Seasoning and Machining Degrade in Young-growth Douglas-fir Dimension Lumber

By

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SUMMARY

The increasing volume of young-growth Douglas-fir timber cut in the Pacific Northwest emphasizes the need for more knowledge on the characteristics of lumber sawed from these trees.

The study described here was initiated to learn the extent and causes of degrade resulting from kiln-drying young-growth Douglas-fir dimension lumber. At the same time it was possible to determine the degree of shrinkage during and after kiln-drying, and to check the final shipping weights of the lumber after drying.

Degrade was measured in ten kiln charges of approximately 6500 fbm (feet board measure) each, of 2- by 8-inch by 16-foot young-growth Douglas-fir dimension lumber which were kiln-dried and surfaced to 1-5/8 by 7-1/2 inches. An additional charge was surfaced green to determine the change in grade caused by machining alone.

Neither the average final moisture content to which the charges were dried (approximate range 12-18 per cent) nor the temperatures used in drying the charges seemed to have an appreciable effect on the amount of degrade. The amount of degrade was greater, however, when a low EMC* level was maintained during the schedule, as shown by the following table:

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* Equilibrium moisture content; the moisture content which wood will attain after long exposure to given atmospheric conditions.

EMC of low humidity step (range)		Average total degrade (fbm basis)[1]	
		No. 1 Common	No. 2 Common
Per cent		Per cent	Per cent
3.3-4.4	Shake & grain separation	0.7	0.6
	Loose knots & edge knots	1.9	0.4
	Planer split and warp	5.7	3.8
	Season checks	1.4	0.2
	Knotholes	3.2	1.0
	Total	12.9	6.0
7.7-11.0	Shake & grain separation	0.7	0.8
	Loose knots & edge knots	1.9	0.7
	Planer split and warp	1.2	1.1
	Season checks	0.0	0.1
	Knotholes	2.1	0.5
	Total	5.9	3.2

[1] Degrade from shrinkage (skips in dressing) is not included.

Total degrade in the Select Structural grade was consistently higher than degrade in No. 1C (Number 1 Common). The amount of lumber in the select structural grade, however, was too small for full analysis.

Although young-growth Douglas-fir lumber is relatively free from the black knots found characteristically in old-growth, an average of 18 per cent of the green pieces in both No. 1C and No. 2C contained black knots over 3/4 inches in diameter. Despite this fact, the average degrade from knot damage including knotholes was only about 4 1/2 per cent in No. 1C and about 1 1/3 per cent in No. 2C. Some of the knotholes that developed during seasoning or machining were too small to lower the original grade. The pieces containing these small knotholes averaged 2.9 per cent in No. 1C and 5.5 per cent in No. 2C.

Degrade from planer split and warp in lumber dried using a high minimum EMC step in the kiln schedule averaged 1.2 per cent in No. 1C and 1.1 per cent in No. 2C. Using a low minimum EMC step in the schedule led to an average degrade from planer split and warp of 5.7 per cent in No. 1C and 3.8 per cent in No. 2C.

Prices received at the mill are usually higher for kiln-dried than for green dimension lumber. Not all of this premium is gained by the mill, however, because of the drop in grade of some pieces during drying and machining. A summary of these factors is shown below.

Grade	Mill prices[1]		Recovery value of kiln-dried lumber		Loss from degrade	
	Green	Kiln-dried	Low EMC	High EMC	Low EMC	High EMC
Sel Str	$78.50	$92.00	$88.24	$89.81	$3.76	$2.19
No. 1C	68.50	82.00	79.66	81.30	2.34	0.70
No. 2C	65.25	76.00	74.19	75.13	1.81	0.87

[1] Prices per M fbm based on Crow's Price Reporter, 20 August 1953. Average of "Most Sales." A price differential of $10.00 is assumed between Select Structural and No. 1C.

Average shrinkage in thickness and width during kiln-drying to 12 per cent average moisture content was 3.5 per cent, with 80 per cent of the pieces shrinking 4.1 per cent or less.

When lumber which had been kiln-dried to 18 per cent average moisture content and surfaced was allowed to dry further to about 12 per cent moisture content, the average additional shrinkage was found to be about 0.9 per cent, with 90 per cent of the pieces shrinking 1.5 per cent or less. The average residual shrinkage when dried from 18 to 5 per cent moisture content was 2.5 per cent.

The shipping weight of S4S green dimension ranged from 2500 to 2800 pounds per thousand board feet. When kiln-dried to 18 per cent average moisture content, the surfaced lumber averaged 2170 pounds per thousand, and when dried to 12 per cent moisture content averaged 2080 pounds per thousand board feet.

Time required for drying to a final average moisture content of 18 per cent ranged from 48 to 90 hours. The shorter interval was needed for kiln schedules with a constant dry-bulb temperature of 200 deg F.

Drying time to 12 per cent average moisture content was 110-120 hours.

A general picture of drying times may be gained by comparing charges 2 and 5A with charges 6 and 7.

Charge	Dry-bulb temperature		EMC		Drying time	Avg final MC
	Initial	Final	Initial	Final	Hours	%
2	135	175	16	4	75	18
5A					110	12
6	180	180	12	9	72	18
7					120	12

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SEASONING AND MACHINING DEGRADE IN YOUNG-GROWTH DOUGLAS-FIR DIMENSION LUMBER

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INTRODUCTION

No one seems to know what the annual cut of second-growth, or, more properly, young-growth Douglas-fir, is at present. But it is known that the proportion of young-growth sawed to the total cut is increasing yearly in the Douglas-fir region, and that small sawmills are being built each year to cut small-diameter logs from young stands. The Douglas-fir lumber industry is beginning the transition from an old-growth to a young-growth economy. European countries and the southern pine region in the United States have made this transition, and have been confronted with problems quite different from those encountered when the lumber production was entirely from old-growth timber. A volume estimate of standing Douglas-fir timber in Oregon and Washington in 1945 placed the old-growth stand at 185 billion fbm and the young-growth stand at 80 billion fbm--defining young growth as under 160 years old.*

As the annual cut of young-growth timber increases, it is inevitable that more young-growth lumber will be kiln-dried. Consequently, interest is increasingly manifested in the problems which will appear as more mills go into the

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* Kirkland Report for the American Forestry Association, 1945.

production of such lumber. One might speculate on seasoning problems to arise with a higher cut of this type of lumber, such as:

1. Small-diameter logs mean greater ring curvature. Should more cupping be expected during kiln-drying, and consequently more planer split during machining?
2. Young-growth frequently has coarse grain. Should season checks be expected, and more grain separation during machining?
3. Young-growth may have a higher percentage of tight knots than does old-growth. Does a possibility exist of drying this tight-knotted lumber to moisture content levels lower than 18-20 per cent without excessive increases in degrade from knot damage?
4. Young-growth may contain more abnormal wood than does old-growth. Will this result in more warp during kiln-drying?
5. The smaller the log diameter, the higher the percentage of sapwood, it is found. Will this increase the incentive to kiln-dry young-growth dimension in order to avoid higher green shipping weights?
6. A higher percentage of sapwood means more susceptibility to stain, mold, and decay of green lumber during bulk shipment and storage. Will this provide another incentive for the kiln-drying of young-growth dimension?
7. Shrinkage of young-growth Douglas-fir lumber may differ from that of old-growth. Will this necessitate an adjustment in width and thickness of rough-green lumber?

To answer some of these questions the Oregon Forest Products Laboratory, in cooperation with the Pacific Northwest Forest and Range Experiment Station, the West Coast Lumbermen's Association, the West Coast Bureau of Lumber Grades and Inspection, and several lumber companies located in the Willamette Valley, recently completed the initial phase of a long-term investigation into effects of seasoning and machining young-growth Douglas-fir lumber. The first part of this study has been concerned with 2- by 8-inch by 16-foot young-growth Douglas-fir dimension lumber, in the grades of Select Structural, No. 1 Common and No. 2 Common.

Most of the Douglas-fir dimension now cut is machined and shipped green. However, for around 25 years some Douglas-fir mills have been kiln-drying common grades of Douglas-fir in order to preshrink the pieces at least partially and remove the risk of stain and decay during bulk shipment and storage. Other reasons for kiln-drying have been to obtain reductions in shipping weights, and higher prices for kiln-dried lumber.

Twenty-seven years ago A. C. Knauss and his co-workers at Vernonia, Oregon, conducted a study of degrade in kiln-dried old-growth Douglas-fir dimension. The results of this study confirmed a prior conclusion of the Oregon American Lumber Company that kiln-drying of this type of lumber would be a practical operation.[1,2,3] This study established the present practice of kiln-drying dimension to a moisture content level of 18-20 per cent. One reason for drying to this level is to limit the degrade from loss of black or encased knots in old-growth lumber. As it is expected that fewer black knots will be found in young-growth, the present study was so planned as to gain information on degrade at various average moisture content levels between 12 and 18 per cent, in order to ascertain if tight-knotted stock could be dried to lower moisture content levels without excessive increase in degrade from knot damage.

The objectives of this study on seasoning and machining degrade in young-growth Douglas-fir dimension lumber are, in part, as follows:

1. To determine the amount and causes of degrade in several grades of young-growth Douglas-fir dimension lumber resulting from kiln-drying

with various kiln schedules to moisture content levels between 12 and 18 per cent.

2. To obtain shrinkage measurements from green to kiln-dried moisture content level.
3. To obtain residual shrinkage from the kiln-dried, surfaced dimension to that reached in use.
4. To obtain shipping weights of lumber dried to various moisture content levels.
5. To determine the effects of kiln-schedule modifications.
6. To determine specific gravity and ring count of lumber used in the study charges.

STUDY CHARGES

There were eleven study charges, each of approximately 6500 fbm.

Charge 1 was planed green to determine the effect on grade of machining only. All other charges were kiln-dried before machining as follows:

Schedules and Drying Times for Kiln-dried Charges.

Charge	Location of kiln	Dry-bulb temperature Initial	Dry-bulb temperature Final	EMC Initial	EMC Final	Drying time	Average Moisture content Initial	Average Moisture content Final
		Deg F	Deg F	%	%	Hours	%	%
2	D.Fir Prod Co	135	175	17.2	4.4	75	48.9	18.4
3	OFPL	135	180	15.9	7.8	76	44.6	18.0
4	OFPL	134	175	15.9	4.3	86	51.6	14.9
5	Timber Struct.	160	190	14.2	3.3	188	44.7	7.8
5A	OFPL	135	175	15.9	4.3	110	44.8	12.4
6	OFPL	180	180	12.1	9.0	119	48.0	12.1
7	OFPL	180	180	12.1	8.8	117	47.8	12.5
8	OFPL	200	200	7.7	7.7	52	48.0	18.0
9	OFPL	200	200	7.7	7.7*	64	40.8	17.0
10	OFPL	130	130	11.0	11.0	90	33.3	17.9

* Equilibrium moisture content level was 13.2 per cent during last 13 hours.

The two commercial kilns used in the study, and the experimental kiln at the Oregon Forest Products Laboratory, were steam-heated, cross-circulation, compartment-type with reversible fans. The loading on kiln cars of all study charges was by the unit package system with fork lift. Sticker size was 3/4 by 1 5/8 inches; sticker spacing was 4 feet. All the lumber used in the study was flat-piled in unit packages which varied from 2 to 4 feet in height. Total length of air travel through the lumber as it was piled on kiln cars was 8 feet. Air velocity through the loads of lumber in the kiln was between 350 and 450 feet per minute. Air circulation was reversed approximately every twelve hours.

Charge 1 was planed at Clear Lumber Sales Company, Lebanon. Charge 2 was kiln-dried and planed at Douglas Fir Products Company, Lebanon. Charge 5 was kiln-dried and planed at Timber Structures, Inc., Portland. All the rest of the study charges were kiln-dried at the Oregon Forest Products Laboratory, and planed at Corvallis Lumber Company, Corvallis. The lumber for the latter charges was obtained at the Bayless Sawmill, Philomath, through the courtesy of the Albertsen Lumber Company, Philomath.

The planer at Corvallis Lumber Company operated at a feed rate of 290 feet per minute. Both the side heads and face heads turned at 3700 revolutions per minute, the side heads with 6 knives and the face heads with 8 knives. The knives on the face heads were set at a cutting angle of 28 degrees, the same cutting angle being used for both green and kiln-dried dimension.

The planer at Douglas Fir Products Company had a 10-knife head turning at 3450 rpm. The knives were ground with a back-bevel. Feed rate was 360 feet per minute, and the knife angle was 27 degrees.

The planer at Timber Structures in Portland had an 8-knife head turning at 3400 rpm. Top and side knives were back-beveled; bottom knives were not back-beveled. Feed rate was 250 feet per minute. Knife angle was 30 degrees.

All lumber in the study was planed to American Lumber Standards size of 1 5/8 inches by 7 1/2 inches.

The lumber used in the study charges was graded three times by inspectors from the West Coast Bureau of Lumber Grades and Inspection. The first grading was done on the rough-green lumber, the second on the rough-dry, and the third on the surfaced-dry lumber.

Such pertinent data as degrade, final moisture content, drying rates, rough weights, shipping weights, shrinkage, and specific gravity were kept on each charge.

RESULTS AND DISCUSSION

Degrade

Charge 1, which was machined green, showed that no change in grade occurred between the rough-green and the S4S (surfaced-four-sides) green conditions. For this reason all the degrade which developed in the kiln-dried S4S lumber was charged to seasoning, even though most of such degrade developed during the machining operation.

Table 1 shows the degrade percentages found in the kiln-dried S4S charges for Number 1 Common and Number 2 Common. The average total degrade found in Number 1 Common was about twice that found in Number 2 Common, although the ratio did not hold very consistently within individual charges. The degrade found in Select Structural averaged about twice that in Number 1 Common.

Table 2 shows the percentage recovery in S4S grade based on the rough-green footage of Number 1 Common in individual charges. The same information for Number 2 Common is presented in Table 3.

Tables 4 through 9 show the effects of three different variables on the degrade found in Number 1 and Number 2 Common. The three variables considered were (1) the lowest EMC step in the schedule, (2) the average kiln-dried moisture content of the charge, and (3) the initial dry-bulb temperature in the schedule. An examination of these data revealed that the lowest EMC step in the schedule was the only one of the three variables which had an important effect on the amount of degrade. When degrade was subdivided according to types of defect it was seen that degrade because of knot damage was rather constant regardless of moisture content to which the stock was dried or how the dry-bulb temperature and EMC were manipulated. In Number 1 Common, knot damage was usually the most important source of degrade. Planer split and warp were affected by the lowest EMC step as well as by the moisture content to which the stock was dried, but not by the initial dry-bulb temperature.

An examination of Table 4 shows that total degrade in both Number 1 and 2 Common was doubled by use of a low-humidity schedule.

Charges dried with schedules having high initial dry-bulb temperatures did not have higher degrade percentages than did charges dried with low initial dry-bulb temperatures (Table 8).

Table 10 presents degrade in terms of dollar value, based on current prices during the summer of 1953. The loss from degrade in the low-humidity schedules was higher than loss in high-humidity schedules by about $1.60 per M fbm for Select Structural, $1.60 for Number 1 Common and $1.00 for Number 2 Common.

Degrade is a function of EMC and time. Final moisture content is also a function of EMC and time. It would be misleading, however, to conclude that degrade is a function of final average moisture content, because a wide range of final average moisture contents can be obtained using low-humidity schedules.

It appeared that the effect of a low EMC schedule on degrade took place much faster than its effect on average moisture content. For further information on this point refer to the section entitled "Remarks".

Because of the importance of knot damage, a supplementary study was made to determine the influence of drying temperature on the development of damage to tight knots. Two small matched charges were dried at a constant EMC of 12 per cent; one of the charges with a constant dry-bulb temperature of 125 deg F, and the other at 175 deg F. No difference could be detected in the development of damage to tight knots as the two charges dried.

An attempt was made in charge 9 to reduce the amount of knot degrade by steaming the charge before unloading, as well as by wetting down the individual boards as they were unstickered. No noticeable reduction in total degrade was experienced as a result of this treatment. However, this charge suffered the least amount of degrade from planer split and warp of any of the kiln-dried charges. No ill effects from the wetting were noted.

Reports of lumber sales showed that in August 1953 kiln-dried Douglas-fir dimension sold at a premium ranging from $10.75 for No. 2 Common to $13.50 for Select Structural and No. 1 Common over the same item shipped green.* As the result of degrade, the dry surfaced lumber failed to fully supply this premium. Results of this study showed that with properly chosen kiln-drying schedules, young-growth Douglas-fir dimension could be kiln-dried to a moisture content of 12 per cent with the degrade reducing the full premium return by $0.70 for No. 1 Common and $0.87 for No. 2 Common, the principal grades produced at the mill.

<u>Black-knotted pieces</u>

The percentages of pieces within individual charges which contained black knots of over 3/4-inch diameter ranged from 10 to 28 per cent (Table 11). Degrade

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* Crow's Price Reporter. August 20, 1953.

from knot damage of all types averaged about 4 1/2 per cent in No. 1C and about 1 1/3 per cent in No. 2C. Some damage to appearance, however, was caused by knotholes which were too small or too few to lower the grade of the piece. Somewhat less than 10 per cent of the pieces within individual charges contained knotholes which affected the appearance but did not lower the grade; the average in all charges was 2.9 per cent in No. 1C and 5.6 per cent in No. 2C.

Shipping weight

Figure 1 shows the relationship of S4S shipping weight to average moisture content in 2- by 8-inch by 16-foot young-growth Douglas-fir dimension. Approximately 20 per cent of the pieces in each charge were weighed rough-green, rough-dry and surfaced-dry. Figure 1 is based on the average surfaced-dry weight for individual charges. It can be seen that kiln-drying will result in a shipping-weight saving of from 350 to 650 pounds per M fbm of surfaced dimension lumber, depending upon the initial green moisture content and the moisture content to which it is dried.

Figure 2 shows the relationship of weight to moisture content in rough 2- by 8-inch by 16-foot dimension. The water removal during kiln-drying varied from 700 to 1000 pounds per M fbm of rough dimension, depending upon the green moisture content and the moisture content to which it was dried.

Figure 3 gives a cumulative distribution of green weight per cubic foot representing 556 individual pieces. Sixty per cent of the pieces measured had green weights between 35 and 45 pounds per cubic foot.

