ASSESSMENT OF THE ACCURACY OF THE ELECTRONIC RESISTANCE AND THE WAGNER HAND HELD METER TO ESTIMATE THE MOISTURE CONTENT OF WOOD

Prepared for:
Wagner Electronic Products Inc

Prepared by:
Mr K W Maun
Centre for Timber Technology and Construction

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Final approval on behalf of BRE (Centre Head) :

Signed _____ *Date* 30. 5. 00

Director, Centre for Timber Technology and Construction

BRE
Bucknalls Lane
Garston
Watford
WD2 7JR

Tel : 01923 664000
Fax : 01923 664010
Email : enquiries@bre.co.uk

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EXECUTIVE SUMMARY

This report covers work carried out to verify the calibration table for the Wagner hand held meter and to provide a comparison between oven-dry moisture content, an electrical resistance meter and a Wagner hand held meter. The work was commissioned by Wagner Electronic Products Inc.

The assessments were carried out on 13 batches of Sitka spruce consisting of between 15 and 20 battens. The samples were representative of UK Sitka spruce and produced commercially. Resistance meter readings and Wagner meter readings were taken in a selected area of each batten which was subsequently cut out to determine oven-dry moisture content.

The assessment verified the existing calibration previously used for the hand held Wagner meter and indicated that it had very good correlation with oven-dry moisture content readings. In general it was more consistent than the resistance meter especially for moisture contents exceeding 18 per cent. However, the device tested in this investigation, was not suitable for determining moisture gradient from the centre to the outside of the samples.

The results of this study indicated that the Wagner meter can be used to provide measurements of moisture contents which are required for structural standards when used on timber stored and graded under cover.

It is recommended that a new European standard is developed to cover the use of capacitance type moisture content meters.

1. INTRODUCTION

Reliable evidence of the moisture content of timber, either for individual battens or for batches of pieces, is becoming increasingly more and more important. This is to ensure compliance with relevant EU and UK standards (e.g. BSEN519) as well as to ensure wood and wood components are dried to the correct moisture content that minimises shrinkage, movement and distortion in use.

The most precise way to measure moisture content is by the oven-dry method which involves cutting out samples from the timber to be assessed, weighing, drying and then re-weighing them. This method, at it's best is inconvenient and often not possible in a commercial environment. Therefore, other methods to determine moisture content are required. The current traditional method is to use an electrical resistance meter in conjunction with deep probes if required. The use of this type of meter is covered by prEN13183-2. However, resistance meters can be misused, often because of worn probes or readings taken at the wrong depth without any adequate allowance made for wood temperature. Current standards which specify a moisture content assessment stipulate that a reading should be taken at a depth of 1/3 the thickness of the timber piece to be measured. Therefore, insulation of the probes and the depth of probe insertion is very important.

An alternative method is to use a capacitance meter. This requires contact with the surface of the timber but does not require any insertion of probes. It is therefore a simpler and quicker system to use compared with the resistance probe meter. However, to use the current devices available, there is a need for information that links wood density to the calibration for the target moisture content of the wood to be measured.

One such device is the Wagner Hand Held capacitance meter and this report specifically addresses the calibration for this meter for British grown Sitka spruce. It provides information to verify existing calibration tables as well as data which may be required to make modifications. It compares Wagner capicitance meter readings with those of the resistance meter and the oven dry method.

2. OBJECTIVES

- To provide data to check and modify as required the calibration table of the Wagner Hand Held moisture meter.
- To compare moisture content readings determined by the oven-dry method, electrical resistance meter and the hand held Wagner meter.

3. ASSESSMENT

The assessment involved 13 batches of Sitka spruce. Density was measured using samples from 8 of these especially selected for this investigation. The other 5 batches were groups of battens taken from consignments of timber received at BRE as part of another project. Each batch consisted of between 15 and 20 samples and moisture content measurements, oven dry moisture content samples and density samples were taken at the same marked position in each batten.

3.1 Wagner Meter

When this device was used the timber pieces were positioned so that there was no obstruction under the measurement position. The density indicated on the meter was set to 0.3 SG (the bottom of the range for Sitka spruce) and the meter was placed centrally on the wide surface of each sample with the measuring plate above the marked measuring position. The Wagner meter reading is designed to give an average moisture content for a timber sample and have good correspondence with the oven dried moisture content readings. These are the criteria required of a moisture content meter for structural standards. The manufacturers literature, "Standard method for measurement of Moisture Content using Wagner hand meters", indicates that normally the meter should be used on timber stored in a dry covered area. However, the meter can be used outside, but the literature emphasises that when it is used on absorbent dried wood which may have been subjected to rain, care must be taken and the wetted wood turned over to allow a measurement to be taken on a dry face.

