Do's and don'ts in respect to moisture measurement

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Abstract

As a manufacturer of moisture meters for wood and construction materials as well as wood strength measurement systems we are often confronted with several questions from the industry related to wood moisture content. Questions can seem to be easy, but answering them can turn out to be very complex. Although the questions generally relate to (kiln dried) wood, we often notice that it is also about the type of moisture meter which is used, or about drying quality, that customers have rejected the wood, or that sizes have changed over time. Also it is not always known which settings must be used for a certain wood species. Questions which probably are known or logical for scientists, but the industry has difficulties with it and therefore is also is confronted with problems.

1 Introduction

Firstly we can ask ourselves why we need to know the moisture content, what the moisture content should be and what the spreading of the moisture content is. Subsequently we can ask ourselves how the moisture content can be determined, how we know that the moisture content found is correct, which tolerances the moisture measurement has, how the different types of moisture measurement methods can be compared to each other, but also what the influence of the drying process is on the moisture measurement as well as the wood species.

2 Equilibrium moisture content

Wood is a hygroscopic material which yields moisture to its surroundings or absorbs moisture from its surroundings. If it yields moisture then the wood shrinks, if it absorbs moisture it will swell. It is a fact that the wood shall try to reach an equilibrium with its surroundings, whereby a small difference will be noticeable if the equilibrium moisture content gets lower with regard to when it gets higher. This difference is called hysteresis.

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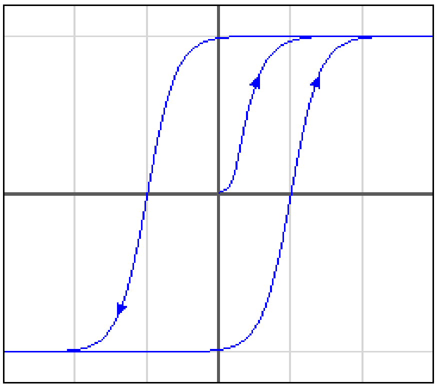

Figure 1: hysteresis

It becomes even more complex when the equilibrium moisture content from different areas taken over the course of one year are being compared with each other.

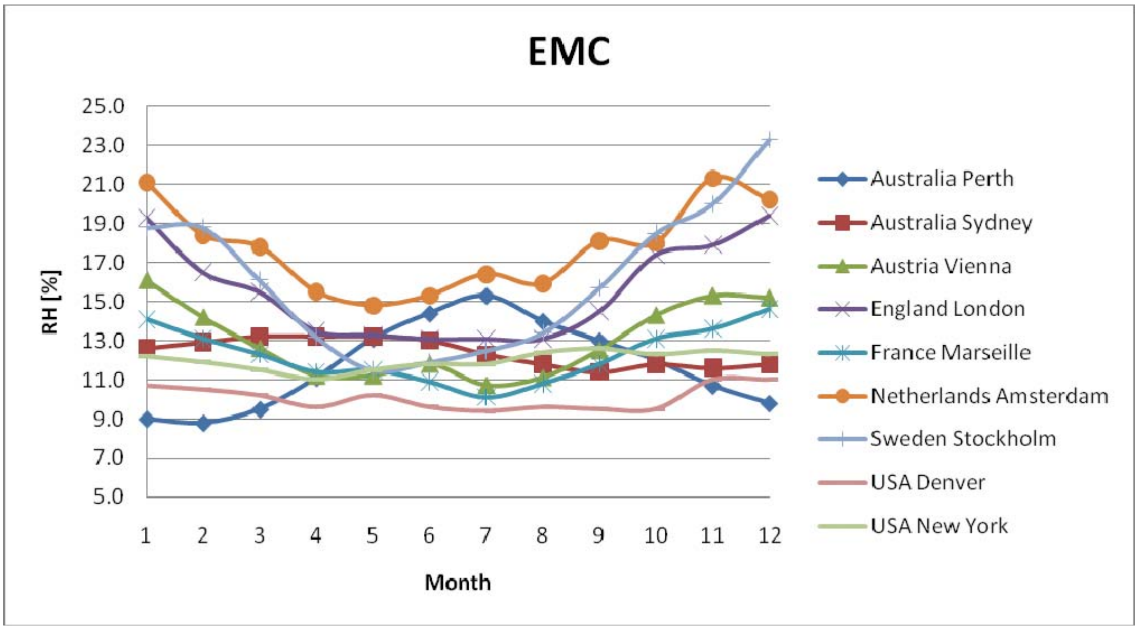

Figure 2: EMC exposed to outdoor atmosphere

Indoor applied wood shall also want to reach an equilibrium with its surroundings.