Specific gravity and ring count

Specific gravity determinations were made on 20 specimens from each of 10 of the test charges. An average specific gravity value of 0.424 was obtained using the oven-dry weight and green volume. Sixty per cent of the specific gravity values fell between about 0.39 and 0.46 (Figure 4).

Figure 5 through 15 are end-grain photographs of the kiln samples used in the kiln-dried charges. The individual sections are marked with their specific gravity values. An indication of the variation in ring count can be obtained by an examination of these photographs. Section number 5 from charge 5 had a ring count of 14 rings per inch (Figure 9). Section number 19 from charge 9 had a ring count of 2 1/2 rings per inch (Figure 14). These sections represented the extreme ring-count values found in kiln samples from all charges.

Drying rate--kiln schedules

Figures 23 through 32 show kiln schedules and drying rates for 20 kiln samples per charge. Drying time to 18 per cent average moisture content for charges 2, 4 and 5A was about 72-75 hours. Drying time to 18 per cent average moisture content for high temperature-high humidity schedules (charges 8 and 9) was about 50 hours. Drying time for a low temperature-high humidity schedule (charge 10) was about 90 hours to an average moisture content at 18 per cent. This charge had a low average green moisture content of about 34 per cent. If the green moisture content of charge 10 had been from 40 to 45 per cent, the drying time to 18 per cent would have been much longer.

Green moisture content

Figure 33 shows the variation in green moisture content of lumber in the 10 charges which were kiln-dried. The median green moisture content value was 40 per cent, with 60 per cent of the boards having green moisture contents between 35 and 52 per cent.

Uniformity of final moisture content

Figures 34 through 43 show moisture-meter readings in the kiln-dried charges. Charge 2 showed more uniformity in final moisture content than did charge 3, probably because charge 2 was subjected to a three-week winter storage period in the cooling shed before unstickering. In general, the schedules using high final humidities showed more uniformity in final moisture content than did those with low final humidities.

Moisture-meter readings

Figure 44 gives a comparison of moisture-meter readings and oven-test moisture-content values found in the kiln-dried lumber. Close correlation was obtained between oven-test values on kiln samples and moisture-meter readings on all S4S boards within individual charges.

Shrinkage during kiln-drying

Cumulative distribution curves for rough-green and rough-dry thicknesses of the lumber used in the study are shown in Figure 45. The rough-dry measurements were made on lumber which was dried to an average of about 12 per cent moisture content. An examination of this curve will show an average shrinkage in thickness of about 3.5 per cent in drying from green to 12 per cent average moisture content.

Figure 46 gives a cumulative distribution of shrinkages in width from green to two different moisture-content levels. When drying to 18 per cent average moisture content the median shrinkage value was about 2.2 per cent, with 80 per cent of the boards shrinking less than 2.8 per cent. When drying to 12 per cent average moisture content the median shrinkage value was about 3.4 per cent, with 80 per cent of the boards shrinking less than 4.1 per cent.

Residual shrinkage

In order to determine the extent of additional shrinkage which dimension lumber would undergo when drying from the kiln-dried moisture content to that reached in use, sections were cut from 20 kiln samples in each charge and measured in width before and after being conditioned to equilibrium with 65 per cent relative humidity at 70 deg F (approximately 12 per cent equilibrium moisture content). The average residual-shrinkage values obtained are shown in Figure 47. When lumber was kiln-dried to 18 per cent average moisture content the average additional shrinkage was found to be about 1.0 per cent. When kiln-dried to 15 per cent average moisture content, the average additional shrinkage was found to be about 0.6 per cent.

Average residual shrinkage values for lumber dried to equilibrium with 25 per cent relative humidity at 100 deg F also are shown in Figure 47.

Figure 48 gives a cumulative distribution curve for residual shrinkage of lumber which was kiln-dried to 16-18 per cent moisture content. The median residual-shrinkage value on this curve is about 0.65 per cent, with 90 per cent of the boards having less than 1.5 per cent residual shrinkage in width.

CONCLUSIONS

Young-growth Douglas-fir dimension lumber was dried to moisture contents down to 12 per cent without excessive degrade when the lowest EMC level in the schedule was kept at 8 per cent or higher. The lower the EMC during the low relative humidity step in the schedule, the higher the resulting degrade was found to be.

Of three variables which affected degrade in young-growth Douglas-fir dimension--the EMC of the low-humidity step in the schedule, the initial dry-bulb temperature, and the final average moisture content--the most important was the EMC of the low-humidity step.

Temperatures up to 200 deg F were used in drying this material without excessive degrade when EMC was closely controlled at a sufficiently high level.

REMARKS

Because of the important effect on degrade of the low EMC step in the schedule, it would be wise to keep the EMC during the kiln schedule as high as possible consistent with a reasonable drying time, in the drying of young-growth Douglas-fir dimension. The dry-bulb temperature should also be kept as high as possible during the schedule, within limits that permit accurate control of the desired EMC as well as reasonable steam consumption.

Certain kiln schedules which have been observed in use for kiln-drying young-growth Douglas-fir dimension lumber could be modified to reduce degrade by:

- Raising the EMC used during the low-humidity step of the schedule.
- Raising the initial dry-bulb temperature to overcome the retarding effect which a higher EMC has on drying time.

It must be recognized that in dry kilns which exhibit large longitudinal or cyclic variations in dry-bulb temperature, the substitution of a high-temperature schedule for a satisfactory low- or medium-temperature schedule might lead to excessively high degrade percentages because of loss of control over EMC.

Drying of young-growth Douglas-fir dimension to an average of 16-18 per cent moisture content is believed to be satisfactory if the lumber is to be used for general construction purposes, for the following reasons:

- An average moisture content of 16-18 per cent can be obtained in a short time using a kiln schedule which results in low degrade.
- Shipping weight is not decreased greatly by drying to moisture content levels below 18 per cent.
- Residual shrinkage of lumber which has been dried to an average of 18 per cent moisture content is low enough to be satisfactory for most construction uses.

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Table 1. Total Degrade in No. 1 and No. 2 Common Young-growth Douglas-fir Dimension Lumber.

Charge	Final average moisture content	Total degrade (fbm basis) No. 1 Common	Total degrade (fbm basis) No. 2 Common
	Per cent	Per cent	Per cent
2	18.4	10.7	4.8
3	18.0	9.7	5.5
4	14.9	13.5	11.3
5	7.8	21.2	5.1
5A	12.4	6.4	2.8
6	12.1	8.3	1.1
7	12.5	4.0	3.0
8	16.4	4.1	3.7
9	16.1	5.6	3.3
10	17.6	3.6	2.4
All Charges		8.7	4.3

Table 2. Kiln-dried S4S Recovery in Grade from No. 1 Common Young-growth Douglas-fir Dimension Lumber.

Charge	Final average moisture content	Recovery in grade (fbm basis) No. 1C	No. 2C	No. 3C	No. 4C	Loss
	- - - - - - - - -	- - - - Per	cent - - - -			
2	18.4	89.3	1.8	8.8	--	0.1
3	18.0	90.3	7.4	2.2	--	0.1
4	14.9	86.5	7.8	5.7	--	0.0
5	7.8	78.8	14.3	4.9	--	2.0
5A	12.4	93.6	5.6	0.7	--	0.1
6	12.1	91.7	8.3	0.0	--	0.0
7	12.5	96.0	2.6	0.9	--	0.5
8	16.4	95.9	3.8	0.0	--	0.3
9	16.1	94.4	5.6	0.0	--	0.0
10	17.6	96.4	0.9	2.4	--	0.3

Table 3. Kiln-dried S4S Recovery in Grade from No. 2 Common Young-growth Douglas-fir Dimension Lumber.

Charge	Final average moisture content	Recovery in grade (fbm basis)			
		No. 2C	No. 3C	No. 4C	Loss
	- - - - - - - - - - - - - - - -	Per cent	- - - - - - - - - - - - - - - -		
2	18.4	95.2	4.8	0.0	0.0
3	18.0	94.5	4.6	0.8	0.1
4	14.9	88.7	11.3	0.0	0.0
5	7.8	94.9	1.6	0.0	3.5
5A	12.4	97.2	2.7	0.0	0.1
6	12.1	98.9	0.5	0.5	0.1
7	12.5	97.0	3.0	0.0	0.0
8	16.4	96.3	3.2	0.0	0.5
9	16.1	96.7	3.1	0.0	0.2
10	17.6	97.6	2.1	0.0	0.3

Table 4. Effects of Low EMC Step in Schedule on Degrade Percentages.

Charge	EMC of low relative humidity step	Total degrade			Falldown below No. 2C			Degrade from knot damage			Degrade from other than knot damage*		
		No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg
	Per cent	Per cent											
2	4.4	10.7	4.8	7.8	8.9	4.8	6.8	3.8	1.8	2.8	6.9	3.0	4.9
4	4.3	13.5	11.3	12.4	5.7	11.3	8.5	6.2	4.0	5.1	7.3	7.3	7.3
5	3.3	21.2	5.1	13.1	6.9	5.1	6.0	6.2	0.0	3.1	15.0	5.1	10.0
5A	4.3	6.4	2.8	4.6	0.8	2.8	1.8	4.2	0.0	2.1	2.2	2.8	2.5
Average above group		12.9	6.0	9.5	5.6	6.0	5.8	5.1	1.4	3.3	7.8	4.5	6.2
3	7.8	9.7	5.5	7.6	2.3	5.5	3.9	6.0	1.6	3.8	3.7	3.9	3.8
6	9.0	8.3	1.1	4.7	0.0	1.1	0.5	7.4	0.0	3.7	0.9	1.1	1.0
7	8.8	4.0	3.0	3.5	1.4	3.0	2.2	2.6	0.6	1.6	1.4	2.4	1.9
8	7.7	4.1	3.7	3.9	0.3	3.7	2.0	2.3	0.0	1.1	1.8	3.7	2.7
9	7.7	5.6	3.3	4.4	0.0	3.3	1.7	4.9	3.1	4.0	0.7	0.2	0.4
10	11.0	3.6	2.4	3.0	2.7	2.4	2.5	0.9	1.6	1.2	2.7	0.8	1.7
Average above group		5.9	3.2	4.5	1.1	3.2	2.1	4.0	1.1	2.6	1.8	2.0	1.9

* Includes degrade from planer split, warp, season checks, shake and grain separation.

Table 5. Effects of Low EMC Step in Schedule on Various Causes of Degrade.

Charge	EMC of low relative humidity step	Degrade from various causes*											
		Loose knots and edge knots			Planer split and warp			Season checks			Knotholes		
		No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg
	Per cent	Per cent											
2	4.4	1.0	0.9	0.9	2.0	1.8	1.9	4.8	0.9	2.9	2.8	0.9	1.8
4	4.3	3.0	0.8	1.9	4.1	5.2	4.6	0.7	0.0	0.3	3.2	3.2	3.2
5	3.3	2.4	0.0	1.2	14.6	5.1	9.8	0.0	0.0	0.0	3.8	0.0	1.9
5A	4.3	1.4	0.0	0.7	2.2	2.7	2.5	0.0	0.0	0.0	2.8	0.0	1.4
Average above group		1.9	0.4	1.2	5.7	3.8	4.7	1.4	0.2	0.8	3.2	1.0	2.1
3	7.8	3.7	0.8	2.2	0.7	0.1	0.4	0.0	0.0	0.0	2.3	0.8	1.5
6	9.0	1.8	0.0	0.9	0.9	0.6	0.7	0.0	0.0	0.0	5.6	0.0	2.8
7	8.8	0.9	0.6	0.7	1.4	1.2	1.3	0.0	0.6	0.3	1.7	0.0	0.8
8	7.7	0.8	0.0	0.4	1.8	3.6	2.7	0.0	0.0	0.0	1.5	0.0	0.7
9	7.7	3.3	1.2	2.2	0.0	0.2	0.1	0.0	0.0	0.0	1.6	1.9	1.7
10	11.0	0.9	1.6	1.2	2.7	0.8	1.7	0.0	0.0	0.0	0.0	0.0	0.0
Average above group		1.9	0.7	1.3	1.2	1.1	1.1	0.0	0.1	0.05	2.1	0.45	1.2

*Degrade from shake and grain separation is not included.

Table 6. Effects of Final Average Kiln-dried Moisture Content on Degrade Percentages.

Charge	Average moisture content	Total degrade			Falldown below No. 2C			Degrade from knot damage			Degrade from other than knot damage*		
		No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg
	Per cent	Per cent											
2	18.4	10.7	4.8	7.8	8.9	4.8	6.8	3.8	1.8	2.8	6.9	3.0	4.9
3	18.0	9.7	5.5	7.6	2.3	5.5	3.9	6.0	1.6	3.8	3.7	3.9	3.8
10	17.6	3.6	2.4	3.0	2.7	2.4	2.5	0.9	1.6	1.2	2.7	0.8	1.7
8	16.4	4.1	3.7	3.9	0.3	3.7	2.0	2.3	0.0	1.1	1.8	3.7	2.7
9	16.1	5.6	3.3	4.4	0.0	3.3	1.7	4.9	3.1	4.0	0.7	0.2	0.4
4	14.9	13.5	11.3	12.4	5.7	11.3	8.5	6.2	4.0	5.1	7.3	7.3	7.3
Average above group		7.9	5.2	6.5	3.3	5.2	4.2	4.0	2.0	3.0	3.8	3.1	3.5
7	12.5	4.0	3.0	3.5	1.4	3.0	2.2	2.6	0.6	1.6	1.4	2.4	1.9
5A	12.4	6.4	2.8	4.6	0.8	2.8	1.8	4.2	0.0	2.1	2.2	2.8	2.5
6	12.1	8.3	1.1	4.7	0.0	1.1	0.5	7.4	0.0	2.7	0.9	1.1	1.0
5	7.8	21.2	5.1	13.1	6.9	5.1	6.0	6.2	0.0	3.1	15.0	5.1	10.0
Average above group		10.0	3.0	6.5	2.3	3.0	2.6	5.1	0.1	2.4	4.9	2.8	3.8

* Includes degrade from planer split, warp, season checks, shake and grain separation.

Table 7. Effects of Final Average Kiln-dried Moisture Content on Various Causes of Degrade.

Charge	Average moisture content	Degrade from various causes*											
		Loose knots and edge knots			Planer split and warp			Season checks			Knotholes		
		No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg
	Per cent	Per cent											
2	18.4	1.0	0.9	0.9	2.0	1.8	1.9	4.9	0.9	2.9	2.8	0.9	1.8
3	18.0	3.7	0.8	2.2	0.7	0.1	0.4	0.0	0.0	0.0	2.3	0.8	1.5
10	17.6	0.9	1.6	1.2	2.7	0.8	1.7	0.0	0.0	0.0	0.0	0.0	0.0
8	16.4	0.8	0.0	0.4	1.8	3.6	2.7	0.0	0.0	0.0	1.5	0.0	0.7
9	16.1	3.3	1.2	2.2	0.0	0.2	0.1	0.0	0.0	0.0	1.6	1.9	1.7
4	14.9	3.0	0.8	1.9	4.1	5.2	4.6	0.7	0.0	0.3	3.2	3.2	3.2
Average above group		2.1	0.9	1.5	1.9	1.9	1.9	0.9	0.1	0.5	1.9	1.1	1.5
7	12.5	0.9	0.6	0.7	1.4	1.2	1.3	0.0	0.6	0.3	1.7	0.0	0.8
5A	12.4	1.4	0.0	0.7	2.2	2.7	2.5	0.0	0.0	0.0	2.8	0.0	1.4
6	12.1	1.8	0.0	0.9	0.9	0.6	0.7	0.0	0.0	0.0	5.6	0.0	2.8
5	7.8	2.4	0.0	1.2	14.6	5.1	9.8	0.0	0.0	0.0	3.8	0.0	1.9
Average above group		1.6	0.1	0.9	4.8	2.4	3.5	0.0	0.15	0.1	3.5	0.0	1.7

* Degrade from shake and grain separation is not included.

Table 8. Effect of Initial Dry-bulb Temperature on Degrade Percentages.

Charge	Initial dry bulb temp	Total degrade			Falldown below No. 2C			Degrade from knot damage			Degrade from other than knot damage*		
		No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg
	Deg F	Per cent											
5	160	21.2	5.1	13.1	6.9	5.1	6.0	6.2	0.0	3.1	15.0	5.1	10.0
6	180	8.3	1.1	4.7	0.0	1.1	0.5	7.4	0.0	3.7	0.9	1.1	1.0
7	180	4.0	3.0	3.5	1.4	3.0	2.2	2.6	0.6	1.6	1.4	2.4	1.9
8	200	4.1	3.7	3.9	0.3	3.7	2.0	2.3	0.0	1.1	1.8	3.7	2.7
9	200	5.6	3.3	4.4	0.0	3.3	1.7	4.9	3.1	4.0	0.7	0.2	0.4
Average above group		8.6	3.2	5.9	1.7	3.2	2.5	4.7	0.7	2.7	4.0	2.5	3.3
2	135	10.7	4.8	7.8	8.9	4.8	6.8	3.8	1.8	2.8	6.9	3.0	4.9
3	135	9.7	5.5	7.6	2.3	5.5	3.9	6.0	1.6	3.8	3.7	3.9	3.8
4	135	13.5	11.3	12.4	5.7	11.3	8.5	6.2	4.0	5.1	7.3	7.3	7.3
5A	135	6.4	2.8	4.6	0.8	2.8	1.8	4.2	0.0	2.1	2.2	2.8	2.5
10	130	3.6	2.4	3.0	2.7	2.4	2.5	0.9	1.6	1.2	2.7	0.8	1.7
Average above group		8.8	5.3	7.0	4.1	5.4	4.7	4.2	1.8	3.0	4.6	3.6	4.1

* Includes degrade from planer split, warp, season checks, shake and grain separation.

Table 9. Effect of Initial Dry-bulb Temperature on Various Causes of Degrade.

