Quality Control of Moisture Determination of Moisture Content

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Moisture Content:

- **Moisture Content.** The amount of water contained in the wood, usually expressed as a percentage of the weight of the ovendry wood.
- **Ovendry—**A term applied to wood dried to constant weight in an oven maintained at temperatures of from 214 to 221°F.

$$MC = \frac{m_{wet} - m_{dry}}{m_{dry}}(100\%)$$

Equilibrium Moisture Content and Relative Humidity

- RH %
  - 90
  - 80
  - 65
  - 50
  - 30
  - 0
- EMC %
  - 20
  - 16
  - 12
  - 9
  - 6
  - 0

Wood used as and for industrial, commercial and consumer applications must be dried:

- Preservative-treated Poles, RR ties, Piling
- Construction lumber and timbers
- Lumber for interior applications
  - Flooring
  - Furniture
  - Cabinets

- Preservative-treated Poles, RR ties, Piling
  - Target - ***below 25-30% MC***, dry enough to treat
- Construction lumber and timbers
  - Target - < ***19% MC***, minimize warp and mold
- Lumber for interior applications
  - Target – ***6-8% MC***, dimensionally stable to interior-use %RH and %EMC

Determination of Wood MC%

- Oven Drying; at 103^{o}C, 218^{o}F
  - Time Consuming
  - Destructive
  - Accurate?
- Moisture Meters
  - Fast
  - Non-Destructive
  - Accuracy?


TotalCheck

ASTM Standard - %MC

ASTM

- **American Society for Testing and Materials**

ASTM Standard - %MC

ASTM D4442 − 16

- **Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials**

ASTM Standard - %MC

ASTM D4442 − 13

- **Standard Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters**

ASTM Standard - %MC

ASTM D4442 − 16

- **Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials**

ASTM D4442-16

- Method A—Primary Oven-Drying
- Method B—Secondary Oven-Drying
- Method C—Distillation (Secondary)
- Method D—Other Secondary Methods.

ASTM D4442-16

The Secondary methods (B through D) are intended for special purposes or under circumstances where the primary procedure (Method A) is not desired or justified. In these procedures, moisture content values cannot be reported with an accuracy greater than integer percentage values (that is, lower than in Method A).

A—Primary Oven-Drying

- *Oven*—A forced-convection oven that can be maintained at a temperature of 103 +/-2°C throughout the drying chamber for the time required to dry the specimen to the endpoint shall be used. Ovens shall be vented to allow the evaporated moisture to escape.

A—Primary Oven-Drying

- *Balance*—Based on a 10 g (oven-dry) specimen, minimum readability of the balance shall be determined by the desired reporting level of precision:
- Reporting Precision Level, *MC*, %
  Minimum Balance Readability, mg

0.01	1
0.05	5
0.1	10
0.5	50
1.0	100

A—Primary Oven-Drying

- *Endpoint*—Assume that the endpoint has been reached when the mass loss in a 3 h interval is equal to or less than twice the selected balance sensitivity.

For example, given a specimen weight of 10 g and for a balance sensitivity of 1 mg chosen in 5.1.2 to allow reporting to a 0.01 % *MC* precision, the endpoint is assumed to have been reached when the change in weight is 2 mg or less in a 3 h period.

B – Secondary Oven-Drying

- *Balance*—The sensitivity shall be a minimum of 0.1 % of the nominal oven-dry mass of the specimen (see 5.1.2).

B – Secondary Oven-Drying

Example - A specimen of wood weighed 56.7 g. After oven-drying, the mass was 52.3 g.

MC% = ((56.7 - 52.3)/52.3) *100% = 8.41%

- Round to 8 % MC
  - (or simply, at best, 8.4% MC).

D – Other Second Methods

- Karl Fischer titration
- infrared (heating and absorption)
- Microwave (heating and absorption)
- nuclear magnetic resonance (NMR),
- vacuum-oven drying, etc.

There are no recommended procedures for these methods.

C – Distillation

- Distillation (secondary) method is intended for use with materials that have been chemically treated or impregnated such that the oven-drying procedures introduce greater error than desired in the results.
- Or if there are volatile extractives.