Table 1: EMC of wood species at different RH

Species	40% RH	60% RH	85% RH	90% RH	100% RH
Pine	9 – 10%	12 – 13%	15 – 18%	17 – 19%	30%
Fir	8 – 9%	11 – 13%	17 – 20%	20 – 22%	30%
Oak	9 – 10%	12 – 13%	17 – 20%	19 – 22%	32%
Meranti	8 – 9%	11 – 13%	17 – 20%	18 – 22%	29%

3 EN 13183 Moisture Content

In Europe the determination of the moisture content of sawn timber is recorded in the following standards.

EN 13183-1 Moisture content of a piece of sawn timber – Part 1: Determination by oven dry method

EN 13183-2 Moisture content of a piece of sawn timber – Part 2: Estimation by electrical resistance method

EN 13183-3 Moisture content of a piece of sawn timber – Part 3: Estimation by capacitance method

In praxis the moisture content is measured with different types of moisture meters and users consider their own moisture meter best. Problems related to moisture measurements can come up when the buyer measures with another moisture meter than the supplier, or when the moisture meter is compared with the oven dryer. Before the user doubts the device, the method or the result it is important to check if the measurement was performed in a correct manner and if it is possible at all to electrically measure that wood species.

4 Electrical moisture meters

Figure 3: Handheld moisture meters

The most commonly used handheld moisture meters are:

- Resistance type moisture meter

The electrical resistance is the property of a material to allow more or less electrical current getting through. From fibre saturation point to oven dried wood the resistance changes form 100 K Ohm to 100 G Ohm which is a range of over 6 orders of magnitude! Above the fibre saturation point the electrical condition properties are hardly influenced by the wood moisture content. The temperature as well as the chemicals of the wood has their influence on the electrical resistance. An accurate moisture meter therefore needs a setting for the wood species and the wood temperature. The actual moisture measurement is performed by electrodes which are placed in or on the wood. With so-called insulated pins measurements can take place at a certain depth.

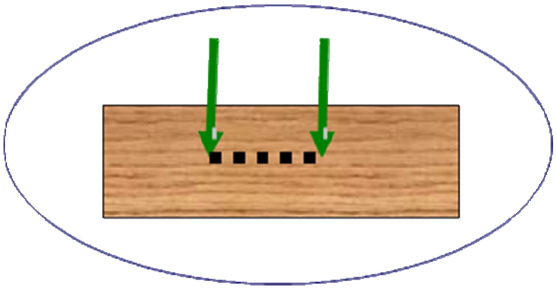

Figure 4: Insulated pins

- Capacitance moisture meters

Capacitance moisture meters measure the moisture content in wood by detecting changes in the electrical field generated by the instrument itself. The so-called dielectric constant of wood is different from that of water and the relation between those two is an indication for the moisture content. The dielectric constant value of wood is different per wood species and is largely determined by the density of the wood. With capacitance moisture meters it is in fact not possible to determine a moisture gradient. Furthermore the field is larger near the instrument than further away as a result of which measurements in depth are not possible. For most capacitance moisture meters the measurement surface must make a good contact with the surface of the wood, air gaps between measurement surface and the wood are not allowed.

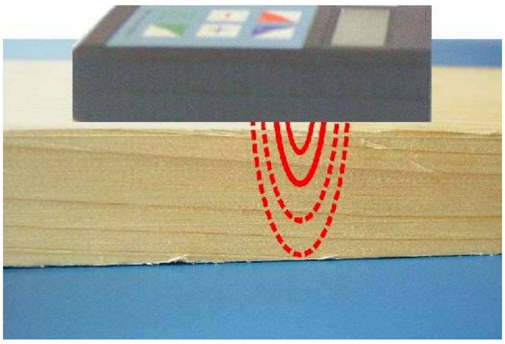

Figure 5: Electrical field

5 Accuracy

The accuracy of a moisture meter is determined by the electrical stability of the instrument, the wood species to be measured and the circumstances in which the measurement takes place.