		Degrade from various causes*											
		Loose knots and edge knots			Planer split and warp			Season checks			Knotholes		
Charge	Initial dry-bulb temp	No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg	No.1C	No.2C	Avg
	Deg F	Per cent											
5	160	2.4	0.0	1.2	14.6	5.1	9.8	0.0	0.0	0.0	3.8	0.0	1.9
6	180	1.8	0.0	0.9	0.9	0.6	0.7	0.0	0.0	0.0	5.6	0.0	2.8
7	180	0.9	0.6	0.7	1.4	1.2	1.3	0.0	0.6	0.3	1.7	0.0	0.8
8	200	0.8	0.0	0.4	1.8	3.6	2.7	0.0	0.0	0.0	1.5	0.0	0.7
9	200	3.3	1.2	2.2	0.0	0.2	0.1	0.0	0.0	0.0	1.6	1.9	1.7
Average above group		1.8	0.4	1.1	3.7	2.2	2.9	0.0	0.1	0.06	2.8	0.4	1.6
2	135	1.0	0.9	0.9	2.0	1.8	1.9	4.9	0.9	2.9	2.8	0.9	1.8
3	135	3.7	0.8	2.2	0.7	0.1	0.4	0.0	0.0	0.0	2.3	0.8	1.5
4	135	3.0	0.8	1.9	4.1	5.2	4.6	0.7	0.0	0.3	3.2	3.2	3.2
5A	135	1.4	0.0	0.7	2.2	2.7	2.5	0.0	0.0	0.0	2.8	0.0	1.4
10	130	0.9	1.6	1.2	2.7	0.8	1.7	0.0	0.0	0.0	0.0	0.0	0.0
Average above group		2.0	0.8	1.4	2.3	2.1	2.2	1.1	0.2	0.6	2.2	1.0	1.6

* Degrade from shake and grain separation is not included.

Table 10. Effect of Low EMC Step in Schedule on Dollar Recovery per Thousand Board Feet of Kiln-dried Dimension Lumber.

EMC of low relative humidity step	Grade of kiln-dried, planed lumber	Value per M fbm of rough-green lumber after kiln-drying and machining		
		Select Str	No.1 Common	No.2 Common
Per cent				
3.3-4.4	Sel Str	$69.74	--	--
	No. 1C	12.79	$71.34	--
	No. 2C	5.32	5.62	$71.44
	No. 3C	0.27	2.70	2.75
	No. 4C	0.12	--	--
	All grades	$88.24	$79.66	$74.19
7.7-11.0	Sel Str	78.75	--	--
	No. 1C	7.87	77.16	--
	No. 2C	3.19	3.65	73.57
	No. 3C	--	0.49	1.51
	No. 4C	--	--	0.05
	All grades	$89.81	$81.30	$75.13

SUMMARY

Grade	Total value per M fbm (S4S)			
	Low EMC schedule	High EMC schedule	KD value with no degrade*	Green value with no degrade*
Sel Str	$88.24	$89.81	$92.00	$78.50
No. 1C	79.66	81.30	82.00	68.50
No. 2C	74.19	75.13	76.00	65.25
No. 3C	--	--	54.00	48.00
No. 4C	--	--	23.00	18.50

* Prices based on Crows Price Reporter, August 20, 1953, average of "Most Sales". A price differential of $10 was assumed between Number 1 Common and Select Structural.

Table 11. Percentages of Green Pieces Containing Black Knots of Over 3/4-inch Diameter.

Charge	Lumber grade	
	Sel Str and No. 1C	No. 2C
	Per cent	Per cent
3	16.9	20.7
4	13.5	11.8
5A	15.4	12.1
6	24.2	17.3
7	22.3	22.0
8	11.6	10.1
9	22.6	26.1
10	18.1	28.2
Above charges	18.1	18.5

FIGURE 1. RELATIONSHIP OF SHIPPING WEIGHT TO AVERAGE MOISTURE CONTENT IN 2- by 8-INCH YOUNG-GROWTH DOUGLAS-FIR, SURFACED FOUR SIDES (AVERAGE OF NO 1 AND 2 COMMON).

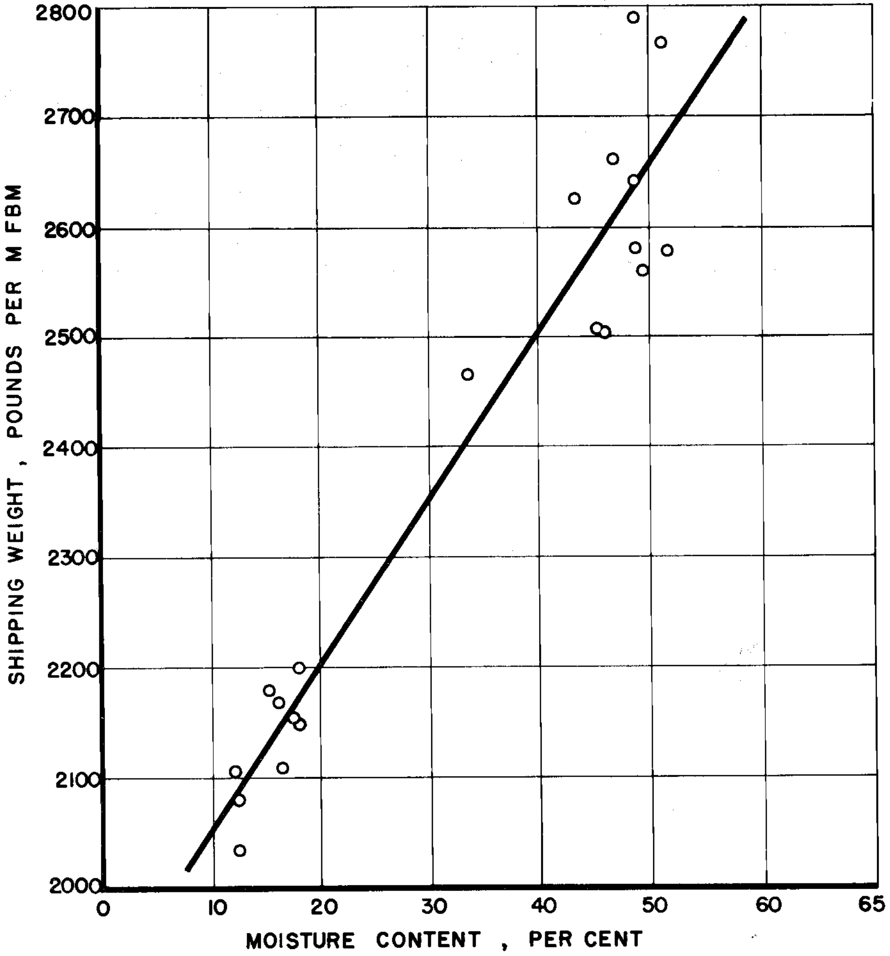


FIGURE 2. WEIGHT PER M FBM BY MOISTURE CONTENT; ROUGH 2-by 8- INCH by 16-FOOT YOUNG-GROWTH DOUGLAS-FIR (AVERAGE OF NO. 1 AND NO. 2 COMMON).

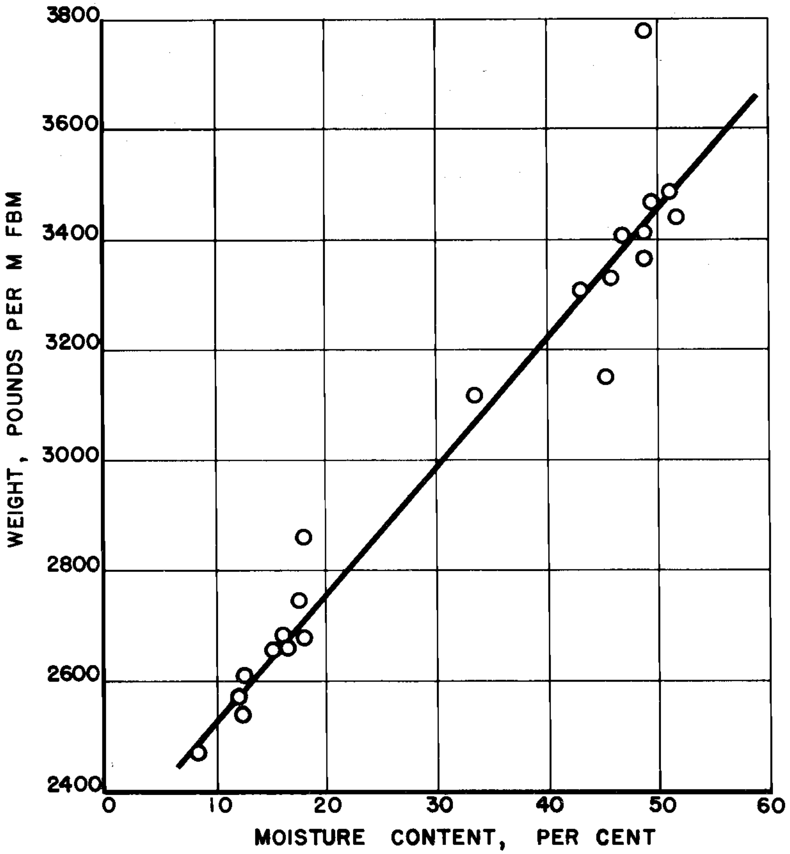


FIGURE 3. CUMULATIVE DISTRIBUTION OF DENSITY VALUES IN 2-by 8-INCH GREEN DOUGLAS-FIR.

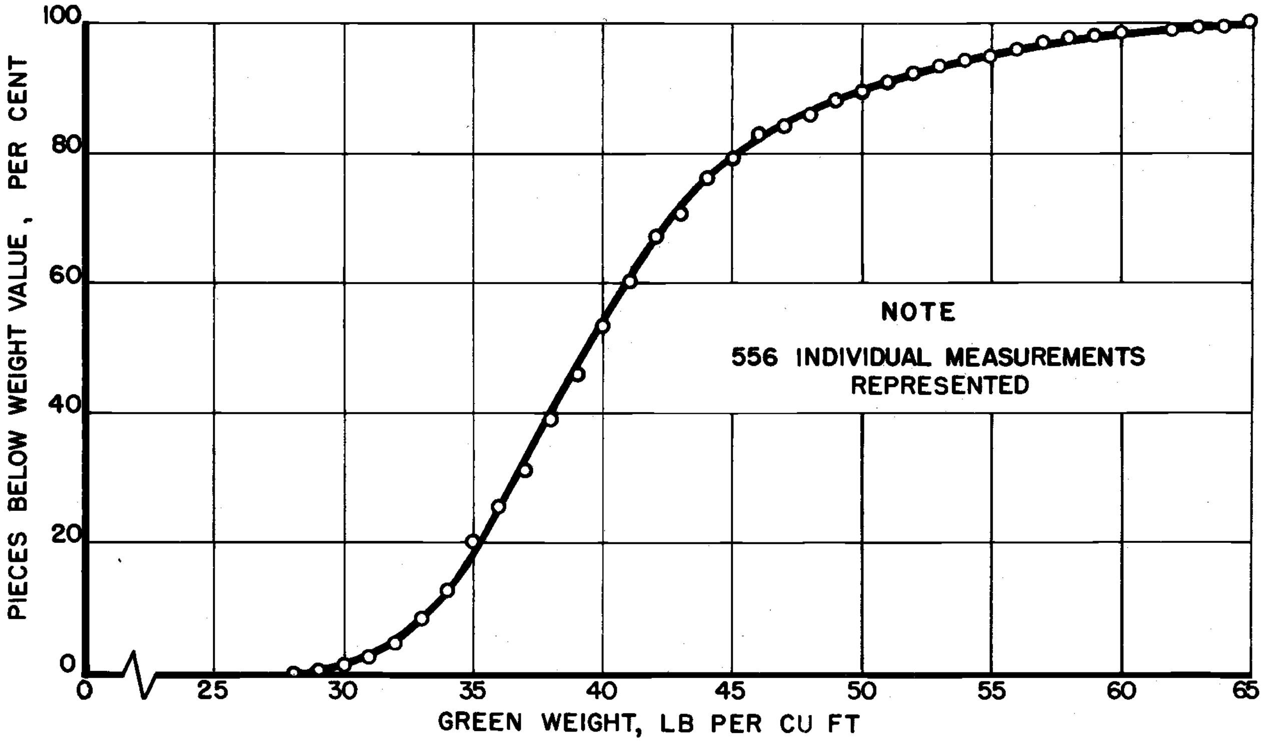
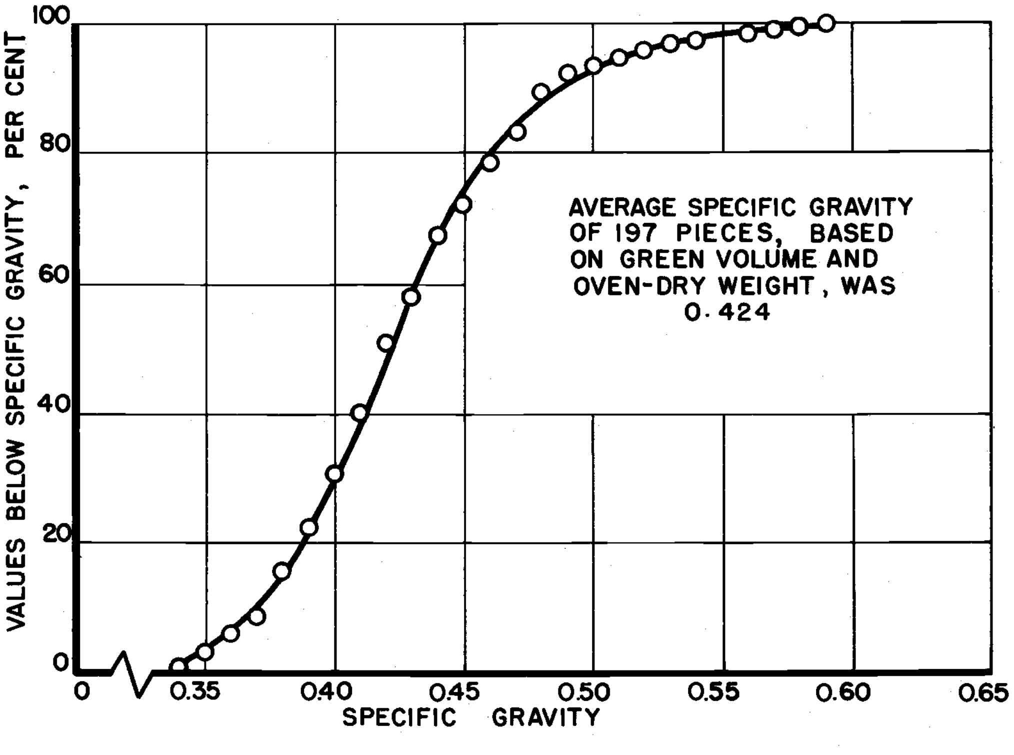


FIGURE 4. CUMULATIVE DISTRIBUTION OF SPECIFIC GRAVITY VALUES IN 2- BY 8-INCH BY 16-FOOT YOUNG-GROWTH DOUGLAS-FIR: CHARGES 1, 3, 4, 5, 5A, 6, 7, 8, 9 AND 10.



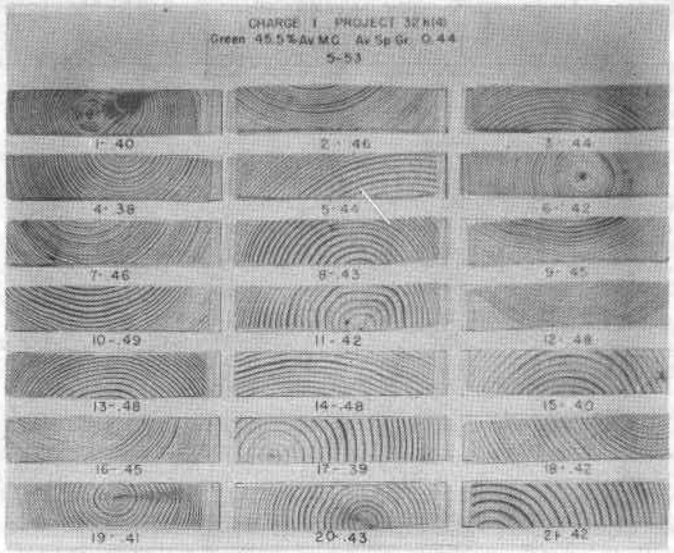


FIGURE 5. END GRAIN AND SPECIFIC GRAVITY OF KILN SAMPLES FROM CHARGE 1.

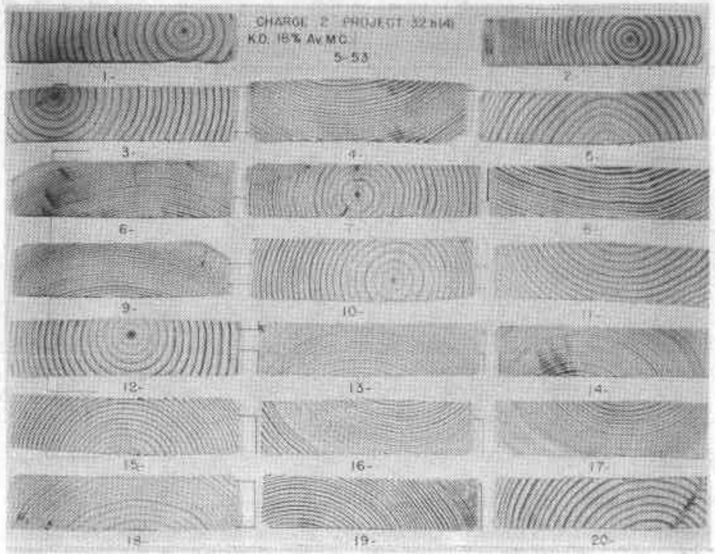


FIGURE 6. END GRAIN OF KILN SAMPLES FROM CHARGE 2.

