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TECHNICAL DATA SHEET
ISSUED BY TIMBER QUEENSLAND

MEASURING THE MOISTURE CONTENT OF TIMBER

27

RECOMMENDED PRACTICE // MARCH 2014

Checking the moisture content of timber prior to installation is important for many applications, including flooring, decking and lining, and to ensure that subsequent movement (shrinkage and swelling) remains within accepted bounds. This data sheet provides information on moisture in timber and outlines the various methods used to test the moisture content of timber. Also included in the data sheet is a method to evaluate the moisture content compliance of packs of timber.

MOISTURE CONTENT MEASUREMENT

Moisture content

Moisture content is simply the mass of moisture present in wood divided by the mass of the wood with no moisture in it, expressed as a percentage. What's important about the moisture content in timber is that the board width will increase with increasing moisture content, and will decrease with decreasing moisture content. At the time of machining, cover width variations are usually minimal and subsequent variations that occur in board widths are usually due to changes in moisture content. It is often the current and future variations in board width that is of primary importance and the purpose of moisture content testing is to indicate what future movement can be expected.

By simply looking at the end of a pack of timber, that may be a month or so old, it is often possible to obtain information about the moisture content of the timber within the pack even without using a moisture meter.

For example in a three month old pack of flooring, some moisture changes are likely to have occurred. If the nominal cover width was 80 mm and:-

- board widths measure between say 79.6 mm and 80.4 mm then the material is likely to have been dried to within narrow moisture content bounds and should perform well in service.
- board widths range from say 78 mm to 81 mm with some boards cupped, this is indicative of material that is likely to havebeen dried to quite wide moisture content bounds and the floor is likely to show some wide gaps at board edges along the length of the board and near end matched joints.
- board widths range from say 80 mm to 82 mm, then some of the material may have become wet after manufacture.

It is therefore important when considering moisture content to also take the board widths into consideration.

Australian Standards that cover the moisture content of seasoned products vary in their limits as this depends on the species and application. Table 1 provides some information on species, associated products and the moisture content tolerances set out in the applicable standard. The number of the standard is also provided.

METHODS OF MEASURING THE MOISTURE CONTENT OF TIMBER

How moisture content is measured

Moisture content is generally measured by either a meter or through oven dry testing. The two common types of meters in use are the resistance meter and the capacitance meter. Meters use changes in electrical properties caused by the wood to provide an estimate of the moisture content. Oven dry testing requires a set of scales and an oven from which the moisture content is determined from the change of mass as the sample dries.

Measurements by different methods

In any piece of seasoned timber the moisture content is likely to vary to some extent down the length of the piece and from the outer surfaces (case) to the center (core). With regard to case to core differences some methods of measurement are able to measure this while others can only measure the average moisture content of the board. This can be an important consideration when choosing a measuring method as case to core variations or the difference between upper and lower case may need to be determined. At other times it may be important to gain many measurements quickly in order to gain an appreciation of the average moisture content. In cases of dispute, accuracy may be of prime importance.

Resistance meters measure the highest moisture across the exposed ends of the pins where as capacitance meters measure an average through the piece. Oven dry testing measures the average moisture content of the sample placed in the oven but by cutting the sample up into applicable smaller pieces, case and core moisture contents can also be determined.

The three common methods of measurement, including their application, benefits, limitations and accuracy are outlined as follows.