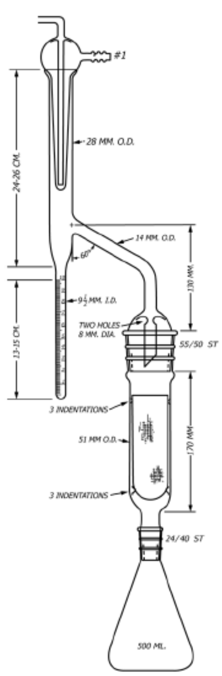
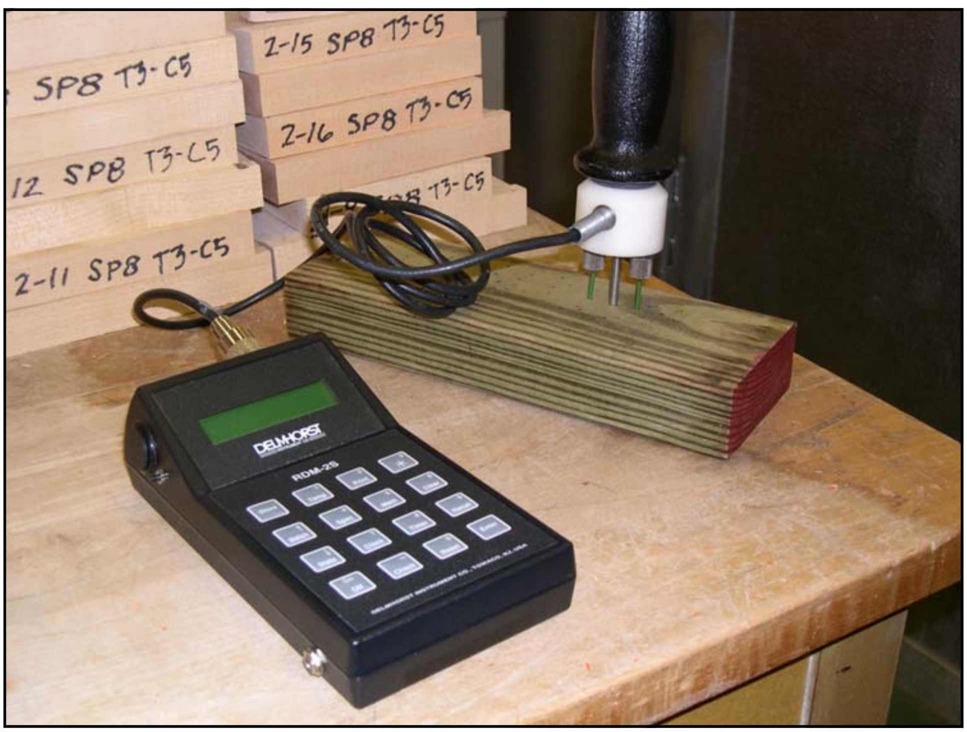


FIG. 1 Extraction Apparatus, Method C

Determination of Wood MC%

- Oven Drying; at 103°C, 218°F
  - Time Consuming
  - Destructive
  - Accurate?
- Moisture Meters
  - Fast
  - Non-Destructive
  - Accuracy?



Correction Factors

- Species
- Temperature
- Pins
  - 2 vs. 4
  - Insulated vs. Uninsulated
- Treatments can effect chemistry of wood

Important Accuracy Issues

- Wood Species - Chemical differences between species affect electrical conductivity
- Temperature – higher temperature increase electrical conductivity
- Density – affects on electro-magnetic field and moisture relationships