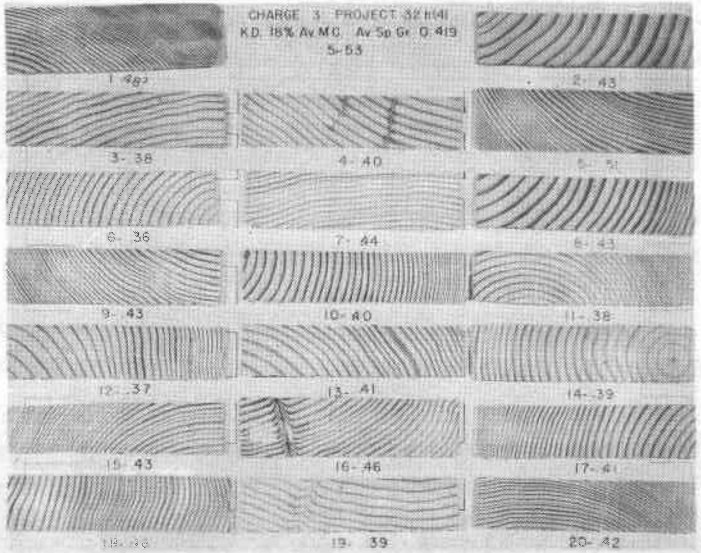


FIGURE 7. END GRAIN AND SPECIFIC GRAVITY OF KILN SAMPLES FROM CHARGE 3.

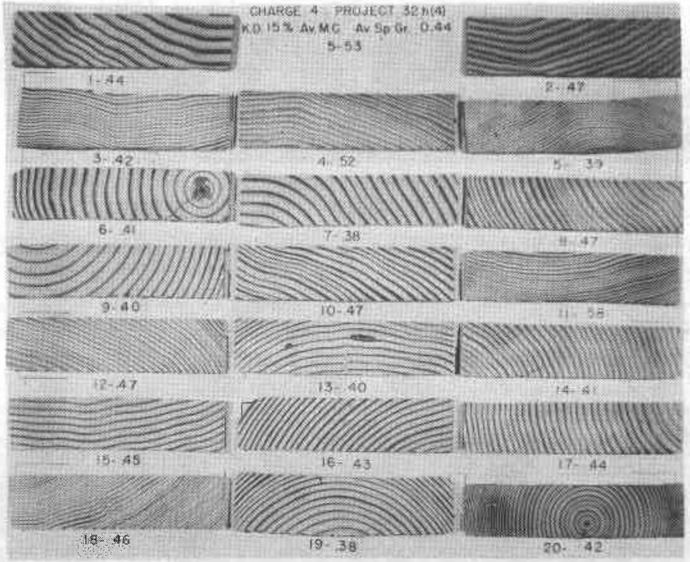


FIGURE 8. END GRAIN AND SPECIFIC GRAVITY OF KILN SAMPLES FROM CHARGE 4.

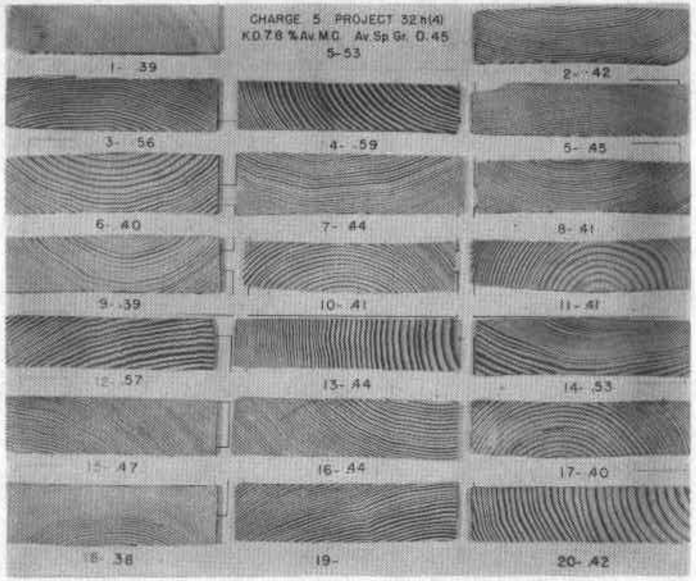


FIGURE 9. END GRAIN AND SPECIFIC GRAVITY OF KILN SAMPLES FROM CHARGE 5.

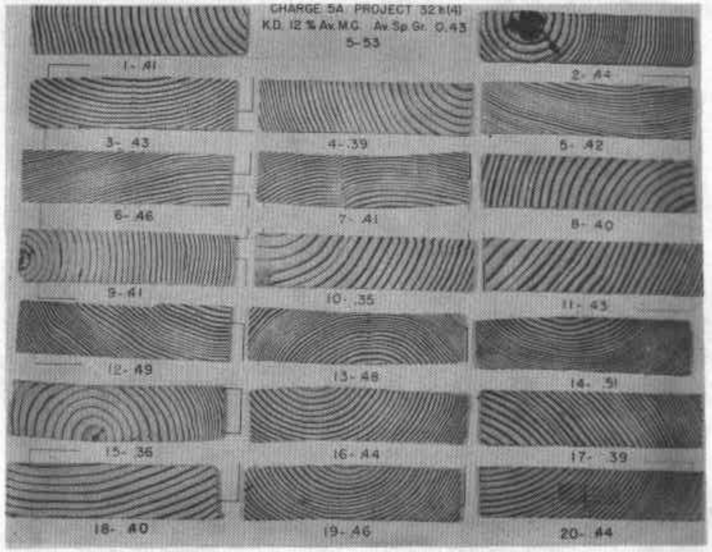


FIGURE 10. END GRAIN AND SPECIFIC GRAVITY OF KILN SAMPLES FROM CHARGE 5A.

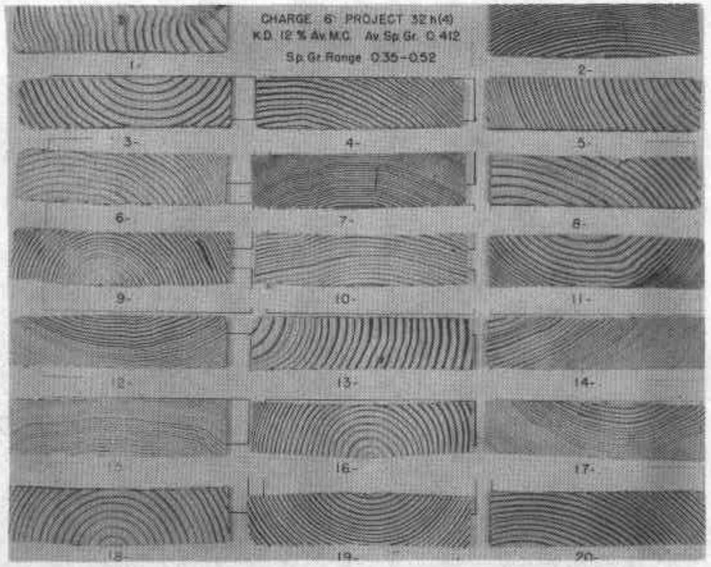


FIGURE 11. END GRAIN AND SPECIFIC GRAVITY OF KILN SAMPLES FROM CHARGE 6.

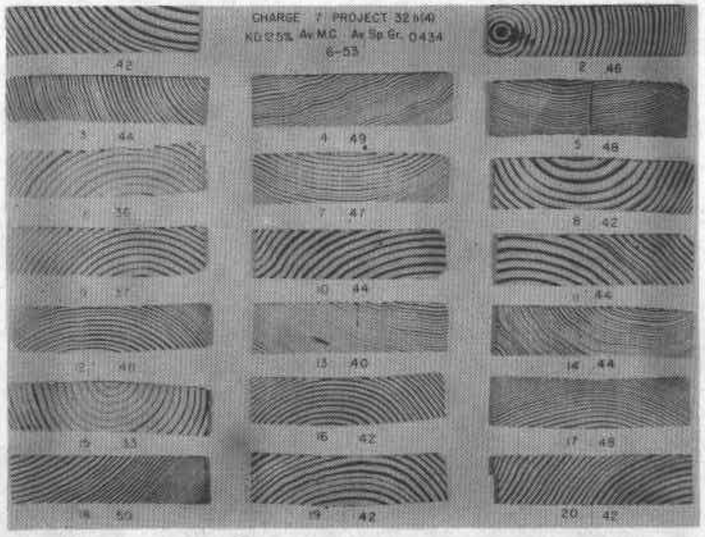


FIGURE 12. END GRAIN AND SPECIFIC GRAVITY OF KILN SAMPLES FROM CHARGE 7.

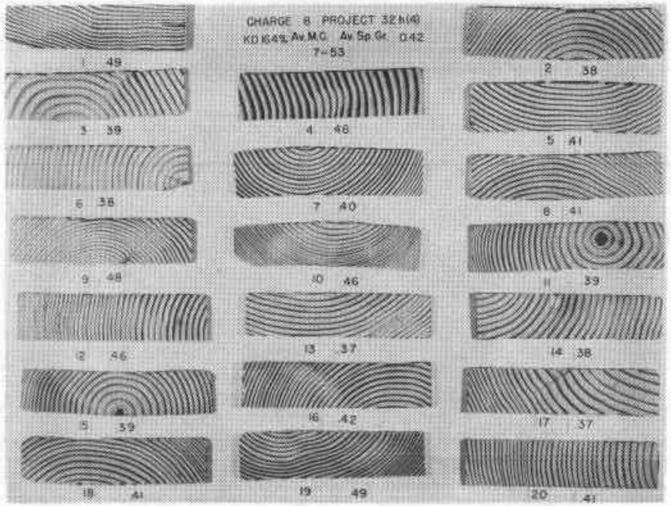


FIGURE 13. END GRAIN AND SPECIFIC GRAVITY OF KILN SAMPLES FROM CHARGE 8.

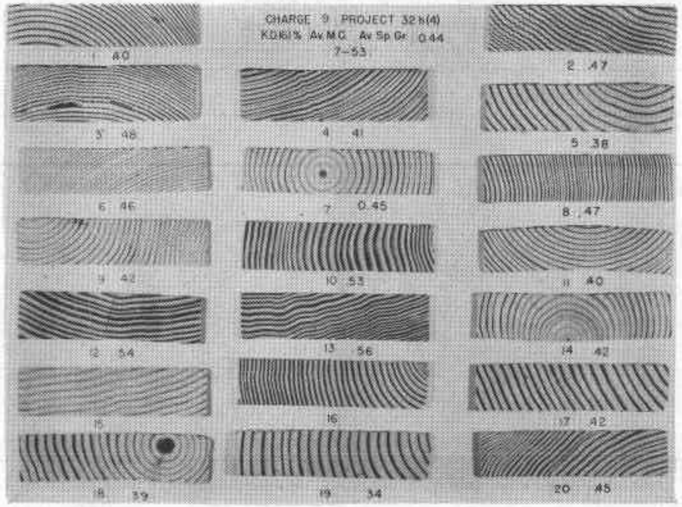


FIGURE 14. END GRAIN AND SPECIFIC GRAVITY OF KILN SAMPLES FROM CHARGE 9.

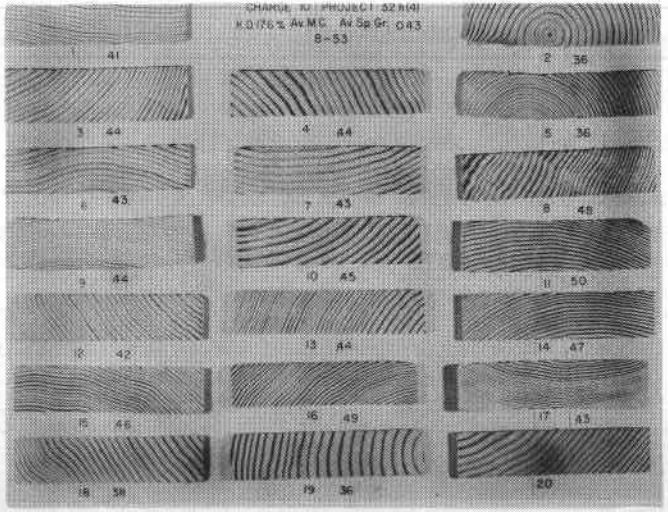


FIGURE 15. END GRAIN AND SPECIFIC GRAVITY OF KILN SAMPLES FROM CHARGE

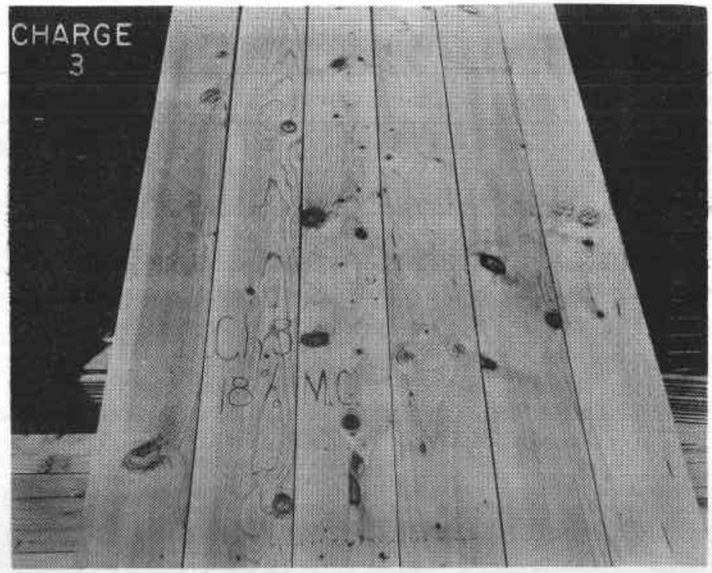


FIGURE 16. CONDITION OF KNOTS AFTER SURFACING: CHARGE 3.

FIGURE 17. CONDITION OF KNOTS AFTER SURFACING: CHARGE 4.

FIGURE 18. CONDITION OF KNOTS AFTER SURFACING: CHARGE 5A.

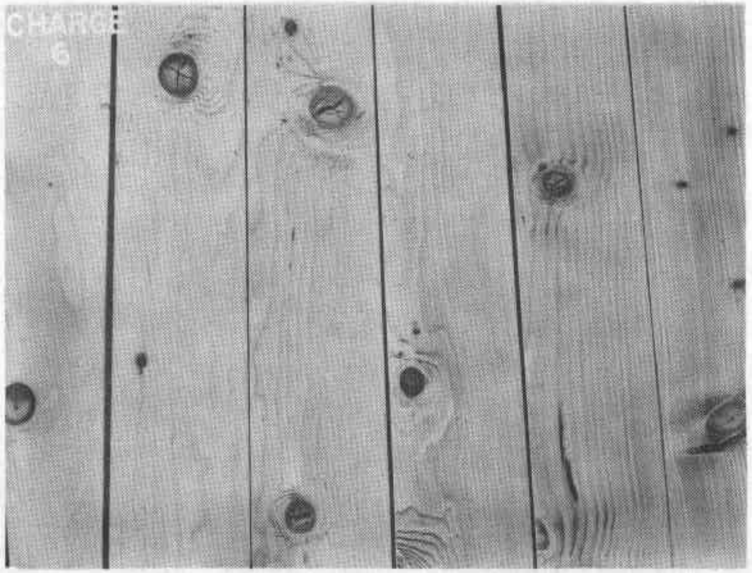


FIGURE 19. CONDITION OF KNOTS AFTER SURFACING: CHARGE 6.

FIGURE 20. CONDITION OF KNOTS AFTER SURFACING: CHARGE 7.

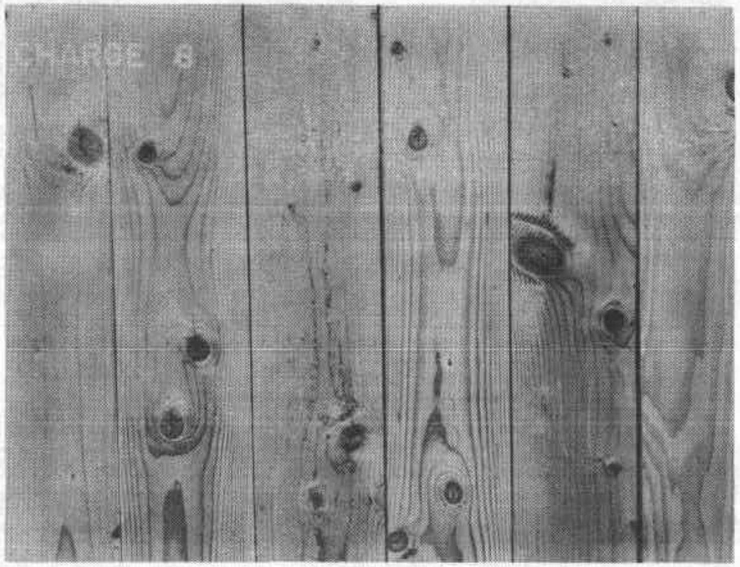


FIGURE 21. CONDITION OF KNOTS AFTFR SURFACING: CHARGE 8.

FIGURE 22. CONDITION OF KNOTS AFTER SURFACING: CHARGE 9.

FIGURE 23. YOUNG-GROWTH 2-by 8-INCH DOUGLAS-FIR; CHARGE 2, DRYING RATE & KILN SCHEDULE.

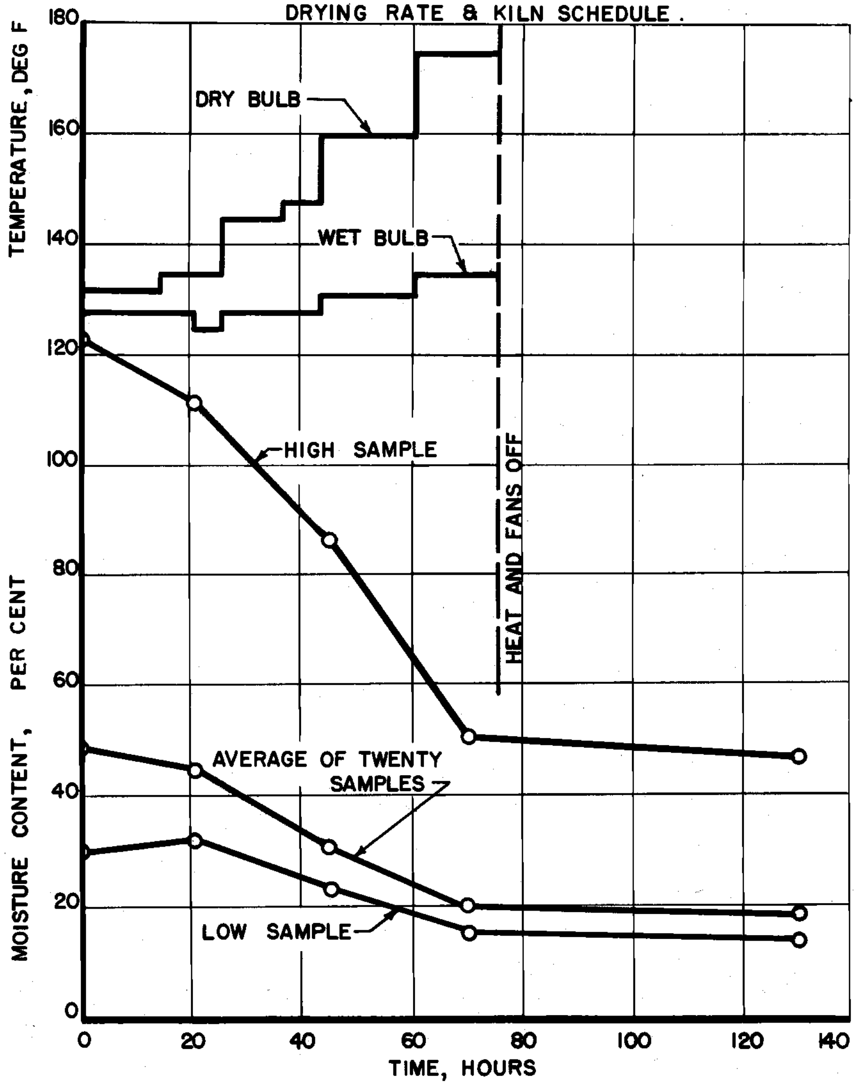


FIGURE 24. YOUNG-GROWTH 2-by 8-INCH DOUGLAS-FIR; CHARGE 3, DRYING RATE & KILN SCHEDULE.