- Resistance method

Although as a rule the resistance method is known as a very reliable electrical moisture measurement, there are still marginal comments. Research has proven that each wood species can be subdivided in accuracy classes so that beforehand it is known how many measurements are necessary for a specific mistake.

The following tables are examples of wood species, the qualification of electrical measurement and the number of measurements necessary to achieve a certain accuracy.

The qualification is determined by the so-called S-value. The S-value is the statistical value with which with a certainty of 95% the moisture measurement with an electrical resistance compares with the oven dry test.

Table 2: Qualification measuring accuracy

Class	**Qualification**	**Accuracy**
1	Well measurable	2S < 1.6%
2	Measurable	1.6% < 2S < 2.5%
3	Poorly measurable	2.5% < 2S < 3.5%
4	Not measurable	3.5% < 2S

Table 3: Qualification wood species

Class 1	**Class 2**	**Class 3**	**Class 4**
Oak	Beech	Abachi	Afzelia
Spruce	Maple	Alder	Poplar
Cherry wood	Merbau	Sapeli	
Pine	Meranti	Teak	

Table 4: Accuracy in relation to number of readings and classification

Class	**1**	**2**	**3**
	2S < 1.6%	1.6% < 2S < 2.5%	2.5% < 2S < 3.5%
Number of measurements	**Accuracy**		
3	+/- 0.92%		
6		+/- 1.02%	
9			+/- 1.1%
18	+/- 0.51%		
25		+/- 0.5%	
35			+/- 0.59%

- Capacitance method

For the capacitance measurement method the density of the wood is an important factor for the accuracy. As a rule it can be established that for each 50 kg/m³ difference in specific weight the measurement deviates about 1%. On the basis of the variations of the specific weight at a certain moisture content, a table can be made for this moisture measurement showing the expected accuracy.

Wood species	Average variation in density	Accuracy
Spruce	40 kg/m³	+/- 0.8%
Oak	60 kg/m³	+/- 1.2%
Meranti	100 kg/m³	+/- 2%

Table 5: Accuracy in relation with density

- Other errors

Much occurring mistakes with the resistance moisture measurements are the measurement depth (1/5 to 1/3 of the wood thickness), insulated or non-insulated measurement pins, temperature of the wood, moisture spreading in the wood, warming up by the sun shining on the wood.

Much occurring mistakes with the capacitance moisture measurements are measurements on wood with a rough surface, measurements on wood with a non-homogeneous moisture spreading, measurements near knots or fissures.

6 Inline moisture measurement

Inline moisture measurement is contact free moisture measurements in production lines. The biggest advantage of an inline moisture measurement is the certainty that every board is measured over the entire board length (L-type) or at more places (X-type). As a result the reliability is better with a factor 1.4 (=√2) compared to a single point measurement.