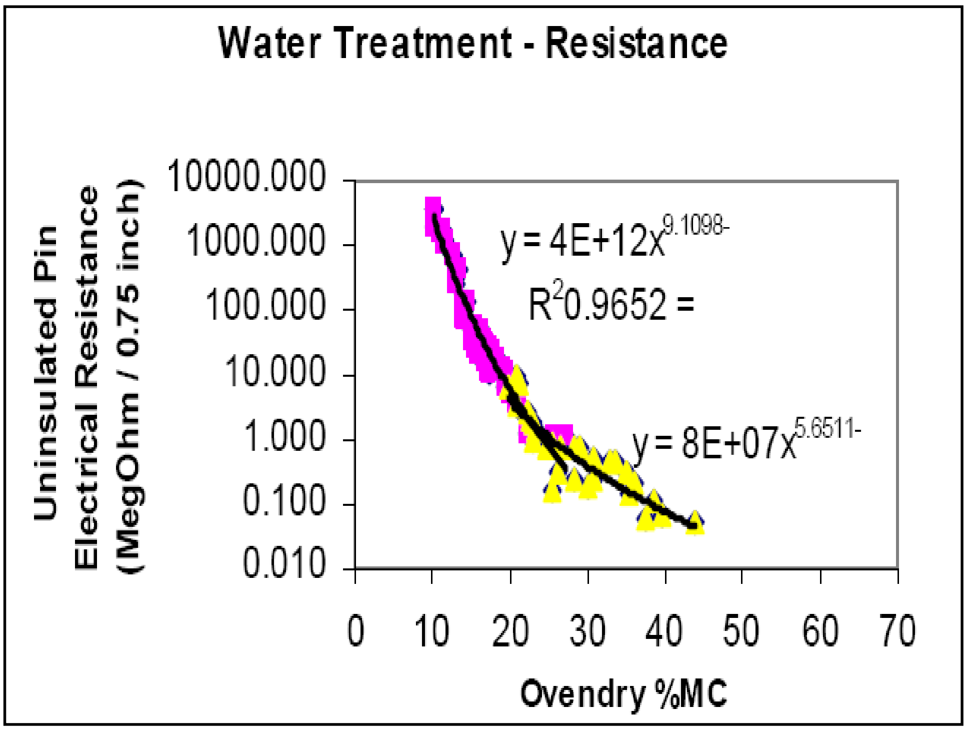


Table 1-11—Average electrical resistance along the grain, for selected species, as measured at 80°F between two pairs of needle electrodes 1-1/4 inches apart and driven to a depth of 5/16 inch

	Electrical resistance (megohms) at different levels of moisture content (percent)																		
Species	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Softwoods																			
Cypress, southern	12,600	3,980	1,410	630	265	120	60	33	18.6	11.2	7.1	4.6	3.09	1.78	1.26	0.91	0.66	0.51	0.42
Douglas-fir (coast type)	22,400	4,780	1,660	630	265	120	60	33	18.6	11.2	7.1	4.6	3.09	2.14	1.51	1.10	0.79	0.60	0.46
Fir, California red	31,600	6,760	2,000	725	315	150	83	48	28.8	18.2	11.8	7.6	5.01	3.31	2.29	1.58	1.15	0.83	0.63
Fir, white	57,600	15,850	3,980	1,120	415	180	83	46	26.9	16.6	11.0	6.6	4.47	3.02	2.14	1.55	1.12	0.86	0.62
Hemlock, western	*22,900*	*5,620*	*2,040*	*850*	*400*	*185*	98	51	28.2	*16.2*	*10.0*	*6.0*	3.89	2.52	*1.58*	*1.05*	*0.72*	*0.51*	*0.37*
Larch, western	39,800	11,200	3,980	1,445	560	250	120	63	33.9	19.9	12.3	7.6	5.02	3.39	2.29	1.62	1.20	0.87	0.66
Pine, eastern white	20,900	5,620	2,090	850	405	200	102	58	33.1	19.9	12.3	7.9	5.01	3.31	2.19	1.51	1.05	0.74	0.52
Pine, longleaf	25,000	8,700	3,160	1,320	575	270	135	74	41.7	24.0	14.4	8.9	5.76	3.72	2.46	1.66	1.15	0.79	0.60
Pine, ponderosa	39,800	8,910	3,310	1,410	645	300	150	81	44.7	25.1	14.8	9.1	5.62	3.55	2.34	1.62	1.15	0.87	0.69
Pine, shortleaf	43,600	11,750	3,720	1,350	560	255	130	69	38.9	22.4	13.8	8.7	5.76	3.80	2.63	1.82	1.29	0.93	0.66
Pine, sugar	22,900	5,250	1,660	645	280	140	76	44	25.7	15.9	10.0	6.6	4.36	3.02	2.09	1.48	1.05	0.75	0.56
Redwood	22,400	4,680	1,550	615	250	100	45	22	12.6	7.2	4.7	3.2	2.29	1.74	1.32	1.05	0.85	0.71	0.60
Spruce, Sitka	22,400	5,890	2,140	830	365	165	83	44	25.1	15.5	9.8	6.3	4.27	3.02	2.14	1.58	1.17	0.91	0.71
Hardwoods																			
Ash, commercial white	12,000	2,190	690	250	105	55	28	14	8.3	5.0	3.2	2.0	1.32	0.89	0.63	0.50	0.44	0.40	0.40
Basswood	36,300	1,740	470	180	85	45	27	16	9.6	6.2	4.1	2.8	1.86	1.32	0.93	0.69	0.51	0.39	0.31
Birch	87,000	19,950	4,470	1,290	470	200	96	53	30.2	18.2	11.5	7.6	5.13	3.55	2.51	1.78	1.32	0.95	0.70
Elm, American	18,200	2,000	350	110	45	20	12	7	3.9	2.3	1.5	1.0	0.66	0.48	0.42	0.40	0.40	0.40	0.40
Hickory, true	—	31,600	2,190	340	115	50	21	11	6.3	3.7	2.3	1.5	1.00	0.71	0.52	0.44	0.40	0.40	0.40
Kahya[1]	44,600	16,200	6,310	2,750	1,260	630	340	180	105.0	60.2	35.5	21.9	14.10	9.33	6.16	4.17	2.82	1.99	1.44
Magnolia	43,700	12,600	5,010	2,040	910	435	205	105	56.2	29.5	16.2	9.1	5.25	3.09	1.86	1.17	0.74	0.50	0.32
Mahogany, American	20,900	6,760	2,290	870	380	180	85	43	22.4	12.3	7.2	4.4	2.69	1.66	1.07	0.72	0.49	0.35	0.26
Maple, sugar	72,400	13,800	3,160	690	250	105	53	29	16.6	10.2	6.8	4.5	3.16	2.24	1.62	1.23	0.98	0.75	0.60
Oak, commercial red[2]	14,400	4,790	1,590	630	265	125	63	32	18.2	11.3	7.3	4.6	3.02	2.09	1.45	0.95	0.80	0.63	0.50
Oak, commercial white	17,400	3.550	1,100	415	170	80	42	22	12.6	7.2	4.3	2.7	1.70	1.15	0.79	0.60	0.49	0.44	0.41
Shorea[3]	*2,890*	*690*	*220*	*80*	*35*	*15*	*9*	*5*	*2.8*	*1.7*	*1.1*	*0.7*	*0.45*	*0.30*	*0.21*	*0.16*	*0.12*	*0.09*	*0.07*
Sweetgum	38,000	6,460	2,090	815	345	160	81	45	25.7	15.1	9.3	6.0	3.98	2.63	1.78	1.26	0.87	0.63	0.46
Tupelo, black[2]	31,700	12,600	5,020	1,820	725	275	120	58	27.6	13.0	6.9	3.7	2.19	1.38	0.95	0.63	0.46	0.33	0.25
Walnut, black	51,300	9,770	2,630	890	355	155	78	41	22.4	12.9	7.8	4.9	3.16	2.14	1.48	1.02	0.72	0.51	0.38
Yellow-poplar[2]	24,000	8,320	3,170	1,260	525	250	140	76	43.7	25.2	14.5	8.7	5.76	3.81	2.64	1.91	1.39	1.10	0.85