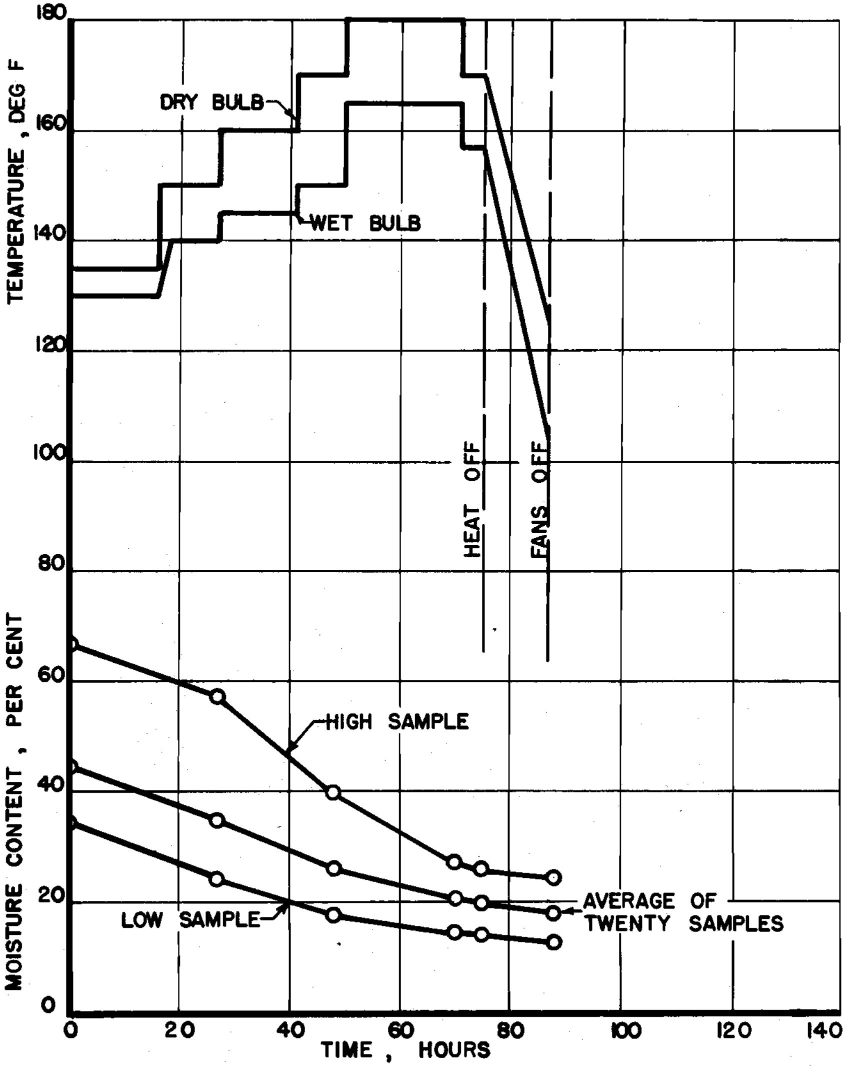


FIGURE 25. YOUNG-GROWTH 2-by 8-INCH DOUGLAS-FIR;
CHARGE 4,
DRYING RATE & KILN SCHEDULE.

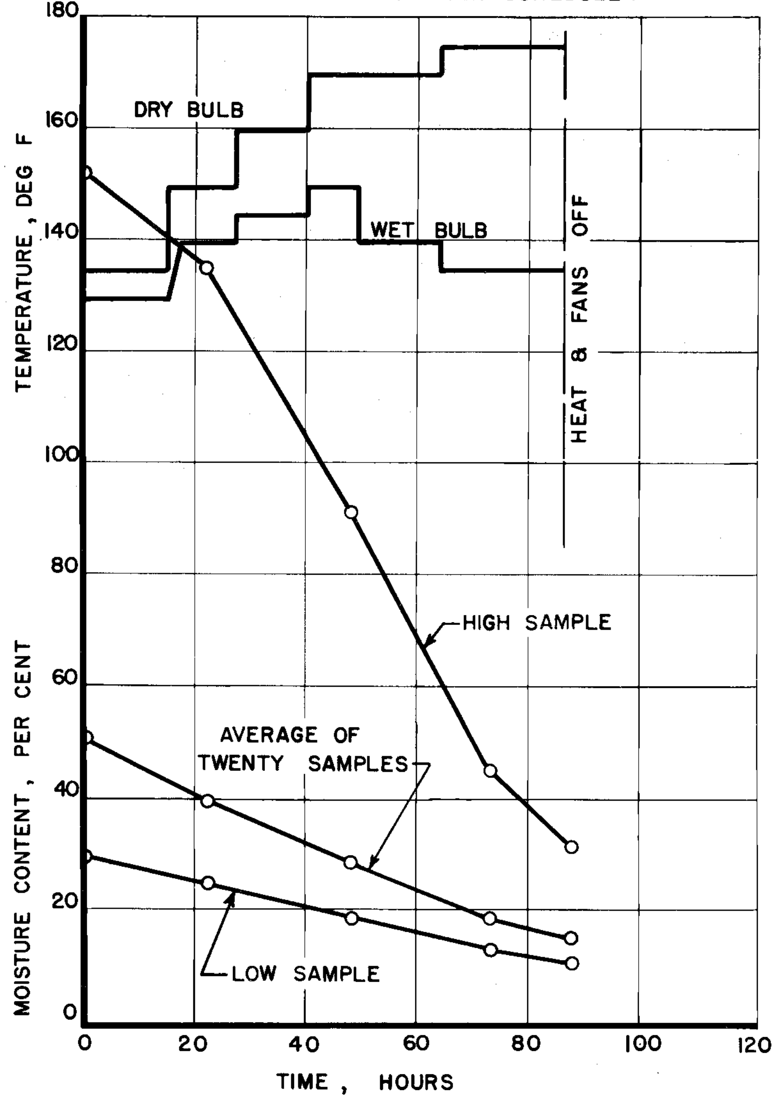


FIGURE 26. YOUNG-GROWTH 2-by 8- INCH DOUGLAS-FIR
CHARGE 5,
DRYING RATE & KILN SCHEDULE.

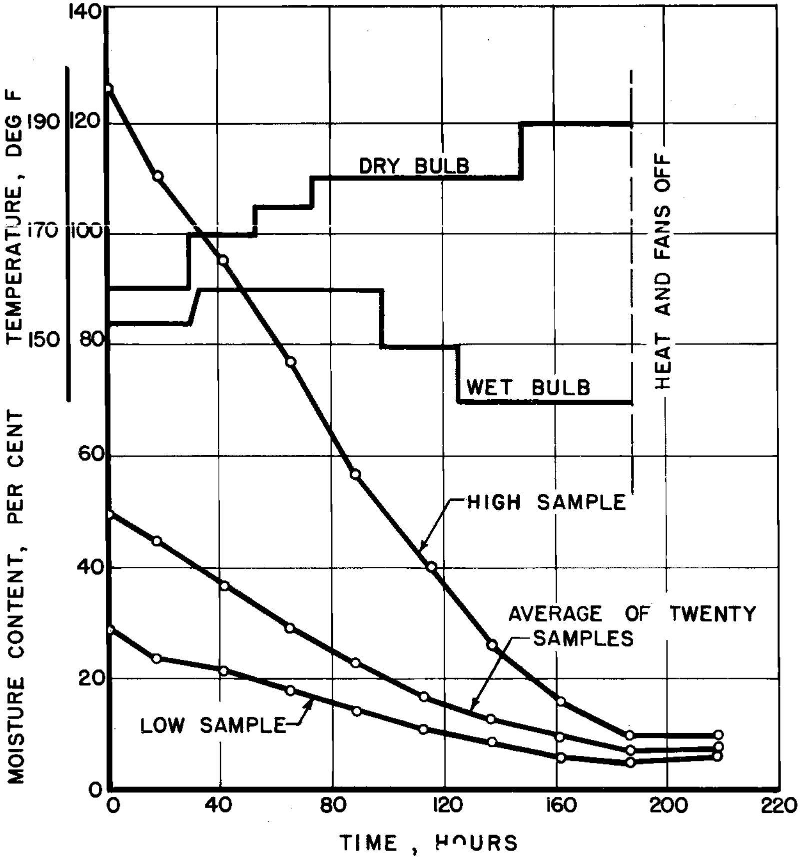


FIGURE 27. YOUNG-GROWTH 2-by 8-INCH DOUGLAS-FIR; CHARGE 5 A, DRYING RATE & KILN SCHEDULE.

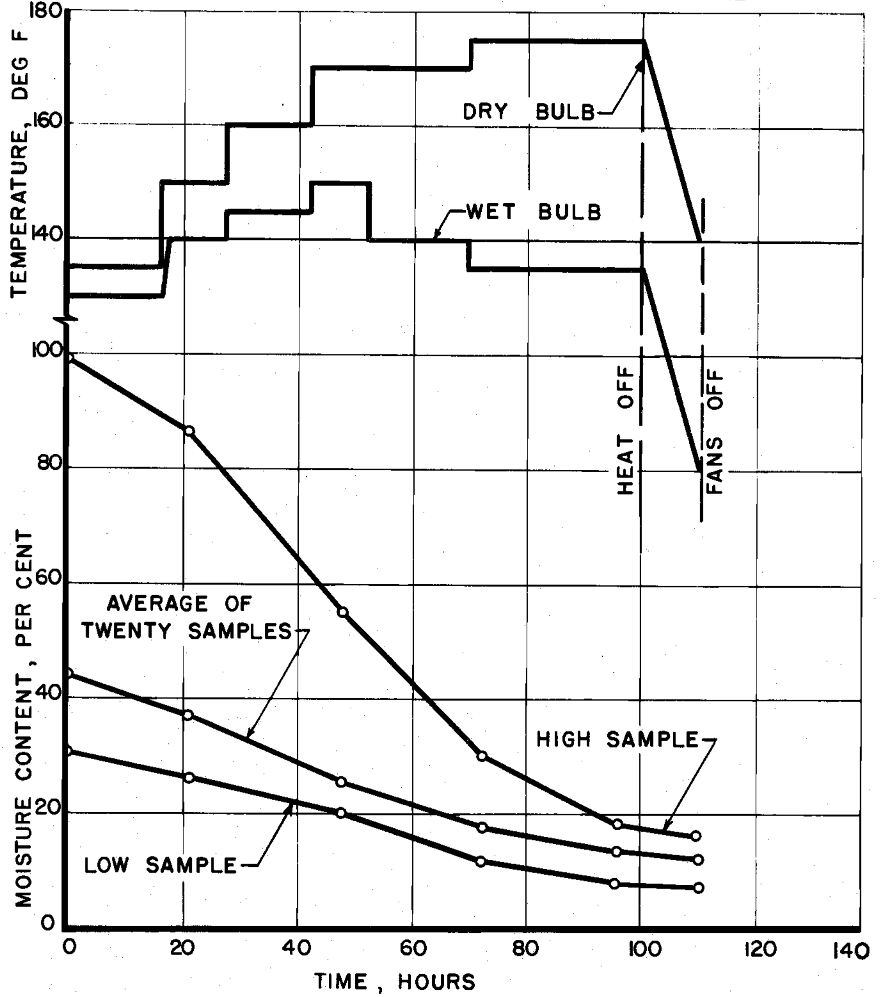


FIGURE 28. YOUNG-GROWTH 2- BY 8-INCH DOUGLAS-FIR; CHARGE 6, DRYING RATE & KILN SCHEDULE.

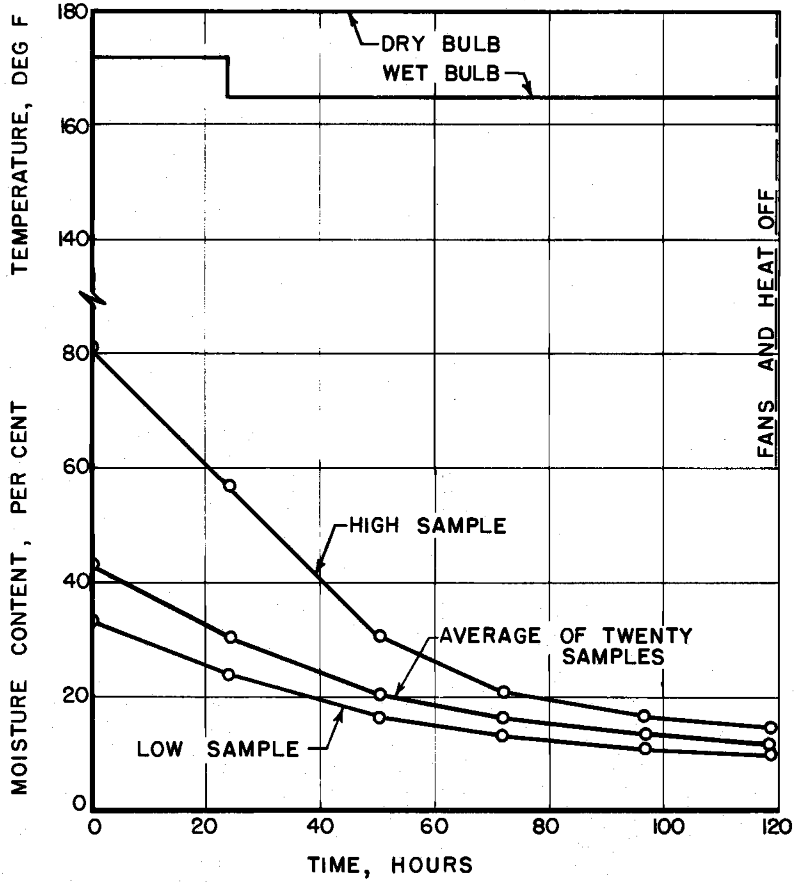


FIGURE 29. YOUNG-GROWTH 2- by 8- INCH DOUGLAS-FIR; CHARGE 7, DRYING RATE & KILN SCHEDULE.

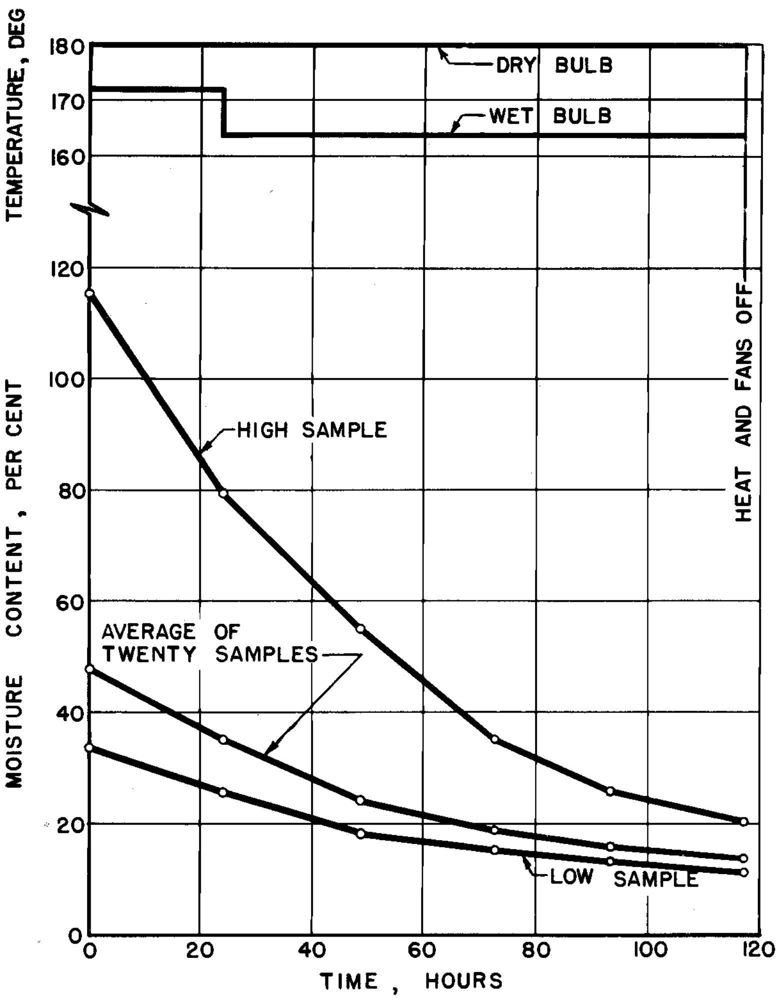


FIGURE 30. YOUNG-GROWTH 2- BY 8-INCH DOUGLAS-FIR; CHARGE 8, DRYING RATE & KILN SCHEDULE.