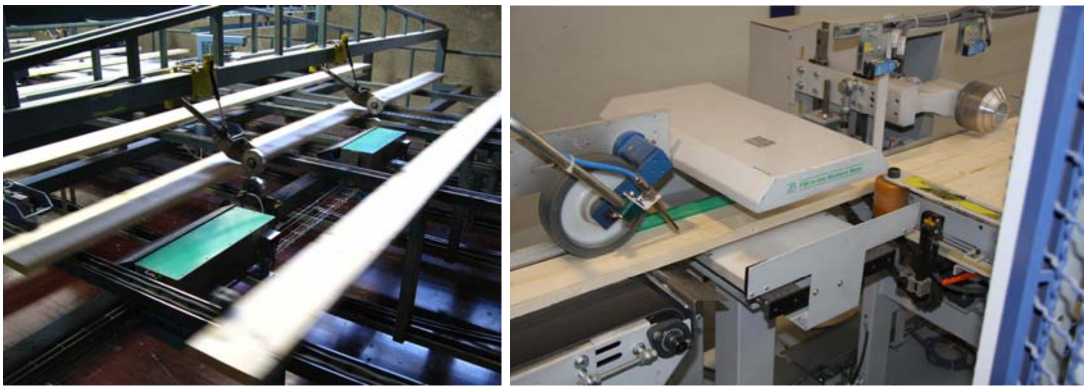

Figure 6: Inline moisture meters

7 Applications for inline moisture meters

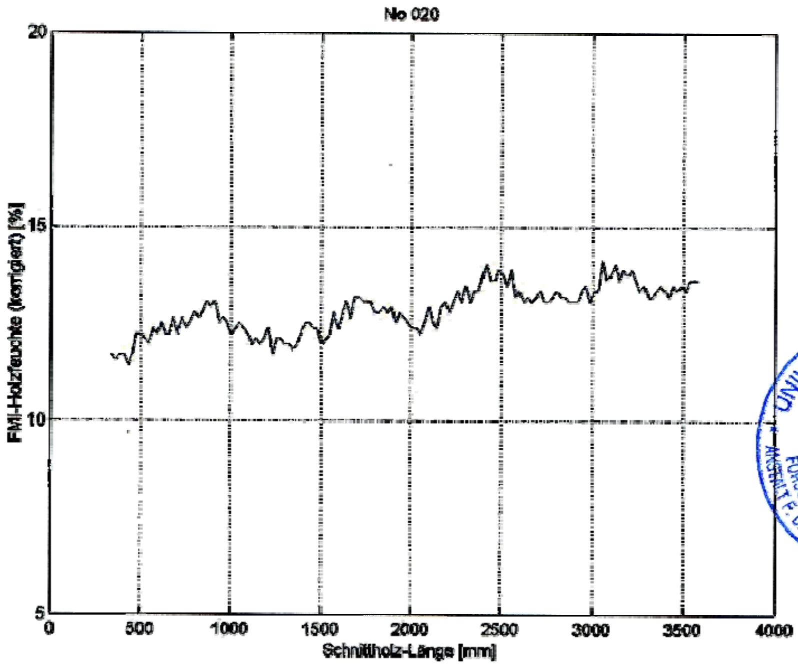

Figure 7: MC profile from 400 mm tot 3600 board length

With inline moisture meters the final target moisture content of the drying process scan be determined and, dependent of the accuracy of the applied inline moisture meter, the spreading of the moisture content in the drying process. Another application is sorting so that only wood with the correct moisture content is allowed further into the production process. Sorting can be resolved by type of product or by land of application.

8 Comparison between measuring methods and over dry method

The oven dry method is the reference method for determination of moisture content and both handheld as well as inline moisture meters are instruments which must equal the reference method as good as possible. Apart from the problems with the measurement instruments and methods as above mentioned there is still another kind of problem, being comparison of different measurement methods.

Say:

- Because of the balance applied the oven dryer has an accuracy of +/- 0.2%
- For measurement of certain wood species the resistance moisture meter has a deviation of +/- 1.2%
- For measurement of the same wood species the capacitance moisture meter also has a deviation of +/-1.2%

Now in order to enable comparison of the accuracy between two measurement devices, the so-called absolute faults must be added up. This will then result in the following maximum fault tolerances:

- oven dryer +/- 0.2% & resistance moisture meters +/- 1.2% → +/- 1.4%
- oven dryer +/- 0.2% & capacitance moisture meters +/- 1.2% → +/- 1.4%
- capacitance moisture meter +/- 1.2% & resistance moisture meter +/- 1.2% → +/- 2.4%

9 Summary

Wood moisture measurement is not difficult if the rules are well obeyed and generally better than what the wood needs when professional instruments are used.

References

William T. Simpson. (1998) "Equilibrium moisture content of wood in outdoor conditions in the United States and worldwide".

CEN (2002) "EN 13183-1 Moisture content of a piece of sawn timber – Part 1 Determination by oven dry method".

CEN (2002) "EN 13183-2 Moisture content of a piece of sawn timber – Part 2: Estimation by electrical resistance method".

CEN (2005) "EN 13183-3 Moisture content of a piece of sawn timber – Part 3: Estimation by capacitance method".