[1]Known in the trade as "African mahogany."
[2]The values for this species were calculated from measurements on veneer.
[3]A Philippine hardwood, identified as tanguile or some similar species.

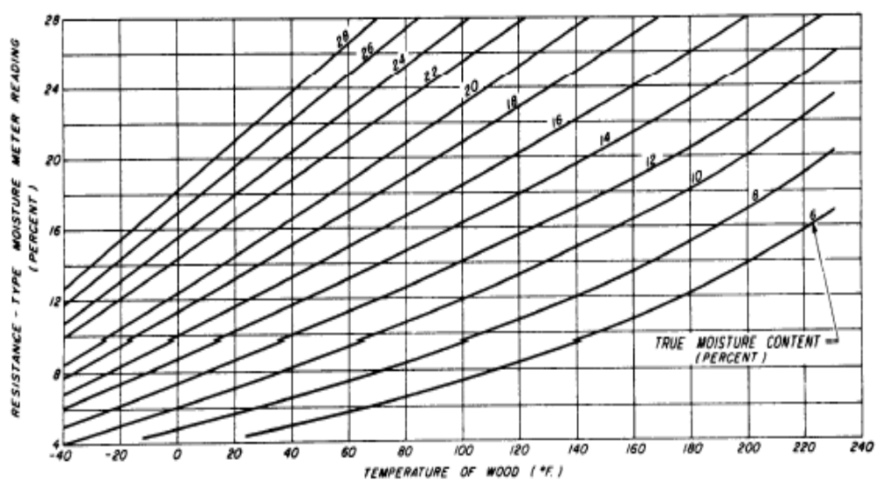


Figure 5— Temperature corrections for reading of conductance-type moisture meters, based on combined data from several investigators. Find meter reading on vertical left margin, follow horizontally to vertical line corresponding to the temperature of the wood, and interpolate corrected reading from family of curves. Example: if meter indicated 18 percent on wood at 120 °F, the corrected reading would be 14 percent. This chart is based on a calibration temperature of 70 °F. For other calibration temperatures near 70 °F, adequate corrections can reobtained simply by shifting the temperature scale so that the true calibration temperature coincides with 70 °F on the temperature scale. (M 76476 F)

