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ASSESSMENT OF ACCURACY OF SPECIES-TEMPERATURE CORRECTION TABLES FOR RESISTANCE-TYPE MOISTURE METERS

by

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SUMMARY

Electrical resistance in wood, and therefore a reading on a resistance-type moisture meter dial, is affected not only by moisture in the wood but also by species and wood temperature, and these must be compensated for. In Canada, the Forintek laboratories have published combined species-temperature correction tables so that adjustment of meter readings can be made in a single step. However, claims have been made that, particularly at low temperatures, the corrected values provided in the Western Laboratory tables for some softwood species are too high. Consequently, to meet grade requirements for moisture content, lumber had to be overdried resulting in unnecessary extension of kiln residence times, energy wastage and increased shrinkage and degrade.

The objective of this study was to examine the validity of these claims and attempt to determine the sources of variation in meter readings.

Moisture-equilibrated samples of Douglas-fir, hemlock, amabilis fir, white spruce and lodgepole pine were tested with a Delmhorst meter and insulated probes over a range of moisture contents between 7 and 25% and at temperatures from -20°C to 27°C. All samples were finally oven-dried to permit calculation of true moisture contents that were then compared to Forintek-corrected meter readings.

Results indicated that the current Forintek tables are, in some circumstances, inaccurate. Compared to oven-dry moisture contents, the tables overestimated values by up to 7% MC at sub-zero temperatures.

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OBJECTIVE

The objective of this study has been to examine the validity of concerns that the Forintek Western Laboratory Combined Species-Temperature Correction Tables for Moisture Meters overestimate actual moisture contents in specific situations.

INTRODUCTION

Resistance-type moisture meters are generally recognized as providing the most reliable non-destructive method for determining moisture contents in dry wood. The meters measure electrical resistance between two electrodes that are driven into the wood parallel to the grain. The electrodes are usually rigid needles, mounted on a probe, that are covered except for the tips with an insulating coating.

Electrical resistance in wood, and therefore a reading on a moisture meter dial, is affected not only by moisture in the wood but also by species and wood temperature, and these must be compensated for. Correction tables are tedious to use if it is necessary to correct for temperature in one table or graph, and to then make a further correction for species using another table. In Canada, the Forintek laboratories have published combined species-temperature correction tables so that adjustment of meter readings can be made in a single step. In the tables produced by the Western Laboratory (Bramhall and Salamon, 1978), species corrections for resistance-type meters were based largely on data obtained at the laboratory by Salamon (1972), while temperature corrections were based on graphical relationships of temperature, meter reading and actual moisture content developed by James (1968) using data from a number of investigators.

In the last two to three years some companies and industry associations have conducted tests comparing adjusted meter readings with actual moisture contents calculated after oven-drying their test samples. Complaints have followed that, for some species, the adjustments to meter readings indicated in the tables published by the Western Laboratory (Bramhall and Salamon, 1978)) are too large, thereby overestimating the moisture content. Most complaints have been directed at those sections of the correction tables that are used when wood is at below-freezing temperatures. The consequence of the species-temperature corrections being too large is that a producing mill would overdry lumber to try to meet grading specifications. In addition to unnecessary extension of kiln residence times, energy is wasted and shrinkage-related degrade is increased.

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MATERIALS AND METHODS

Species tested to date are amabilis fir (*Abies amabilis*), western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*), western white spruce (*Picea glauca*), and lodgepole pine (*Pinus contorta*).

Approximately 600 samples of Hem-Fir and 400 samples of Douglas-fir were obtained from local sawmills. Samples were green, 2 by 4 mill ends up to 2 ft. long. The Hem-Fir material was later identified as either hemlock or amabilis fir, and results for the two species are reported separately.

Half of the samples were placed in a constant humidity chamber and left to equilibrate to 12 percent MC at a temperature of 25°C. After four months each sample was removed from the chamber and resistance moisture meter readings were taken. The 1.5 in.-long electrodes were insulated except for the tips, and were inserted parallel to the grain at mid-length of each sample. Entry of the electrodes into the wood was through slots cut in plastic shims of different thicknesses so that measurements could be made at pre-determined depths, namely 0.25, 0.5, 0.75, 1.0 and 1.25 in.

