absorption takes place, and is predictable through capillary action into the surface fibers of rough cut lumber.

There was solvent in substantially every piece. It was evident that the penetration was deep and that some areas were considerably 'wetter' than others. Close examination indicated that there was some structural damage. However, it was generally agreed that an improved drying schedule would correct this.

Table 3 at the end of the report, contains temperature, vacuum and time data of this test.

CONCLUSIONS

As a result of this initial experimental test of the THERMODRI process for drying green redwood the following conclusions are drawn:

The process is a possibility for drying redwood and could provide a technique for carrying out the complete drying operation from the green state in a period of about 5 days.

A commercial process unit can be operated automatically and unattended with only routine monitoring of instrumentation.

The test demonstrated the feasibility of the process on a scale sufficiently large to be of commercial interest since 2000 BM were processed in a unit having a capacity of 5500 BF.

Absorption of solvent by the redwood was excessive and must be reduced by a factor of at least five. This absorption probably occurred during the first part of the cycle when temperature differentials fell below minimum limits required for the process.

Solvent absorption averaged 0.15 lbs. per square foot of wood surface area during this test. Prior small scale tests have shown that this absorption averages about 0.03 lbs. per square foot.

With the exception of one sample the variations in moisture content between shell and core samples was slight.

The redwood lumber dried during the test was not visibly damaged except that nearly all birdseyes were popped. However, close inspection showed some collapse. Internal stresses were also present as stress specimens cut from the moisture content samples had varying degrees of case hardening. Also, after a few days exposure some warping occurred in some pieces.

No difficulty was experienced in commercially planing the dried redwood even though there was excessive solvent in the wood surface.

A finishing operation completed as soon as possible after removal of the dried wood is necessary in order to remove the surface absorption before it diffuses deep into the wood.

This initial test did not produce commercially useable redwood since the dried wood contained an excessive quantity of solvent. On the other hand, the test did produce, in a drying period of about 4 1/2 days, dried redwood with an average moisture content of below 10%.

Additional research is needed to establish precise causes of solvent absorption and means for its prevention on a repeatable basis.

In our opinion further research and development is required in order to establish the process as a basic new method for rapidly drying redwood. The additional research should be directed towards reduction of solvent absorption losses and improved drying schedules.

TABLE 1: MOISTURE CONTENT OF REDWOOD LUMBER

Wt. in Grams

<u>Sample</u>	<u>Green wt.</u>	<u>Ovendry wt.</u>	<u>wt. of Water</u>	<u>% M. C.</u>
1	90.9	31.1	59.8	192.3
2	49.3	26.4	22.9	86.7
3	56.6	25.0	31.6	126.4
4	74.1	36.4	37.7	103.6
5	52.9	25.7	27.2	105.8
6	69.4	30.1	39.3	130.6
7	69.5	35.8	33.7	94.1
8	50.9	22.1	28.7	129.9
9	54.9	30.4	24.5	80.6
10	76.0	33.9	42.1	124.2
Average M. C.				117%
Final M. C. Check before Run				

TABLE 2: MOISTURE & OIL CONTENTS FOR OIL-DRIED REDWOOD

<u>Sample</u>	<u>Shell Sample</u>		<u>Core Sample</u>		<u>Whole Sample</u>	
	<u>Moisture Content</u>	<u>Oil Content</u>	<u>Moisture Content</u>	<u>Oil Content</u>	<u>Moisture Content</u>	<u>Oil Content</u>
	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
1	6.85	29.63	8.01	12.01	7.41	20.99
2	9.05	38.32	10.21	16.26	9.63	29.93
3	5.36	39.00	6.05	6.37	5.72	21.61
4	9.56	12.50	11.22	0.63	10.44	6.19
5	6.34	22.07	5.95	4.70	6.13	12.65
6	6.35	20.63	7.05	14.10	6.68	17.53
7	17.48	10.93	30.47	3.46	24.11	7.11
8	5.65	31.50	5.12	12.47	5.44	23.92
9	6.09	22.51	6.96	2.20	6.57	11.80
10	<u>12.48</u>	<u>24.96</u>	<u>12.52</u>	<u>18.97</u>	<u>12.50</u>	<u>22.36</u>
Average	8.52	25.18	10.36	9.13	9.46	17.40