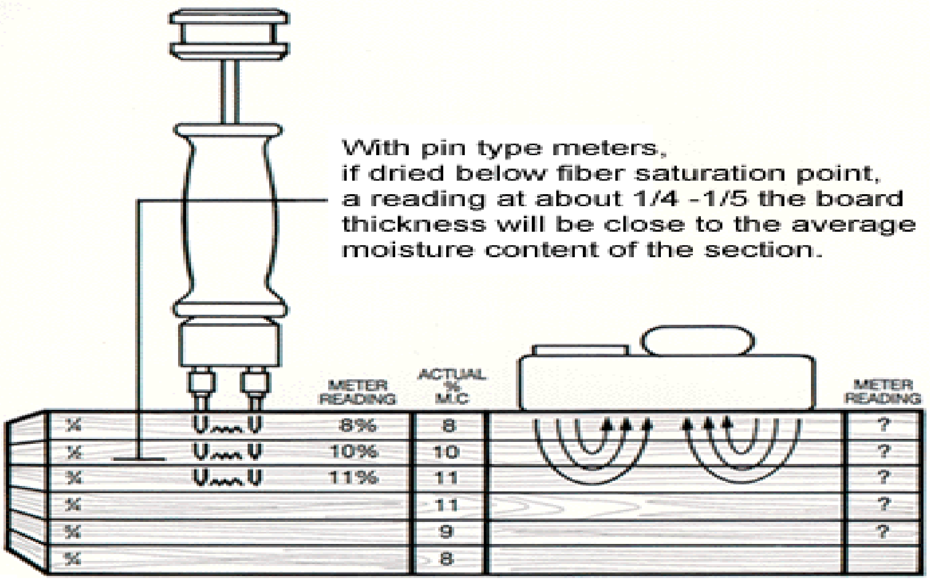


FIGURE I

PIN TYPE METERS VS. SURFACE TYPE METERS.
(HYPOTHETICAL DRAWING OF 6/4 BOARD WITH
VARYING LEVELS OF MOISTURE.

Several examples of Moisture Meter Accuracy in Practical Use:

- Eastern red cedar
- White Oak
- Pressure-Treated Pine

Eastern red cedar -

- Extractives in eastern red cedar appeared to be causing incorrect %MC values during oven-drying.

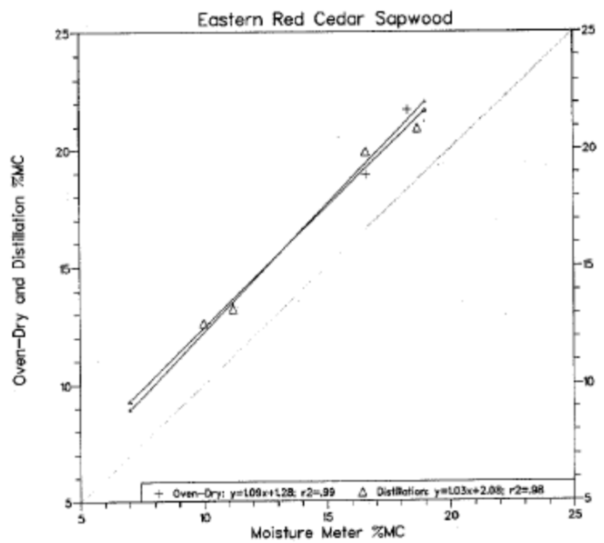


Figure 1.—Relationship between moisture meter, ovendrying, and distillation methods of determining MC in eastern redcedar sapwood.