A sample was accepted as being in moisture content equilibrium if all five of the meter readings were within a range of one percent MC. Samples not meeting this specification were set aside and not used. A 4 in.-long section of each metered sample, enclosing the position that was metered, was sawn, weighed, oven-dried, and reweighed. Average moisture contents of all samples were calculated.

The remaining Hem-Fir and Douglas-fir samples were left to equilibrate in an outside storage shed at the laboratory for 16 months. The above metering procedures were carried out at ambient temperatures of 4°C or 10°C, after which oven-dry moisture contents were determined.

Approximately 250 samples 2 by 4 and 4 in.-long were sawn from kiln-dried white spruce lumber that had been strength tested to failure at the laboratory. One sample only was sawn from each full length piece. All were placed in a constant humidity chamber to equilibrate to about 10% MC at 21°C. Moisture meter readings were taken, then samples were weighed and placed in a second humidity chamber to equilibrate to about 22% MC. A further set of meter readings was obtained after which each sample was weighed, wrapped in Saran film to minimize moisture change, and placed in a freezer to reduce wood temperature to -20°C. Each was then weighed and metered a third time. Finally oven-dry weights were obtained to allow calculation of moisture contents corresponding to each time of moisture measurement.

Similar procedures as used for spruce were repeated with approximately 240 lodgepole pine samples, also obtained at the laboratory. The sequence of temperature and target moisture contents was, 19% MC at 23°C, 19% MC at -20°C, 22% MC at 26°C, and 22% MC at -20°C.

The data were assembled to allow comparisons of oven-dry moisture contents of groups of samples all with the same meter reading, with the corrected value of that meter reading as determined from the Western Laboratory tables.

The effect of low temperature on meter performance was examined briefly. Meters were stored at -20°C for several hours then were tested against standardized calibration resistors which were at either room temperature or -20°C. Comparisons were made of moisture meter readings and the moisture content shown on the calibration resistors.

RESULTS AND DISCUSSION

Table 1 shows the results obtained with amabilis fir. At each of three levels of temperature, the number of equilibrated samples i.e., those with less than 1% MC spread throughout their thickness, for given moisture meter readings are shown. The calculated average oven-dry MCs for these groups can be compared with the corrected meter values to gauge the accuracy and reliability of the correction tables (Bramhall and Salamon, 1978).

Tables 2 through 5 present similar data for the other four species tested.

The data for amabilis fir indicate that corrected values were within 1% MC of actual values in the range of 10 to 17% MC and at temperatures between 4 and 25°C. This level of accuracy is considered to be acceptable.

Table 1

Temperature °C	Number of Samples	Meter Reading % MC	Oven-Dry MC %	Corrected Meter Reading % MC
4	14	12	16.9	17
4	21	13	17.4	18
10	30	12	16.2	16
10	25	13	16.6	17
25	34	9	10.4	11
25	41	10	11.2	12
25	20	11	12.0	13

At three levels of temperature, the number of MC - equilibrated amabilis fir samples at given moisture meter readings, the average oven-dry MC of each group of samples, and the corrected (Bramhall and Salamon, 1978) moisture meter reading for species and temperature.

Table 2

Temperature °C	Number of Samples	Meter Reading % MC	Oven-Dry MC %	Corrected Meter Reading % MC
4	20	12	16.1	18
4	77	13	17.2	19
4	73	14	18.0	21
10	18	12	16.1	17
10	24	13	17.0	18
25	51	10	11.2	12
25	51	11	12.0	13
25	52	12	12.9	14

At three levels of temperature, the number of MC - equilibrated western hemlock samples at given moisture meter readings, the average oven-dry MC of each group of samples, and the corrected (Bramhall and Salamon, 1978) moisture meter reading for species and temperature.

Table 3

Temperature °C	Number of Samples	Meter Reading % MC	Oven-Dry MC %	Corrected Meter Reading % MC
10	9	11	12.8	15
10	86	12	13.4	16
10	83	13	14.2	17
25	17	7	7.0	9
25	83	8	8.2	10
25	63	9	8.9	11
25	27	10	9.6	12

At three levels of temperature, the number of MC - equilibrated Douglas-fir samples at given moisture meter readings, the average oven-dry MC of each group of samples, and the corrected (Bramhall and Salamon, 1978) moisture meter reading for species and temperature.

