Yale University

School of Forestry

THE CALIBRATION OF TWO TYPES OF MOISTURE METERS

for

SEVERAL TROPICAL WOODS

Technical Report No. 2

Project N6-ori-44, Task Order XV-0

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THE CALIBRATION OF TWO TYPES OF MOISTURE METERS FOR SEVERAL TROPICAL WOODS[1]

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By

William W. Rice and Fred E. Dickinson

This study is one of a series undertaken as part of a continuing investigation of the properties of tropical woods. The investigation is being conducted at the Yale School of Forestry and is sponsored by the Office of Naval Research, Department of the Navy, under Contract N6 ori-44, Task Order XV (Project Designation NR-033-020). The scope of the complete research program is indicated in Properties and Uses of Tropical Woods, I published in TROPICAL WOODS 95 (June 1, 1949).

Electric moisture meters have been used in making moisture content determinations of native woods for a number of years. Their widespread use results from the ease and rapidity with which the determinations can be accomplished. While these instruments can be employed to determine the moisture content of tropical woods, their use in this field has been limited because of the lack of the necessary calibration data. Such data are essential inasmuch as species have inherent differences which result in different moisture meter readings for the same moisture content.

In this study two resistant type moisture meters were used - the Hart Moisture Gauge and the Delmhorst Moisture Detector, and a high

[1] This report summarizes a special study made by William W. Rice as partial fulfillment of the requirement for the M. F. degree at the School of Forestry, Yale University.

frequency power absorption type instrument - the Moisture Register.[2] The resistant meters operate on the principle that below the fiber saturation point the electrical resistance of wood varies widely with changes in moisture content with the resistance increasing as the moisture content decreases. The measurement of moisture content by the high frequency power absorption type is based on the principle that the dielectric properties of wood vary in proportion to the quantity of water held by wood. When the condenser plates or electrodes of this type of instrument are placed on the surface of wood, a change in the high frequency circuit results and the magnitude of this change is related to the amount of moisture the material contains.

Calibration data were collected for the following five tropical wood species:

Species	Source	Specific Gravity[1]
Balsa (Ochroma lagopus)	Honduras	0.11
Roble Blanco (Tabebuia pentaphylla)	British Honduras	0.57
Ocote Pine (Pinus oocarpa)	Honduras	0.59
Courbaril (Hymenaea courbaril)	Surinam	0.76
Abiurana (Ecclinusa sp.)	Brazil	1.09

[1] Specific gravity based on oven-dry weight and oven-dry volume.

Test Procedure

For each species three pieces 10 inches long by 3 inches wide were cut from air-seasoned stock and surfaced to a thickness of 1 inch.

[2] The two instruments, the Delmhorst Moisture Detector and the Moisture Register, were made available for this study by their respective manufacturers, the Delmhorst Instrument Company, Boonton, New Jersey and the Moisture Register Company, Alhambra, California.

All specimens of each species were taken from the same log with the exception of the balsa for which information was lacking as to exact source.

The specimens were then exposed to a known equilibrium moisture content condition until constant weight was reached after which each piece was tested three times with each meter. Equilibrium moisture content conditions of 18, 15, 12, 10, and 7 percent were used in that order. Following the testing at the last condition, a moisture sample was taken from each specimen and the moisture content determined by the oven process. The oven-dry weight of each specimen was then calculated on the basis of these moisture content determinations using the following formulae:

Oven-dry weight of the 10 inch by 3 inch by 1 inch specimen equals

$$\frac{\text{weight of specimen at 7 percent condition}}{1 \text{ plus the moisture content of the oven sample expressed as a decimal}}$$

Using these oven-dry weights, the moisture contents of the specimens were then calculated for the remaining four equilibrium moisture content conditions as follows:

Moisture content in percent for the desired equilibrium moisture condition equals

$$\frac{(\text{weight of specimen at desired equilibrium moisture content condition} - 1)100}{(\text{oven-dry weight of specimen})}$$

The calculated moisture contents at each condition were averaged by species and the averages used as the correct moisture contents at the five conditions.

Calibration Data

For each species and moisture meter, the instrument readings were plotted against moisture content and a smooth calibration curve drawn. No temperature correction of the instrument readings was made as, by means of thermocouples imbedded in the wood, the specimens were found to reach room conditions of 72° F. in a very short period following removal from the humidity chamber and testing was delayed until the end of this cooling period.

Calibration charts, see tables 1, 2, and 3, were prepared for each species and instrument from the calibration curves. While an 18 percent equilibrium moisture content condition was the highest use, all curves were extrapolated to approximately 21 percent moisture content. As seven is the lowest meter reading found on the two resistance meters, this is used as the starting point for both the Delmhorst and Kaydel instruments.

Use of the Calibration Data

The data presented in tables 1, 2, and 3 represent average moisture contents as determined from the specimens tested and are subject to certain limitations in use.

1. Resistance meters measure the resistance between the electrodes at the point where the wood is the wettest, thus, the calibration data given in tables 1 and 2 are suitable when the material has a uniform moisture content or where a normal drying moisture gradient exists with the moisture content of the wood not exceeding the fiber saturation point.

When wood with a normal drying moisture gradient is being tested, the electrodes should penetrate one-fifth the thickness of the stock, as studies of normal drying moisture gradients have shown that the average moisture content is represented by the moisture content at this depth.