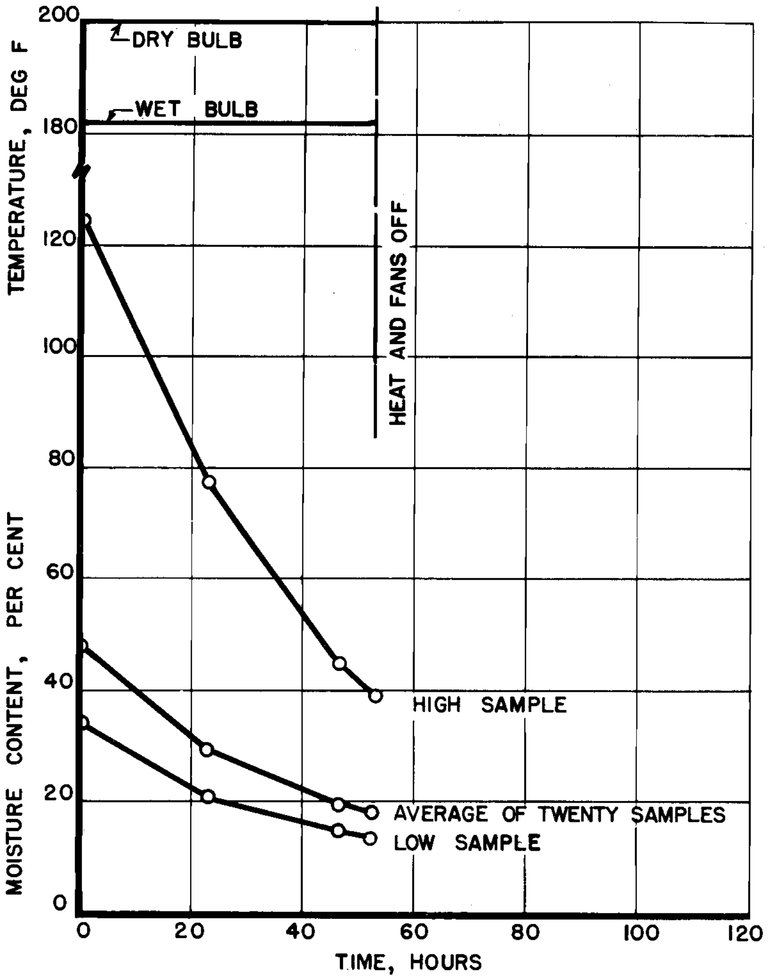


FIGURE 31. YOUNG-GROWTH 2-by 8-INCH DOUGLAS-FIR, CHARGE 9, DRYING RATE & KILN SCHEDULE.

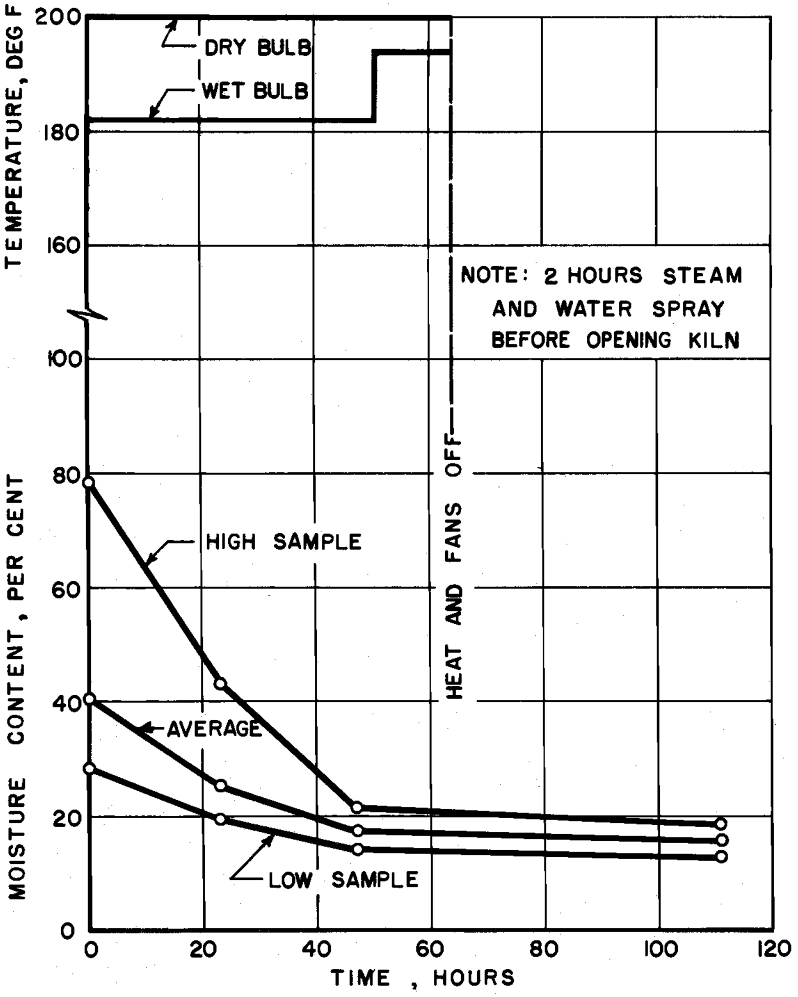


FIGURE 32. YOUNG-GROWTH 2- BY 8-INCH DOUGLAS-FIR; CHARGE 10, DRYING RATE & KILN SCHEDULE.

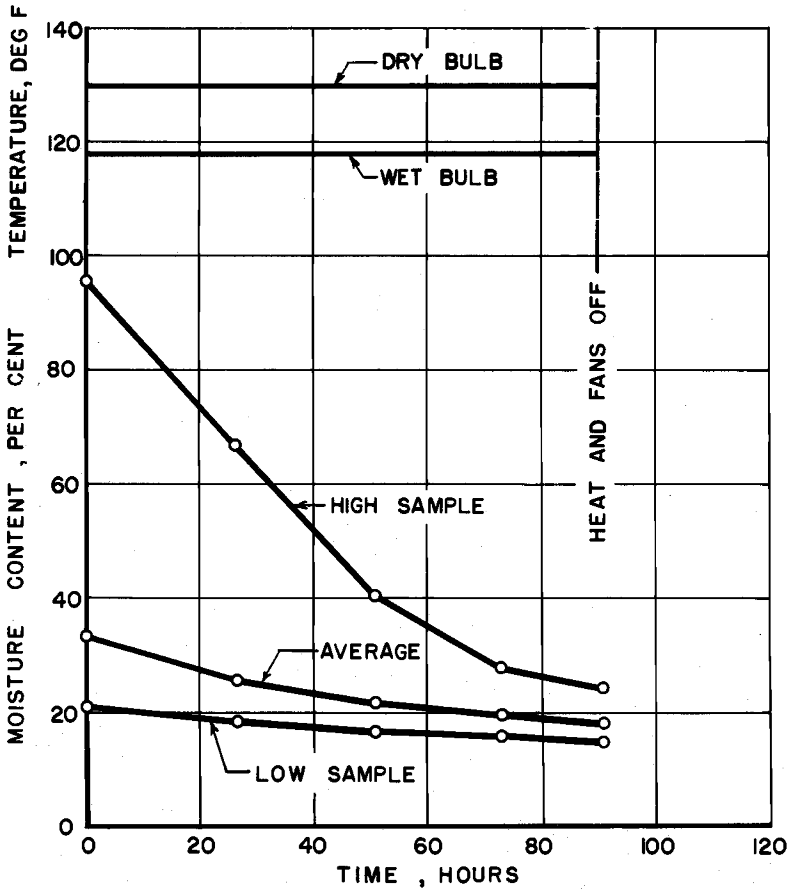


FIGURE 33. CUMULATIVE PERCENTAGES OF PIECES ACCORDING TO MOISTURE CONTENT IN GREEN 2- BY 8-INCH YOUNG-GROWTH DOUGLAS-FIR; TEN CHARGES.

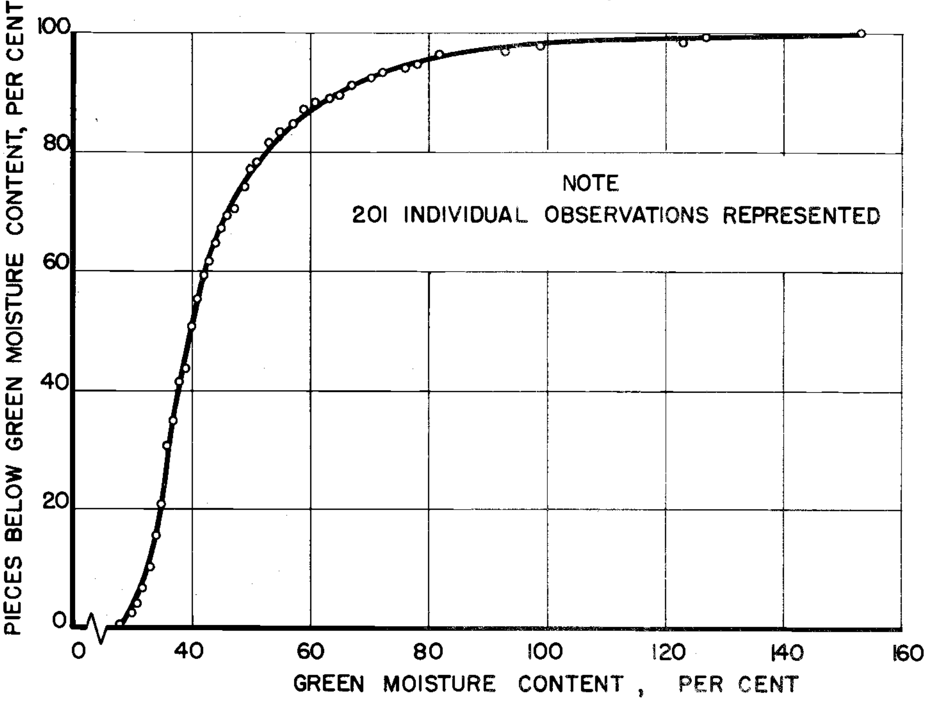


FIGURE 34. DISTRIBUTION OF MOISTURE METER READINGS IN 2-by8-INCH YOUNG-GROWTH DOUGLAS-FIR; CHARGE 2, KILN-DRIED TO 18.4 % AVG M.C.

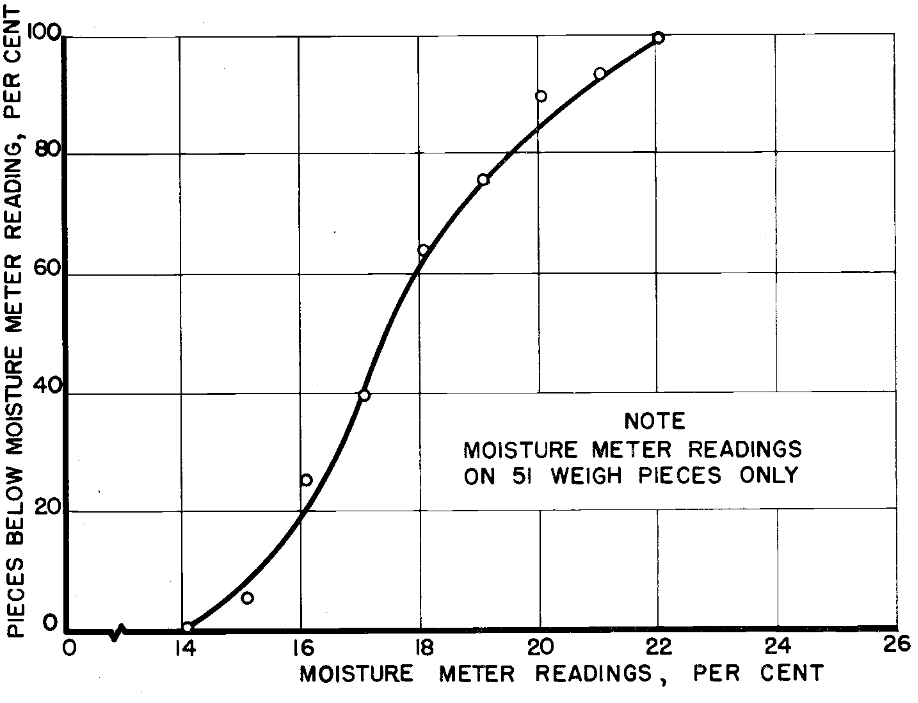


FIGURE 35. DISTRIBUTION OF MOISTURE METER READINGS IN 2-by 8-INCH YOUNG-GROWTH DOUGLAS-FIR; CHARGE 3, KILN-DRIED TO 18.0 % AVG M C.

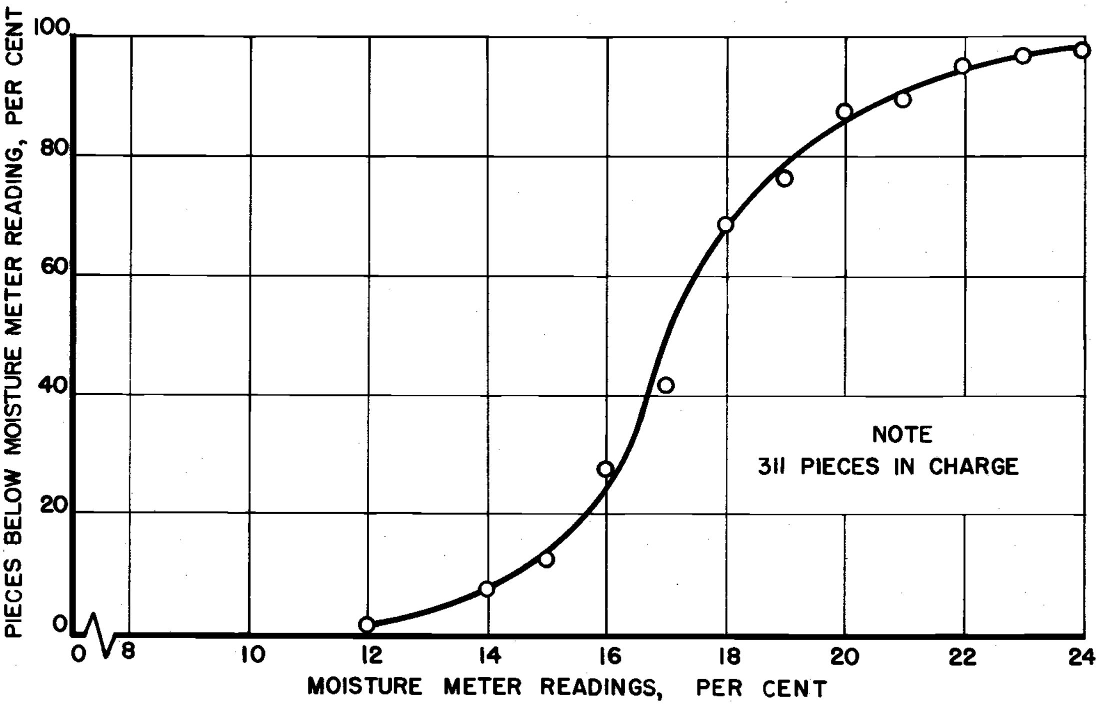


FIGURE 36. DISTRIBUTION OF MOISTURE METER READINGS IN 2- BY 8-INCH YOUNG-GROWTH DOUGLAS-FIR; CHARGE 4, KILN-DRIED TO 15.2 % AVG M C.

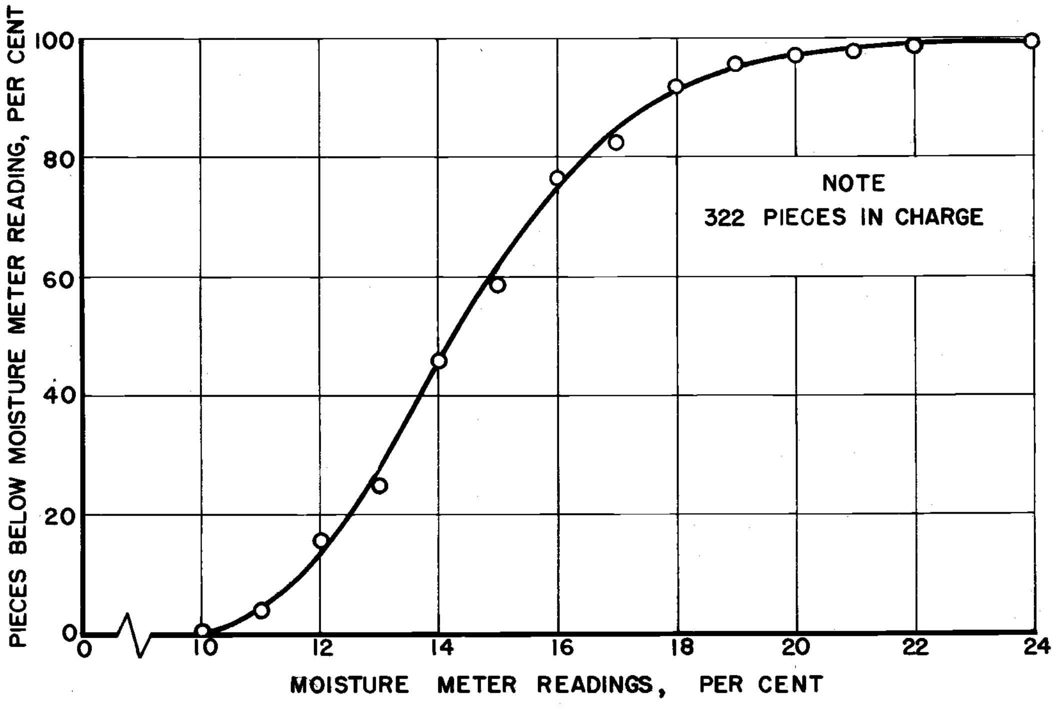


FIGURE 37. DISTRIBUTION OF MOISTURE METER READINGS IN 2-by 8- INCH YOUNG-GROWTH DOUGLAS-FIR; CHARGE 5, KILN-DRIED TO 7.8 % AVG M C.

