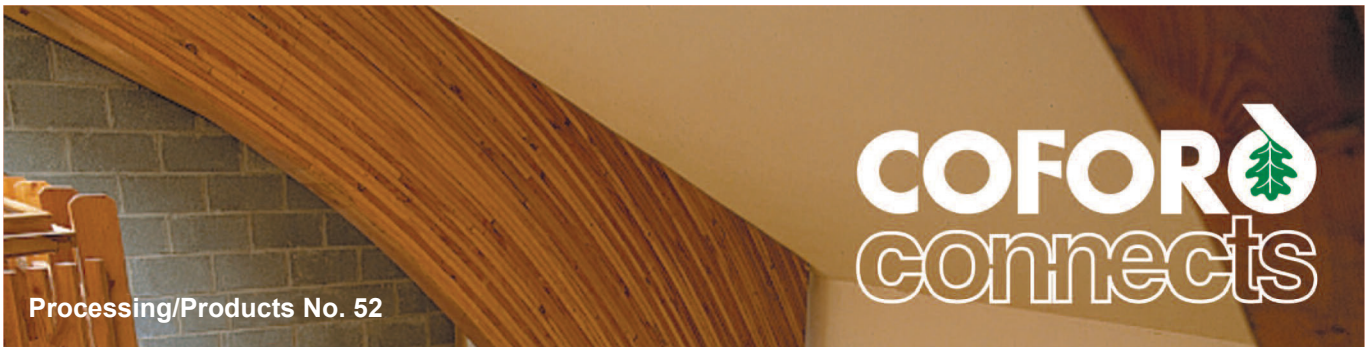

- ***Rapid moisture meters are an aid to see if firewood is ready for use.***
- ***Rapid moisture meters are not very accurate.***
- ***Rapid moisture meters only work below the fiber saturation point, i.e. below 28% moisture content on wet basis.***
- ***Most rapid moisture meters give a result based on dry basis, which is somewhat too high compared to wet basis.***
- ***The moisture content for trade must be measured with the drying cabinet method to ensure accuracy.***

Use of rapid moisture meters to estimate firewood moisture content

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Introduction

Firewood is a suitable woodfuel for domestic heating as long as it is sustainably sourced, and the moisture content of the wood does not exceed 20% (on a wet weight basis). Above 20%, the amount of fine dust and carbon monoxide in the flue gasses increases rapidly which can cause problems for air quality and consequently for human health.

Therefore, it is important to know that the firewood you plan to use is at or below 20% moisture. Measuring the moisture content according to international standards (as used for example by the Wood Fuel Quality Assurance scheme – WFQA) requires sampling and drying for at least 24 hours at a temperature of 105 ºC. The WFQA certifies that firewood bought with their certificate fulfils the requirements of the ISO standard on graded firewood (ISO 17225-5).

That is where rapid moisture meters can come into play. Provided the wood is not too wet to begin with, there are several ways to rapidly assess firewood moisture content:

- by measuring the electrical resistance of the wood
- di-electric measurement
- by infrared measurement.

The most common one for household use is the one where the electrical resistance is measured in the wood. The di-electric system only works on the surface of the wood and requires a smooth surface, which firewood does not have. The infrared measurement system is for industrial use only because it is too expensive for ordinary use.

A number of years ago, the University of Copenhagen did an evaluation of electric resistance measurement systems (Bergstedt 2010). The evaluation compared seven of the most commonly available instruments with each other. Even though this test was carried out some time ago, all the brands tested remain on the market.

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The advice in this COFORD Connects Note draws on the University of Copenhagen work.

Moisture content

The moisture content of firewood (and any other biofuel) is always expressed as a percentage of fresh or total weight. This total weight thus includes the water which is present at the start of the measurement.

Even so, the differences between the moisture content expressed on a wet basis and a dry basis only differ little in the low moisture content range where the firewood should be. In Table 1, one can see the difference between the two methods.

Table 1: Comparison of moisture content measured on a wet and dry weight basis

Wet basis	Dry basis
%	
5	5.3
6	6.4
7	7.5
8	8.7
9	9.9
10	11.1
11	12.4
12	13.6
13	14.9
14	16.3
15	17.6
16	19.0
17	20.5
18	22.0
19	23.5
20	25.0
21	26.6
22	28.2
23	29.9
24	31.6
25	33.3

Cost

These instruments are available in a wide price range from less than €15 to €500.

Measurement principle

With electrical resistance measurement tools, resistance is measured between two electrodes (prongs) inserted into the wood (see Figure 1).

Figure 1: Example of a rapid moisture meter with electrodes (prongs)

Electrical resistance is caused by the amount of moisture in the wood – the more moisture the higher the flow of electricity between the electrodes (water being an excellent conductor of electricity) and the lower the resistance. As moisture content drops, resistance increases (wood is a good insulator itself and hence has low electrical conductance). As a result of these factors, below 5% moisture content no reasonable measurement can be carried out using a moisture meter. While above 25%, the electrical resistance is so low that the meters do not work and will give erroneous results.