2. The readings obtained by a high frequency power absorption meter are proportional to the specific gravity of the wood as well as to its moisture content. Consequently, the calibration data shown in table 3 for the Moisture Register, is reliable only when wood of these five species of like specific gravity is being tested. In addition, the data are for stock one inch in thickness. The manufacturer recommends that when lumber stock less than one inch in thickness is being tested, the average of several readings taken on one side of the material should be used as the moisture content. For stock over one inch and up to two inches, the average of several readings taken from both sides should be used. No attempt was made in this study to determine how suitable the calibration figures were under these conditions.

3. While all meters of a given type operate on the same principle, the fact that only one of the high frequency power absorption type was used and that the two resistant meters gave somewhat different results makes inadvisable, without checking their applicability, the use of the calibration data with other than the three makes of instruments used in the study.

In all situations where the moisture content of wood is determined by an electric moisture meter, accurate results will only be obtained if the manufacturer's instructions accompanying the instrument are carefully followed.

References

Dunlap, M. E., and E. R. Bell. 1947 Electrical Moisture Meters for Wood. U. S. Dept. Agr. Forest Prod. Lab. mimeo R1660, 10 pp., illus.

Table 1

Calibration Chart

for

Delmhorst Moisture Detector

Meter Reading	Species				
	Balsa	Roble Blanco	Ocote Pine	Courbaril	Abiurana
	Moisture Content - - percent				
7	6.0	6.3	6.9	7.0	6.4
8	6.4	7.4	8.7	7.8	7.3
9	7.0	8.1	9.4	8.5	8.1
10	7.6	8.8	10.3	9.3	9.0
11	8.3	9.6	11.3	10.0	9.9
12	9.1	10.3	12.3	10.8	10.7
13	9.9	11.1	13.3	11.6	11.6
14	10.8	11.9	14.2	12.3	12.7
15	11.8	12.6	15.0	13.0	13.8
16	12.8	13.4	15.8	13.8	15.0
17	13.8	14.2	16.4	14.6	16.3
18	14.8	15.0	17.0	15.3	17.8
19	15.8	15.8	17.6	16.0	19.4
20	16.9	16.6	18.1	16.8	21.5
21	18.0	17.4	18.7	17.5	
22	19.1	18.4	19.3	18.2	
23	20.3	19.5	19.9	19.0	
24	21.5	20.9	20.4	19.8	
25			21.0	20.5	
26				21.3	

Table 2

Calibration Chart

for

Kaydel Moisture Gauge

Meter Reading	Species				
	Balsa	Roble Blanco	Ocote Pine	Courbaril	Abiurana
		Moisture Content	-	percent	
7	5.8	6.6	7.8	7.0	6.6
8	6.3	7.4	8.8	7.8	7.4
9	6.9	8.2	9.8	8.7	8.2
10	7.4	9.0	10.8	9.5	9.0
11	8.1	9.8	11.7	10.3	9.8
12	8.9	10.6	12.5	11.1	10.6
13	9.9	11.4	13.4	11.8	11.5
14	11.0	12.1	14.2	12.5	12.3
15	12.1	12.9	14.9	13.1	13.2
16	13.4	13.8	15.6	13.7	14.3
17	15.0	14.5	16.2	14.4	15.4
18	16.6	15.3	16.8	15.2	16.7
19	18.4	16.1	17.3	16.1	18.3
20	20.1	16.9	17.8	16.9	21.0
21	22.4	17.8	18.3	17.6	
22		18.7	18.8	18.3	
23		19.8	19.3	19.0	
24		21.1	19.7	19.6	
25			20.1	20.1	
26			20.5	20.9	
27			20.9		

Table 3

Calibration Chart

for

Moisture Register

Species									
Balsa		Mayflower		Ocote Pine		Courbaril		Abiurana	
Meter Reading	Moisture Content percent	Meter Reading	Moisture Content percent	Meter Reading	Moisture Content percent	Meter Reading	Moisture Content percent	Meter Reading	Moisture Content percent
2	6.0	12	6.5	14	6.5	14	6.3	27	6.2
3	8.0	14	8.4	15	8.0	16	7.9	28	8.3
4	9.3	16	9.9	16	9.6	18	9.4	29	10.1
5	10.5	18	11.2	17	11.1	20	10.4	30	11.7
6	11.7	20	12.3	18	12.5	22	11.4	31	13.1
7	12.6	22	13.3	19	13.4	24	12.3	32	14.3
8	13.4	24	14.2	20	14.3	26	13.1	33	15.2
9	14.2	26	15.0	21	15.2	28	13.8	34	16.1
10	15.0	28	15.7	22	16.1	30	14.4	35	17.0
11	15.7	30	16.4	23	17.0	32	15.0	36	17.9
12	16.4	32	17.0	24	17.9	34	15.5	37	18.6
13	17.1	34	17.7	25	18.7	36	16.0	38	19.2
14	17.8	36	18.4	26	19.4	38	16.4	39	19.9
15	18.5	38	19.0	27	20.1	40	16.8	40	20.6
16	19.1	40	19.7	28	20.7	44	17.6		
17	19.7	42	20.3			48	18.3		
18	20.3	44	20.9			52	18.9		
19	20.9					54	19.5		
						58	20.1		

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Materials (Non-Metallic) (14)
Wood (10)
Research & Research Equipment (30)
Instrumentation (3)

Wood - Moisture content
Instruments - Calibration
Meters

A Moisture Content Measuring Instruments Wood

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