3.2 Electrical resistance meter

With this device moisture content readings were measured using deep probes inserted into the face of the sample, at the marked position. The probes were pushed into the wood to a depth of 1/3 the thickness of the sample. This is recommended in structural standards to give an average moisture content for a timber sample and, as with the Wagner meter, have good correspondence with the oven dried moisture content readings. Insulation on probes was always at a maximum and great care was taken to insert them to the correct depth. This was to ensure a point moisture reading at the correct depth. The meter was regularly calibrated, during the assessment, using the special calibration block supplied by the makers.

3.3 Oven-dry moisture content

This was determined from a 100 mm long sample cut equal distance each side of the marked measurement position. The moisture content was determined in accordance with prEN 13183-2.

3.4 Density

This was determined using the sample taken for oven dry moisture content measurements. The dimensions were measured at the time of wet weighing and density was calculated at oven dry weight, thus the numerical result indicated relative specific gravity. The density at 12% moisture content (or any other MC) can be interpreted from the collected data.

4. RESULTS

The results which compare the resistance meter and the Wagner meter readings with oven dry MC are summarised in Tables 1 and 2. The target moisture content selected was the kiln operators desired MC and this has been used in conjunction with the current Wagner calibration table to convert the actual mean Wagner meter readings to give the corrected mean Wagner meter readings. It should be

emphasised that the calibration table used for the Wagner meter was produced totally independently of the data collected in this current investigation.

5. DISCUSSION

The dry weight density range measured in this investigation for Sitka spruce was 325-403 Kg/m^3 with a mean of the range of 366 kg/m^3. This compares with the 340 kg/m^3 reference value set out in the BRE publication "The Mechanical Properties of Timber". The density value for this investigation is a little high compared with the reference value, but this can be accounted for because the reference dimensions were measured green where as samples in this investigation were measured after initial drying. Also, in this assessment, a greater number of samples were taken from the usually denser out side part of the log. Therefore, it is assumed that the Sitka spruce samples assessed in this investigation are representative of the British grown Sitka spruce.

The moisture content comparison in tables 1 and 2 show that the corrected Wagner meter readings, using the Wagner supplied look-up calibration table, gave a better estimate of oven-dry moisture content than did the electrical resistance meter. This is confirmed by detailed analyses in tables 3 and 4.

- Table 3 indicates the percentage of readings achieved within 1% of the oven-dry MC for both the resistance and the Wagner meters.
- Table 4 summarises the errors (from the oven-dry MC) for the two estimating systems

Tables 3 and 4 indicate that:

- Considering all the readings, the Wagner meter achieved 46% within +/- 1% of the oven-dry moisture content (ODMC) and the resistance meter achieved 37% of readings within +/- 1% of ODMC
- The Wagner meter was more consistent, i.e. the resistance meter produced readings for 4 batches of battens where less than 20% of readings were within 1%, where as for the Wagner meter none of the batches had less than 20% of readings within 1%.

- For 11 of the 13 samples the Wagner meter had a smaller or equal error and was more consistent than the resistance meter in predicting the oven-dry moisture content.
- The mean error of the group of samples for the Wagner meter was 0.5 percentage points compared with 1.1 for the resistance meter.
- The difference in errors was larger for the targeted moisture content of 20%. For this moisture content the Wagner meter error was 0.7 percentage points compared with 1.5 for the resistance meter. In general the resistance meter tended to give lower readings.

It must be emphasised that the probes of the resistance meter were changed regularly to maintain their insulation so that they gave an accurate point reading as required by some standards. Also, the resistance meter reading was corrected for temperature using the designated formula of ½ a percentage point correction per 5°C each side of 20°C. It is important that in practice, that the resistance meter is used with similar precision to avoid the risk of inaccurate readings. It should also be emphasised that the Wagner meter readings were taken on samples stored under cover to avoid errors from surfaces newly wetted by rain. The Wagner meter may give inaccurate readings (high) on dried absorbent wood (such as Pine and Spruce) , if newly wetted by rain. This was not assessed in this investigation, but any such pieces should be turned over and measured from their dry face, as recommended in the Wagner publication "Standard Method for measurement of Moisture Content in lumber using Wagner hand meters".