Table 4

Temperature °C	Number of Samples	Meter Reading % MC	Oven-Dry MC %	Corrected Meter Reading % MC
-20	48	12	22.0	25
-20	134	13	23.5	27
-20	45	14	24.4	29
-20	9	15	25.4	30
21	174	8	10.2	11
21	65	9	11.0	12
27	9	17	21.4	21
27	33	18	22.5	22
27	75	19	23.4	23
27	46	20	24.2	24
27	16	21	25.1	26

At three levels of temperature, the number of MC - equilibrated white spruce samples at given moisture meter readings, the average oven-dry MC of each group of samples, and the corrected (Bramhall and Salamon, 1978) moisture meter reading for species and temperature.

Table 5

Temperature °C	Number of Samples	Meter Reading % MC	Oven-Dry MC %	Corrected Meter Reading % MC
-20	41	9	17.2	19
-20	87	10	18.2	21
-20	53	11	19.4	23
-20	19	12	21.1	24
-20	13	13	22.8	26
23	16	13	16.6	16
23	64	14	17.7	17
23	66	15	18.6	18
23	30	16	19.6	20
23	14	17	20.9	21
-20	60	14	21.7	28
-20	62	15	22.8	30
-20	48	16	24.4	off scale
-20	18	17	24.7	"
26	34	18	21.6	22
26	51	19	22.5	23
26	35	20	23.3	24
26	14	21	24.3	25

At three levels of temperature, the number of MC - equilibrated lodgepole pine samples at given moisture meter readings, the average oven-dry MC of each group of samples, and the corrected (Bramhall and Salamon, 1978) moisture meter reading for species and temperature.

From Table 2 it is apparent that for western hemlock at moisture contents between 11 and 17% MC and at temperatures in the range of 10 to 25°C, the corrected meter readings are no more than 1% MC above the calculated MCs. However, between 16 and 18% MC at 4°C, the corrected meter readings overestimated MC by up to 3% MC.

Similar overestimates of MC were found with Douglas-fir at MCs from 7 to 14% in a temperature range of 10 to 25°C (Table 3). The degree of overestimation appears to increase with increasing MC.

Data for both white spruce and lodgepole pine (Tables 4 and 5) were similar in that MCs in a range of 10 to 25% for spruce and 17 to 24% for pine at temperatures between 21 and 27°C, corrected meter readings were within 1% MC of calculated MCs. However at -20°C the corrected meter readings consistently overestimated MCs by 2 to 7% MC.

After prolonged exposure at -20°C, meter performance was found to be unaffected with respect to readings obtained on manufacturers' present calibration resistors representing 12 and 21% MC.

The source of inaccuracies in the tables has clearly not been identified. However, the assumption made that the curves for temperature, meter reading and actual moisture content that were developed by James (1968) are applicable to all species in the tables is likely incorrect. To address this problem it would be necessary to obtain new correction factors by following the general procedures used in the present screening tests, using moisture-equilibrated samples of all commercial species conditioned to temperatures spanning the range experienced in commercial production.

CONCLUSIONS AND RECOMMENDATIONS

The current Forintek Western Laboratory species-temperature correction tables for Delmhorst resistance-type moisture meters (Bramhall and Salamon, 1978) are, in some circumstances, inaccurate. Compared to oven-dry moisture contents, the tables were found to overestimate by up to 7% MC, the moisture contents of equilibrated samples at sub-zero temperatures. This finding is consistent with observations made by industry personnel and conveyed to the laboratory.

Since no malfunction of the meter was apparent when exposed to low temperatures, the observed errors must be attributed to the tables. Use of the tables for estimating moisture contents at low temperatures should therefore be discouraged.

Consideration should be given to establishing a joint industry association-Forintek study to develop either new correction tables for western softwoods, or alternative moisture assessment procedures acceptable to Canadian and American Lumber Standards Authorities.

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