Once the moisture content of the wood exceeds approximately 28%, the so-called fibre saturation point, the wood has free water within and between the cells and this results in negligible resistance to electricity flow.

Practical measurement

It is necessary to fully insert the prongs into the wood, because often wood has a different moisture content on or near the surface, compared with some millimetres below the surface. It is also a necessity to split the piece of firewood and take the measurement from the freshly exposed surface. Moisture content varies between firewood pieces, so at least 5 pieces should be tested to get an accurate picture of the average moisture content of a batch of firewood.

The prongs should be inserted across the fibres and not along them – in other words across the grain as shown in Figure 1. Conductivity is greater across rather than along the fibres. Most manuals do recommend measurement across the fibres and that the equipment has been calibrated to do so. But always check the manual before deciding in which direction to insert the electrodes.

In practice, the qualifying value for quality firewood is normally set at 20% or below. If any one of the test pieces exceeds 20% the batch is not ready to burn and requires further seasoning.

Factors that can influence measurement accuracy

Apart from moisture content, there are a number of other factors that can influence the accuracy of moisture content measurement using a moisture meter:

- tree species
- basic density of the wood
- temperature of the wood at measurement
- physical state of the wood, and
- how the electrodes are placed into the sample pieces.

Electrical conductivity varies to some extent based on the wood anatomy of different tree species. Research in Denmark has shown that nearly all hardwoods and spruce have a slightly lower conductivity than other species, of the order of 1-2%. For most practical purposes, however, this variation is not of concern.

Basic density, which also varies among species, is another factor influencing the accuracy of measurement - the denser the wood the lower the conductivity. But differences in basic density arise not just between tree species, but also within the same species. For example, slowly growing wood will have a lower conductivity than fast grown wood.

With regard to wood temperature during sampling, every 10°C plus or minus room temperature (say 20°C) will result in about a 1% difference from the "true" moisture content. If the wood is frozen, no reliable measurement can be carried out.

If the physical state of the wood has been degraded as a result of fungal decay, even to a minor degree, then conductivity will increase rapidly. The moisture meter will thus show too high a moisture content. The same holds true if the wood has been impregnated with preservative or has been in contact with salt. Needless to say, in neither case should the wood ever be used as a fuel.

Placement of the electrodes also has an influence on the accuracy of the measurement, as has been pointed out. Placement is especially important when the wood is close to the borderline whether it is ready or not to burn. Here incorrect placement parallel to the grain can mean up to 2% too high a moisture content.

Also, and importantly, carefully check the surface of the firewood piece once split and before any measurements are taken. This is to avoid placing the electrodes in or near knots or resin pockets (the latter especially in conifers) - features that are not always immediately visible on freshly exposed wood surfaces. Finally, always remember to measure on a surface that has just been exposed by splitting the firewood.

Moisture meter accuracy

Here we come to the weakest point of moisture meters. As we have seen, there are many factors that influence their accuracy.

The Danish tests showed that none of the instruments was fully accurate, at best the true moisture content based on the oven-dry method (as used for quality schemes etc) differed from the rapid moisture meters by at least 2%. This level of difference was obtained in the range where the moisture meters work best: between 10 and 20%. If the moisture content was higher or lower than the aforementioned range, the accuracy was less.

The price of the moisture meter also had an influence on accuracy: the cheapest units had the lowest accuracy and sometimes the reading differed by as much as 5% from the true value.

Despite these findings, the conclusion is that rapid moisture meters have a use as a way to check if firewood is ready to burn (or ready for full testing in quality assurance scheme) or not: in general, this will mean that each of the moisture content values of the 5 samples is at or below 20% moisture content and that none of the samples are above 20%.

It is important to point out that moisture meters are not an acceptable way to document the moisture content of firewood at the moment of sale: in those cases, the oven test method alone is suitable.

Wet and dry weight – knowing what is being measured

Most moisture meters have been developed for use in the timber industry, where measured moisture content is expressed on a dry weight basis. These units will display a higher value than those calibrated on a wet weight basis (for use with firewood). Make sure to check the meter manual to confirm which way the moisture content is expressed.

Some of the more expensive meters can be calibrated for either wet or dry weight moisture content. Some can even be calibrated according to which tree species is being measured. Again, the manual will tell you about these possibilities.
These units are not suitable to measure the moisture content of wood chips nor of wood pellets, since the particles are too small for that.

A simple way to get an indication of moisture content

There is a simple way to check if firewood is ready for burning or not without the use of any equipment:
Bang two pieces of firewood together:

- if the sound is crisp, then most likely the firewood is dry
- if the sound is dull, then it is almost certain that the firewood is too wet

Avoid getting your fingers between the logs: it hurts.

Reference

Bergstedt, A. 2010. Afprøvning af fugtmålere til brænde (Test of moisture meters for firewood). Københavns Universitet, Center for Skov & Landskab. Danish report with English summary.

ISO 17225 part 5 — Solid biofuels — Fuel specifications and classes — Part 5: Graded firewood (available from NSAI, Dublin)

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