6. CONCLUSIONS

- The Wagner meter gives a very good correlation with oven-dry moisture content readings.
- The Wagner meter is more consistent and has a smaller error from the oven-dry moisture content than the resistance meter for predicting MC in the range 12% - 20%. This is especially true for target moisture contents of above 18%.
- This assessment confirms the accuracy of the current Wagner meter calibration table.

- Wagner correction values are small for low moisture content readings (less than 12%) and significant at high moisture content readings
- When using the Wagner meter, the calibration look-up table must be used to measure material with a target moisture content over 15%.
- The Wagner meter tested was not suitable for measuring the moisture gradient from the centre to the outside of a sample. This is best achieved by using a resistance meter with well insulated hammer probes.
- The Wagner meter can be used to provide measurements of moisture content as required for compliance with structural standards when used on timber stored and graded under cover. If the manufactures guidelines are followed (turning timber over to be sure of measuring on a dry face) it is likely to perform satisfactory in the open even if the material to be measured has been subjected to some top surface wetting by rain. However, the performance of the Wagner meter for use in the uncovered environment was not assessed in this investigation.
- The Wagner meter was faster, easier to use, and more consistently accurate than the resistance meters tested.
- A European standard is required to cover the use of capacitance type moisture content meters. This has been requested by BSI Sub-Committee B/543.

TABLE 1 Density and Comparison of Moisture Content Readings

Sample No.	Sample thickness (mm)	Mean density (Dry weight) Kg/m^2	Target MC (%)	Mean Oven dry MC (%)	Mean resistance probe MC at 1/3 depth (%)	Mean Wagner meter actual MC reading (%)	Corrected Mean Wagner MC reading (%)
A1	22	388	12	12.3	11.2	12.4	12.7
A2	19	363	12	12.2	11.3	11.5	11.8
A3	19	352	20	20.5	18.3	17.2	20.2
A4	22	372	20	22.0	19.4	19.4	22.4
A5	47	344	20	18.9	17.8	16.6	19.6
A6	47	368	15	14.3	13.7	13.8	15.0
A7	47	371	20	22.8	20.8	20.2	23.2
A8	47	366	12	13.8	13.4	13.4	13.7

TABLE 2 Comparison of Moisture Content Readings

Sample No.	Sample thickness (mm)	Target MC (%)	Mean Oven dry MC (%)	Mean resistance probe MC at 1/3 depth (%)	Mean Wagner meter actual MC reading (%)	Corrected Mean Wagner MC reading (%)
Al1	47	20	22.5	21.8	18.9	21.9
A12	47	20	19.2	18.9	14.6	17.5
A13	47	18	17.3	16.8	14.8	17.1
A14	47	20	20.6	18.9	17.0	19.9
A15	47	12	14.5	14.9	13.9	14.1

Table 3 Percentage of reading within one percentage point of oven dry moisture content

Batch No.	Target Moisture Content %	Resistance meter (Percentage number of readings)	Wagner meter (Percentage number of readings)
A1	12	36	68
A2	12	65	60
A3	20	5	50
A4	20	0	50
A5	20	40	50
A6	15	85	45
A7	20	13	63
A8	12	45	40
A9	20	40	37
A10	20	24	24
A11	15	69	44
A12	20	19	21
A13	12	45	45

From Table 3:

AVERAGE % within 1percentage point of ODMC	37%	46%
No.of Batches with less than 50% within 1%	10	7
No.of Batches with less than 40% within 1%	6	3
No.of Batches with less than 30% within 1%	5	2
No.of Batches with less than 20% within 1%	4	0

Table 4 Mean error of meters (percentage points)

Batch No.	Target Moisture Content %	Resistance meter	Wagner meter
A1	12	1.1	0.4
A2	12	0.9	0.4
A3	20	2.2	0.3
A4	20	2.6	0.4
A5	20	1.1	0.7
A6	15	0.6	0.7
A7	20	2.0	0.4
A8	12	0.4	0.1
A9	20	0.7	0.6
A10	20	0.3	1.7
A11	15	0.5	0.2
A12	20	1.7	0.7
A13	12	0.4	0.4

From Table 4:

Mean error for all samples	1.1	0.5
Mean error for samples with a target MC of 20%	1.5	0.7