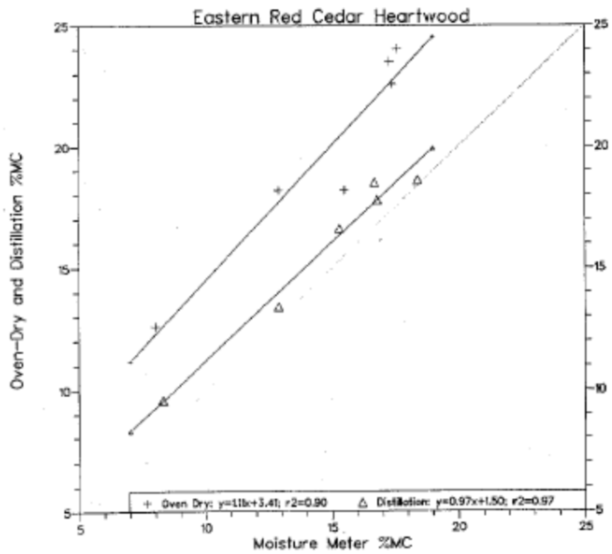


Figure 2.—Relationship between moisture meter, ovendrying, and distillation methods of determining MC in eastern redcedar heartwood.

TABLE 1. – *Eastern redcedar moisture content analysis.*

	A section				B section		
Sample no.	Moisture meter	OD–MM[a]	Ovendry	OD–TD[b]	Moisture meter	TD–MM[c]	Toluene distillation
Heartwood							
1-H	38.4		80.6	12.0	26.8		68.6
2-H	37.5		69.9	1.5	34.0		68.4
6-H	8.0	4.6	12.6	3.0	8.3	1.0	9.6
7-H	15.5	2.7	18.2	1.6	15.3	1.3	16.6
8-H	12.9	5.3	18.2	4.8	12.9	0.5	13.4
11-H	17.3	6.2	23.5	4.9	18.4	0.2	18.6
12-H	17.4	5.2	22.6	4.8	16.8	1.0	17.8
13-H	17.6	6.4	24.0	5.5	16.7	1.8	18.5
Average difference		**5.1**		**4.8**		**1.0**	
Sapwood							
3-S	16.6	2.3	18.9	-1.0	16.6	3.3	19.9
4-S	18.3	3.4	21.7	0.8	18.7	2.2	20.9
5-S	10.1	2.5	12.6	0.0	10.0	2.6	12.6
9-S	>60		83.9	1.5	46.6		83.3
10-S	11.2	2.1	13.3	0.1	11.2	2.0	13.2
Average difference		**2.6**		**0.3**		**2.5**	

[a] OD–MM = Ovendry – moisture meter value.
[b] OD–TD = Ovendry – toluene distillation value.
[c] TD–MM = Toluene distillation – moisture meter value.

Eastern Red Cedar

- True %MC of heartwood and sapwood was determined using toluene solvent distillation.
- It was proved that due to evaporation of heartwood extractives oven drying did not accurately determine %MC.
- The resistance moisture meter accuracy was comparable to oven-drying with e.r.cedar sapwood.
- The resistance moisture meter accuracy was much better than oven-drying with e.r.cedar heartwood

8/4 inch White Oak

- A furniture company was concerned because their white oak appeared to be too wet
  - Wagner Meter – 10.7% MC
    - Range – 8.5 – 13%

8/4 inch White Oak

- Wagner Meter – 10.7% MC
  - Range – 8.5 – 13%
- …so we checked the wood with a resistance meter, and then oven dried samples as well…
- Delmhorst Meter – 7.9% MC
  - Range – 6.3 – 8.8%

8/4 inch White Oak

- Oven Dry – 6.8% MC (18 specimens)
  - Range – 6.1-7.4%
- Wagner Meter – 10.7% MC
  - Range – 8.5 – 13%
- Delmhorst Meter – 7.9% MC
  - Range – 6.3 – 8.8%

8/4 inch White Oak

- Wagner Meter – 10.7% MC
  - Range – 8.5 – 13%
  - Specific Gravity Average = 0.79;
    book value = 0.68
- Delmhorst Meter – 7.9% MC
  - Range – 6.3 – 8.8%
- Oven Dry – 6.8% MC (18 specimens)
  - Range – 6.1-7.4%

8/4 inch White Oak

- In this case :
- Because the white oak density was greater than normal (book value), the Wagner electromagnetic meter tended to overestimate true % MC.
- Because the Delmhorst resistance meter is not affected by density it more accurately predicted true % MC.
- Which is the better meter???
  - Both meter technologies are good. However each has differing limitations and benefits. Take advantage of the benefits, understand and account for the limitations.

%MC Determination – what and how best?

- Oven Dry method?
- Meters?
- Circumstances
- Accuracy
- Precision
- * see NEKDA Spring 2013, Jake Seidel presentation.

Thank you!

- Questions?
- Comments?
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