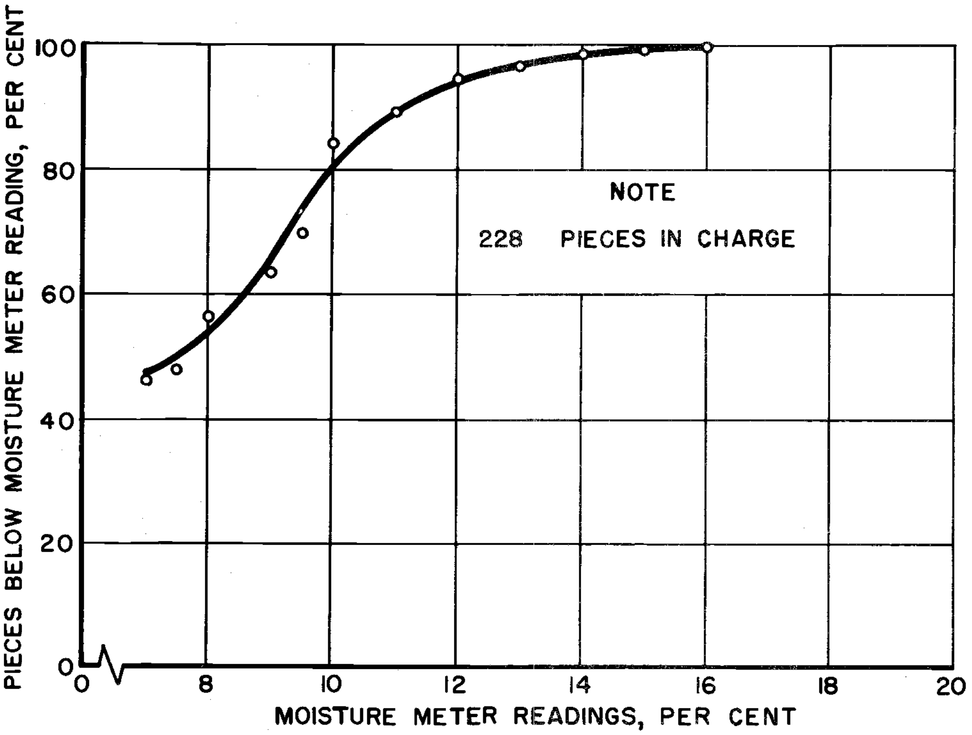


FIGURE 38. DISTRIBUTION OF MOISTURE METER READINGS IN 2- BY 8-INCH YOUNG-GROWTH DOUGLAS-FIR; CHARGE 5-A, KILN-DRIED TO 12.4 % AVG MC.

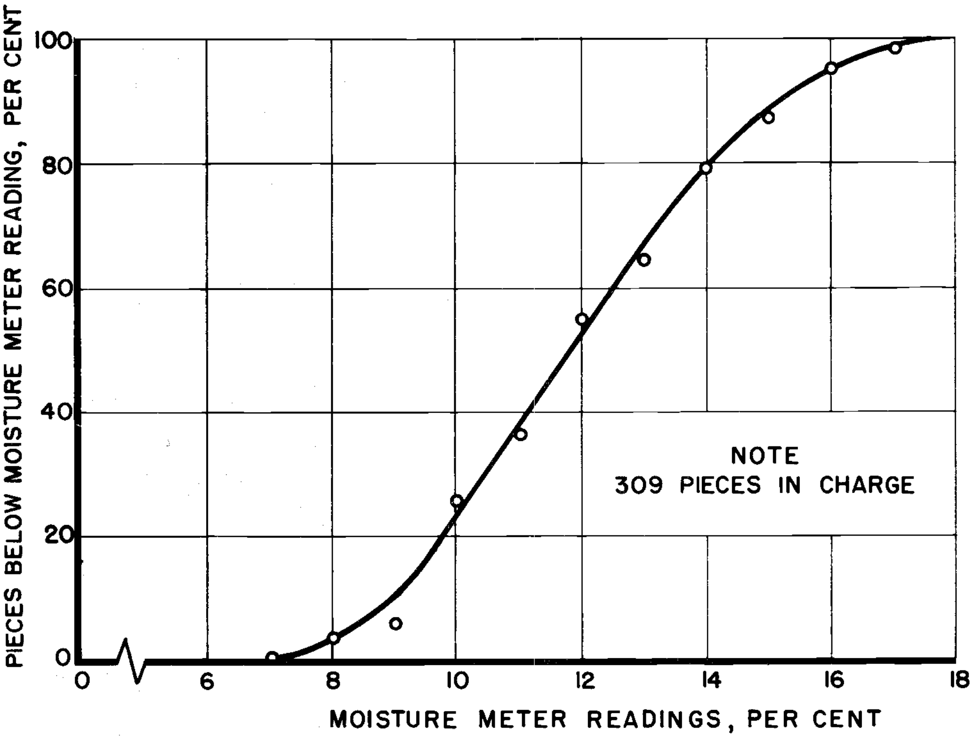


FIGURE 39. DISTRIBUTION OF MOISTURE METER READINGS IN 2- BY 8-INCH YOUNG-GROWTH DOUGLAS-FIR; CHARGE 6, KILN-DRIED TO 12.1 % AVG MC.

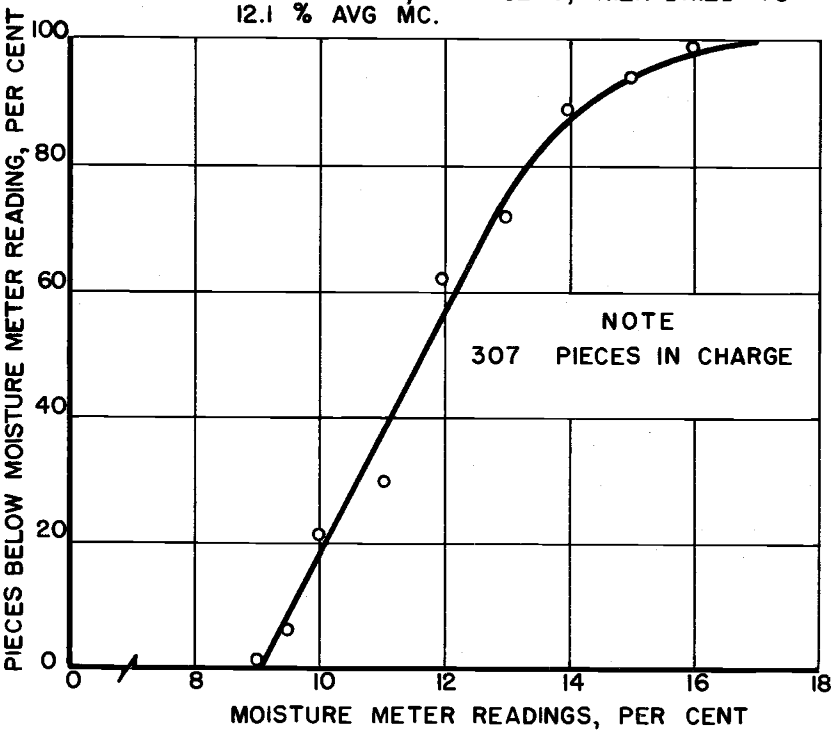


FIGURE 40. DISTRIBUTION OF MOISTURE METER READINGS IN 2- BY 8-INCH YOUNG-GROWTH DOUGLAS-FIR;

CHARGE 7, KILN-DRIED TO 12.5 % AVG MC.

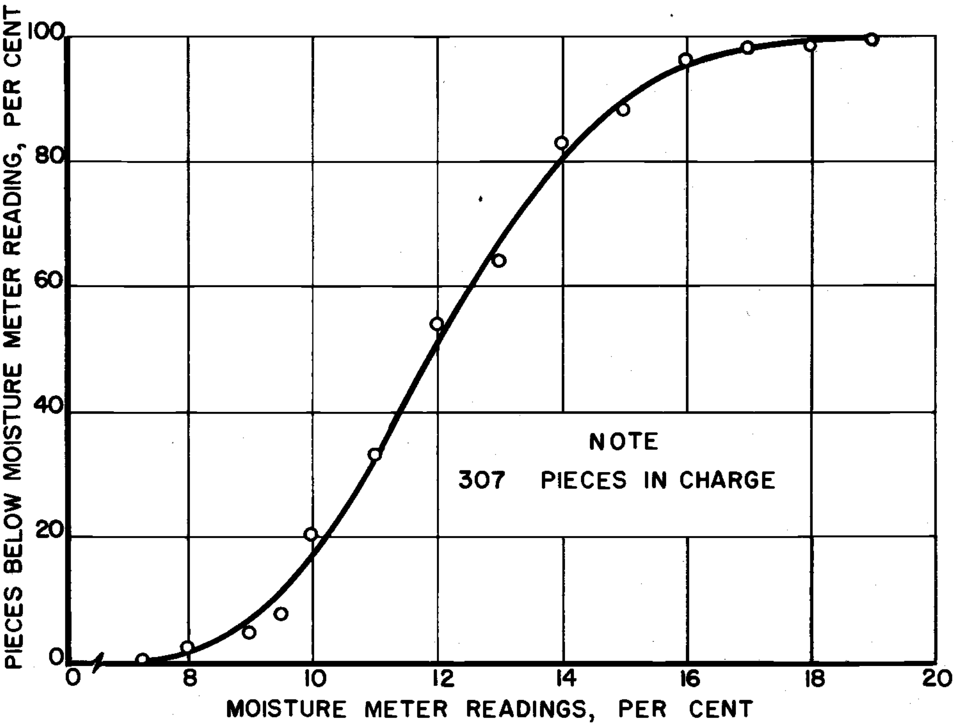


FIGURE 41. DISTRIBUTION OF MOISTURE METER READINGS IN 2- by 8- INCH YOUNG-GROWTH DOUGLAS-FIR; CHARGE 8, KILN-DRIED TO 16.4 % AVG MC.

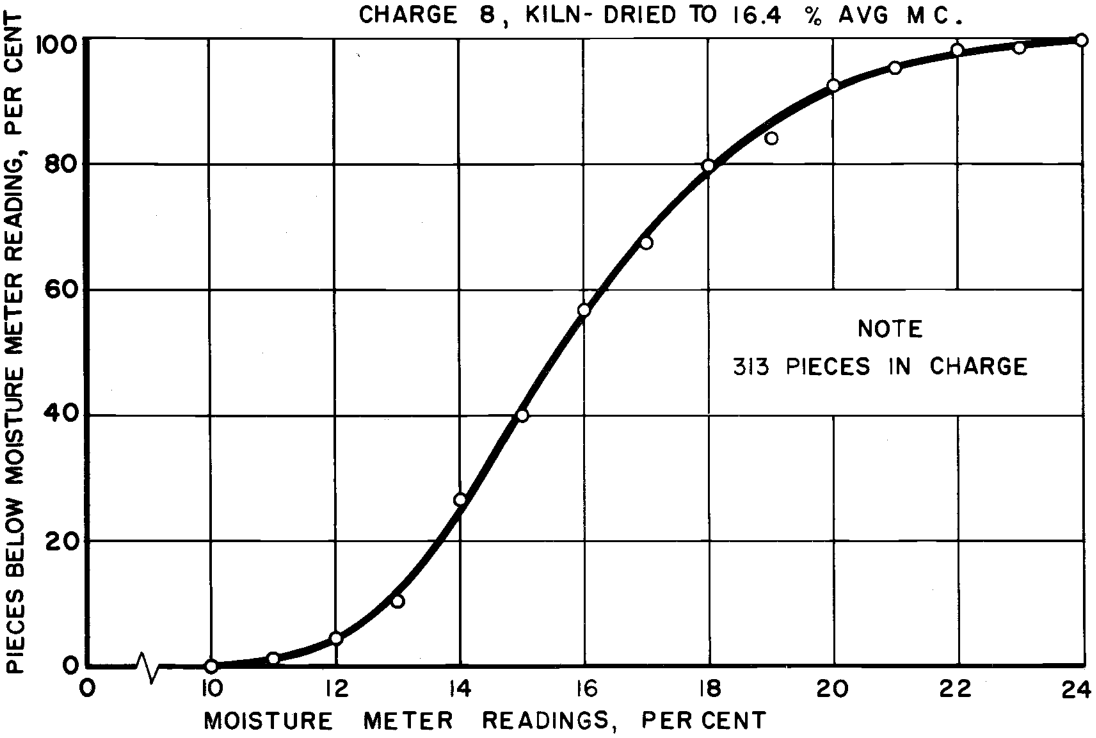


FIGURE 42. DISTRIBUTION OF MOISTURE METER READINGS IN 2- by 8- INCH YOUNG-GROWTH DOUGLAS-FIR, CHARGE 9, KILN-DRIED TO 16.1 % AVG MC.

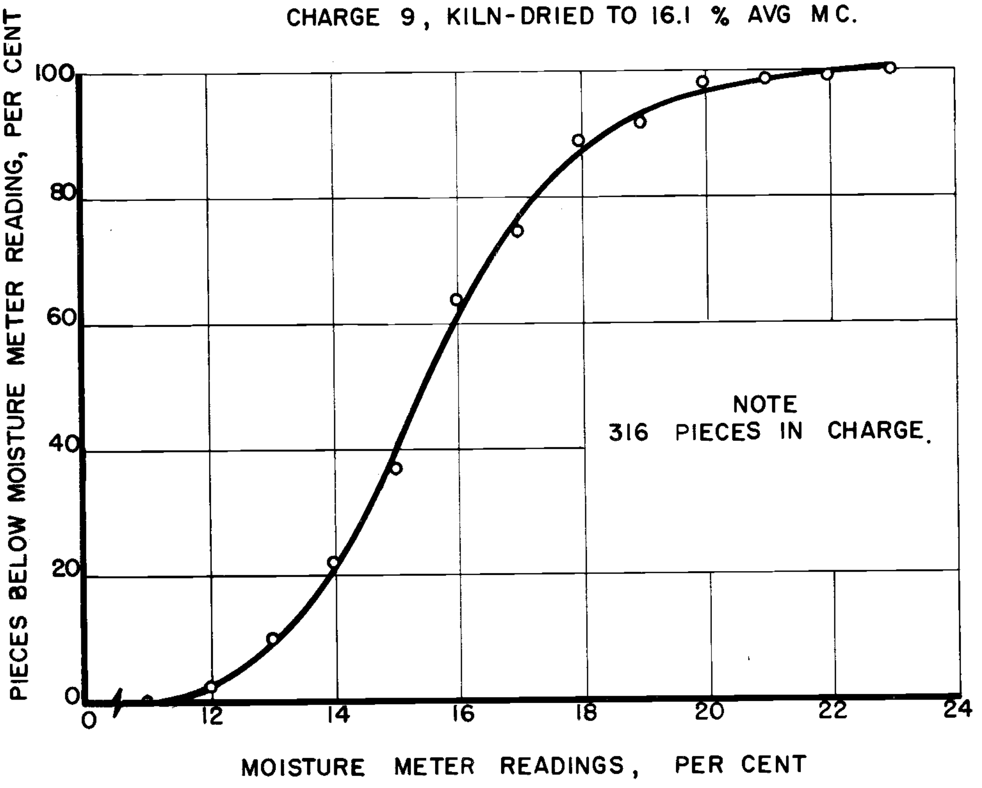


FIGURE 43. DISTRIBUTION OF MOISTURE METER READINGS IN 2- BY 8-INCH YOUNG-GROWTH DOUGLAS-FIR; CHARGE 10, KILN-DRIED TO 17.6 % AVG MC.

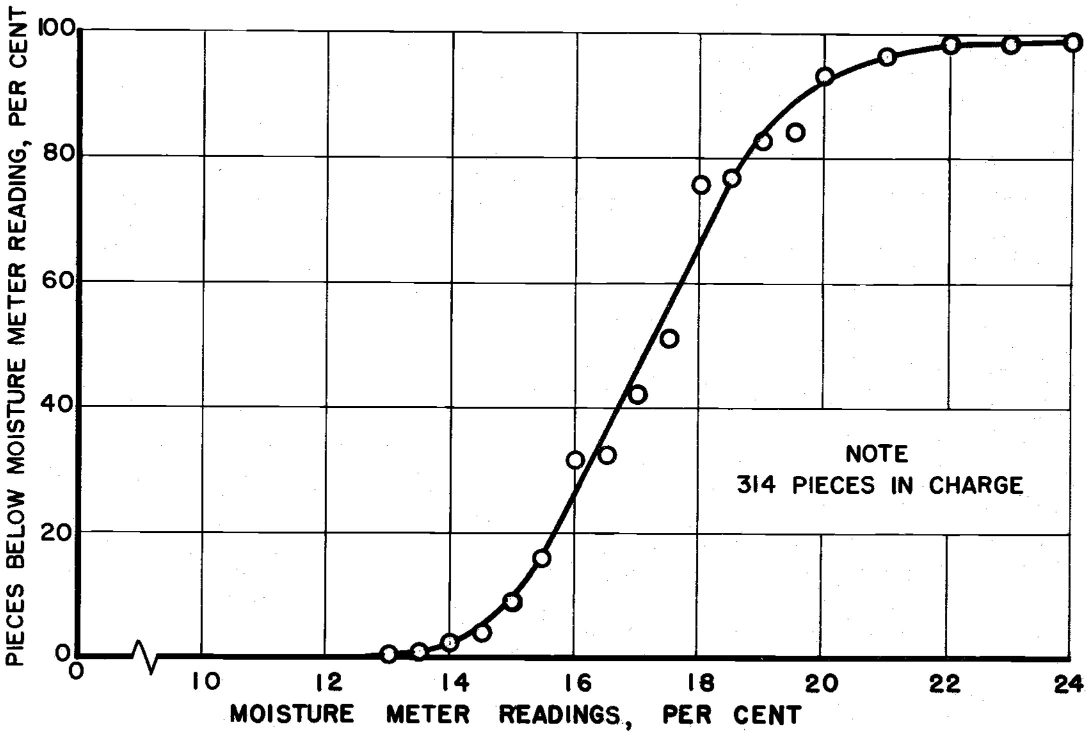


FIGURE 44. MOISTURE METER READINGS COMPARED TO OVEN-TEST MOISTURE CONTENT VALUES IN 2-by 8- INCH YOUNG-GROWTH DOUGLAS-FIR, IN PER CENT.

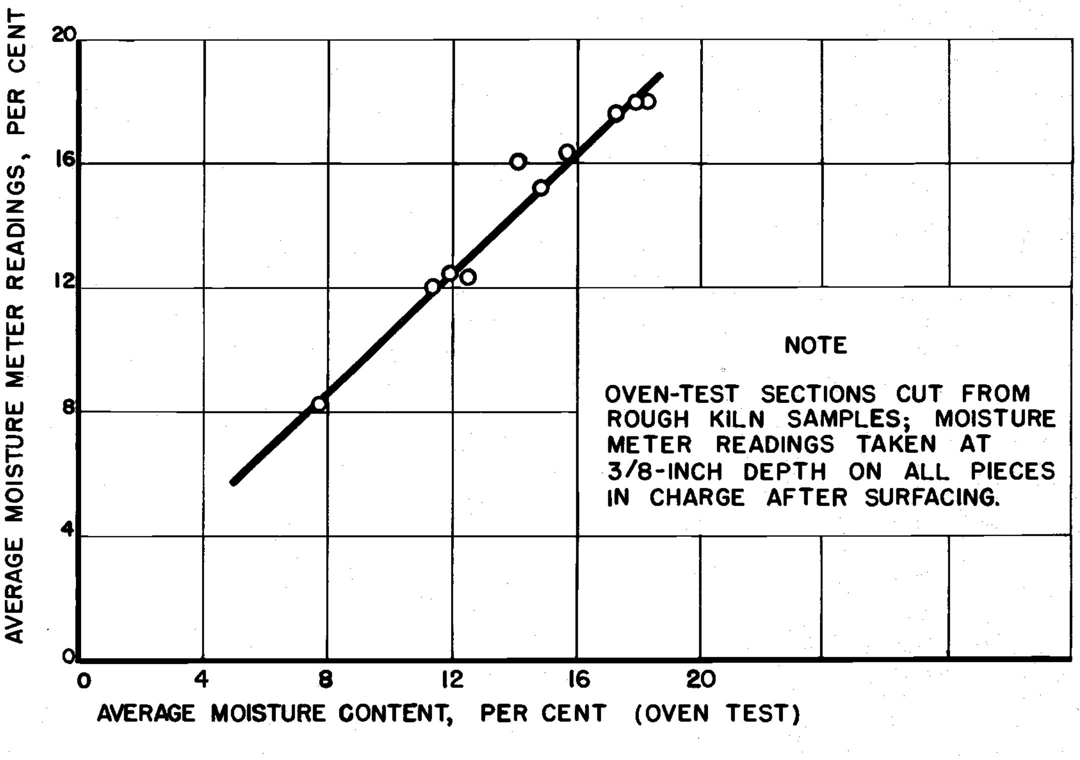


FIGURE 45. CUMULATIVE DISTRIBUTION, IN PER CENT, OF THICKNESS IN 2- BY 8-INCH YOUNG-GROWTH DOUGLAS-FIR; GREEN AND KILN-DRIED.

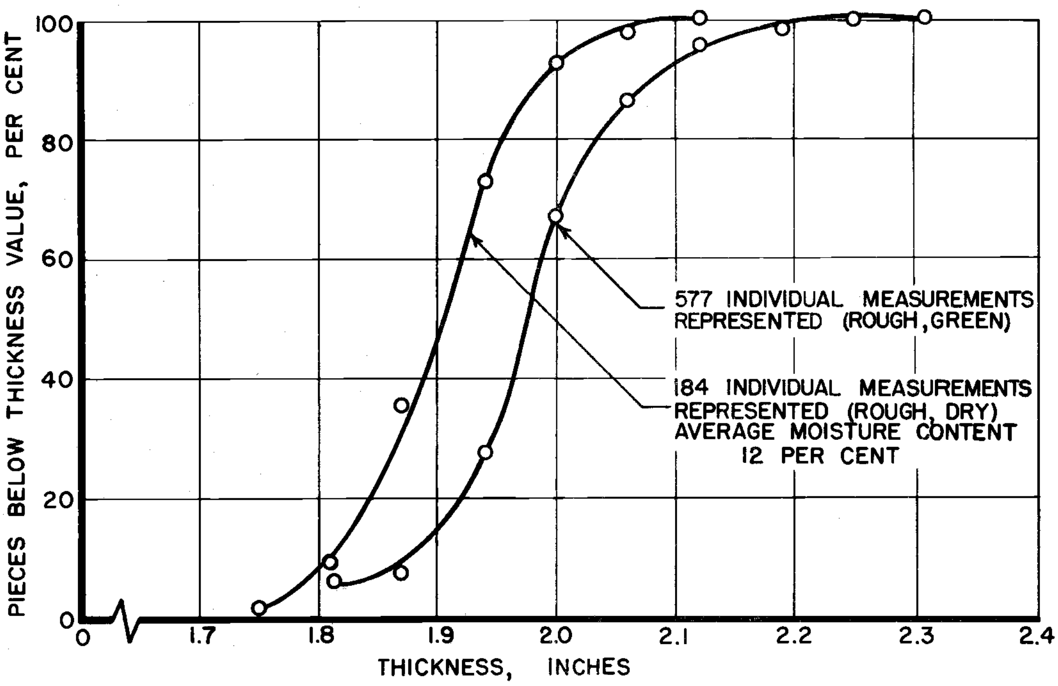


FIGURE 46. CUMULATIVE DISTRIBUTION OF SHRINKAGE VALUES DURING KILN-DRYING OF GREEN 2- by 8- INCH YOUNG-GROWTH DOUGLAS-FIR.

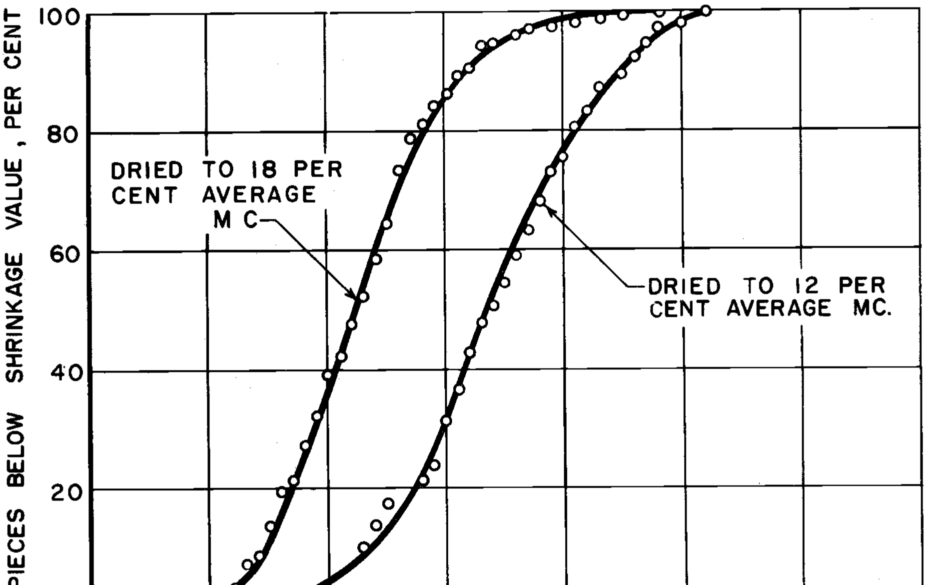


FIGURE 47. RESIDUAL SHRINKAGE OF 2- BY 8-INCH YOUNG-GROWTH DOUGLAS-FIR FROM KILN-DRIED WIDTH TO EQUILIBRIUM WITH 25 AND 65 PER CENT RELATIVE HUMIDITY.

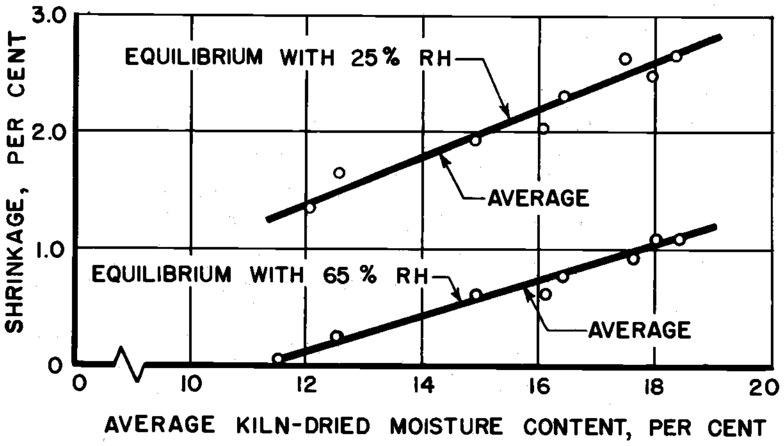
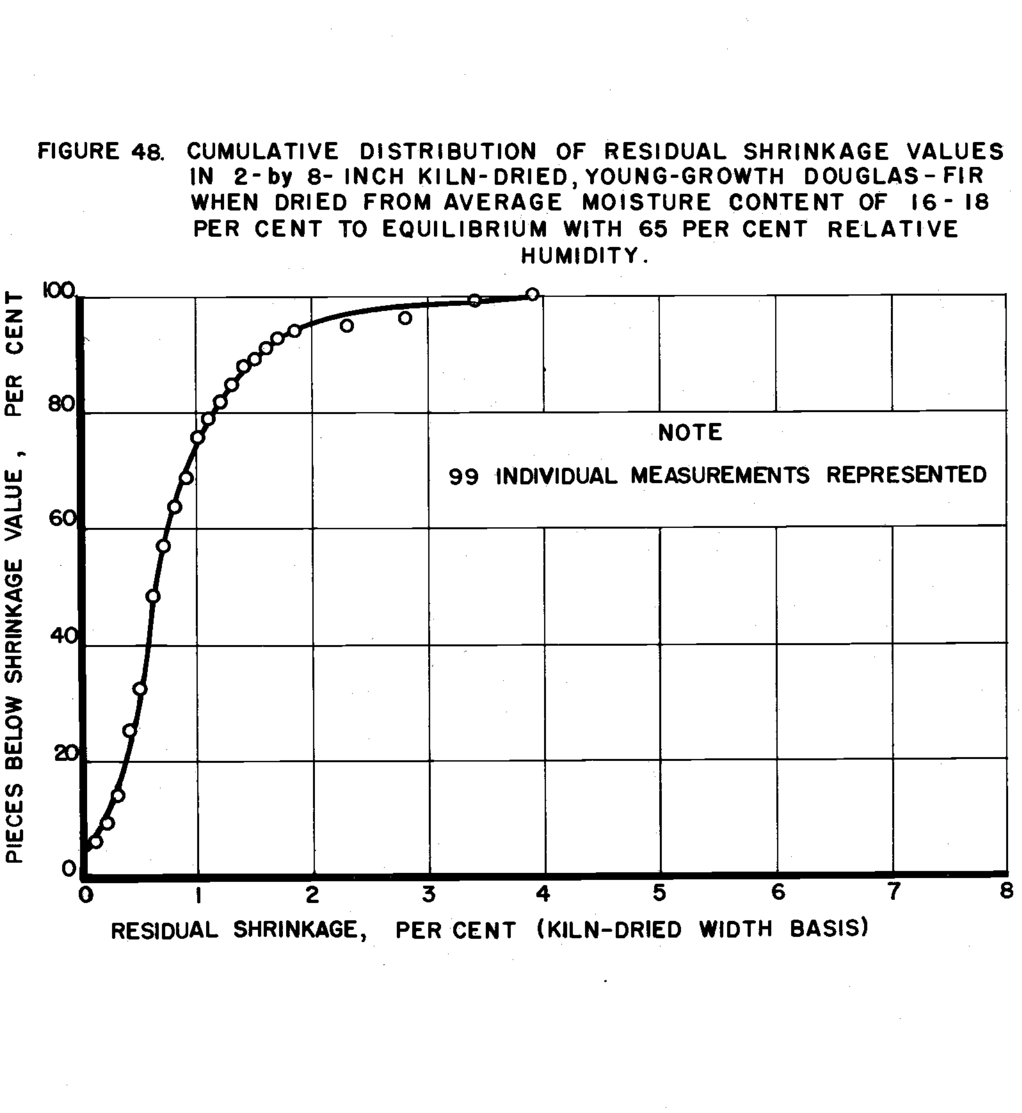


FIGURE 48. CUMULATIVE DISTRIBUTION OF RESIDUAL SHRINKAGE VALUES IN 2-by 8-INCH KILN-DRIED, YOUNG-GROWTH DOUGLAS-FIR WHEN DRIED FROM AVERAGE MOISTURE CONTENT OF 16-18 PER CENT TO EQUILIBRIUM WITH 65 PER CENT RELATIVE HUMIDITY.



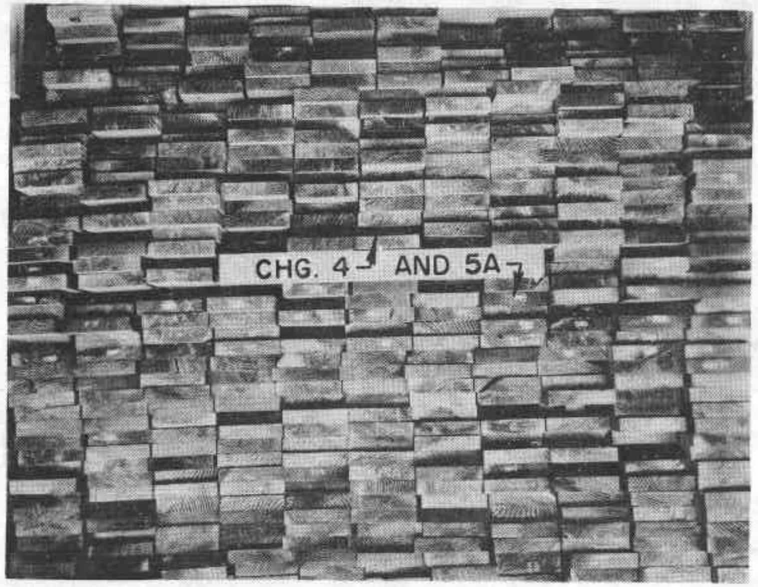


FIGURE 49. END GRAIN VIEW OF S4S DIMENSION: CHARGES 4 AND 5A.

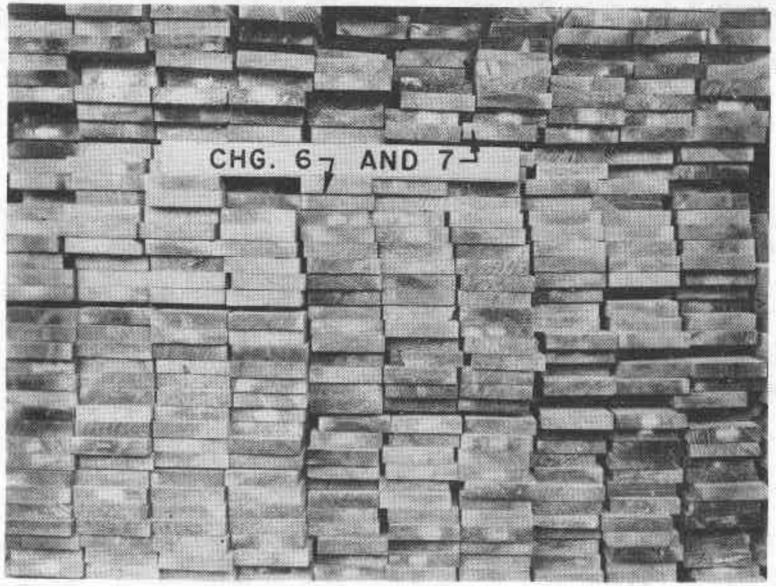


FIGURE 50. END GRAIN VIEW OF S4S DIMENSION: CHARGES 6 AND 7.

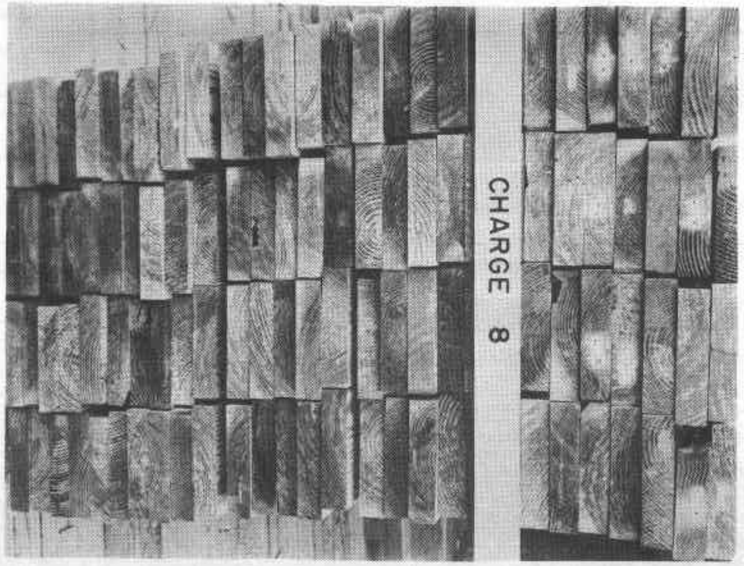


FIGURE 51. END GRAIN VIEW OF S4S DIMENSION: CHARGE 8.

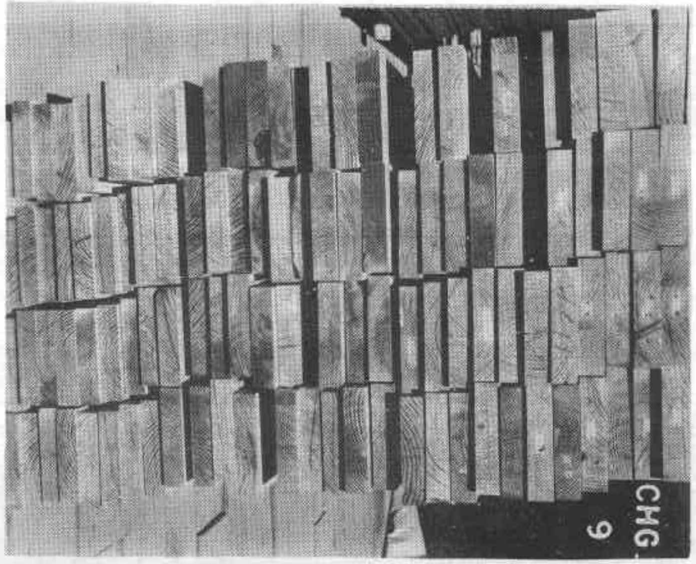


FIGURE 52. END GRAIN VIEW OF S4S DIMENSION: CHARGE 9.