TABLE 1 - SPECIES, PRODUCTS, MOISTURE CONTENT & APPLICABLE STANDARDS

Species Group	Seasoned Product	Moisture Content Bounds (moisture content anywhere within a board)	Number of the applicable standard
Hardwood	Flooring, lining, dressed boards	9% -14%	AS 2796
	Decking	10% to 18% *	AS 2796
	Framing	- 90% of pieces less than 15% - all pieces less than 18%	AS 2082
Softwood	Flooring, lining, dressed boards	9% -14%	AS 4785
	Decking	10% to 18%	AS 4785
	Framing	- 90% of pieces less than 15% - all pieces less than 18%	AS 2082
Cypress	Flooring, decking	10% to 15%	AS 1810

** TQ recommends a maximum moisture content of 15%.*

OVEN DRY METHOD

When is it used

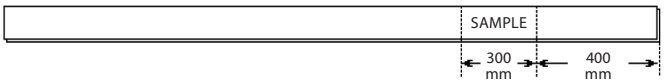
- Oven dry testing is often carried out where variations in moisture content in the final product can have a significant effect on the performance of the product.
- In case of disputes Australian Standards generally refer to this method as it provides measurements that are more accurate and reliable.
- Manufacturers of board products often undertake oven dry testing as a check in the manufacture of their products.
- Organisations such as TQ also have the appropriate testing equipment and contract out these services.

Testing equipment and facilities

- The equipment required is an accurate balance or set of scales and a laboratory oven that is able to maintain a temperature of 103°C ± 2°C.

Sampling from a pack

- The samples need to be representative of the timber in the pack being tested and capture the variation present. This may therefore include some outside boards as well as some from within the pack.
- If cupping is present or there is variation in the cover width by more than 1 mm, samples should be provided which include 2 boards that are cupped, 2 with wider cover widths and 2 with narrower cover widths. *(Packing pieces are not to be provided as samples).*
- If boards are not cupped and there is little variation in cover width throughout the pack, 5 boards should be chosen. *(Packing pieces are not to be provided as samples).*
- The samples from which test pieces will be cut should be taken not less than 400 mm from the end of a board and should be approximately 300 mm long.



(Note: If the sample is from a board on the top, bottom or edge of the pack, it should be marked as being an outside board.)

Testing Procedure

- The samples should be individually wrapped in "glad wrap" or similar to reduce moisture content changes during transport.
- The samples should be stored in a cool place and delivered to the testing facility within 24 hours.
- From the 300 mm long pack samples, test pieces are cut with a length between 15 mm and 30mm so that the required mass is achieved to suit the accuracy of the mass measuring equipment. If the equipment measures to 0.1g then a test sample of at least 50gm is required. The sample may be less that 50g if the equipment measures to 0.01g.
- The initial masses of the test pieces (and usually the cover widths) are recorded. The test pieces are placed in the oven for at least 24 hours and then reassessed at four hour intervals until there is minimal change in mass. For longer samples in denser species, times of 48 hours or so may be required. The mass after drying in the oven (i.e. oven dry weight) is recorded.
- The moisture content is then calculated for each test piece by applying the following equation.

  Moisture content (%) = ((Initial mass – oven dry mass)/ oven dry mass) x 100 %

  For example if the initial mass is 57.6 g and the oven dry mass is 43.3 g then the moisture content is:-
  Moisture content (%) = ((57.6 g – 49.3 g)/ 49.3 g) x 100 % = 16.8%
- This method provides the average moisture content for the test pieces. Case and core measurements can be obtained by cutting the appropriate sections out of larger test pieces.

Interpreting results

- The sampling method outlined above aims to capture the variation present in a pack of timber and from this it can be assumed that most of the timber within the pack will fall within the upper and lower moisture content measurements.
- In applications where cover width is important, both the cover width and the moisture content should be considered. Often boards of lower cover width are also those of higher moisture content and further shrinkage of this material can be expected.

Benefits and limitations

- The main advantage of this method is its accuracy.
- The method is time consuming, not portable and more expensive.
- The most common error results from insufficient drying, which underestimates the moisture content. If sample masses are small then measuring errors can significantly affect the moisture content calculation.

- Microwave ovens can produce good results and speed up testing, however there are no formal procedures and there is the risk of evaporating volatile compounds in addition to the water which affects accuracy.

RESISTANCE METER

Principal of operation

The electrical resistance of timber reduces as the moisture in timber increases. These meters measure the flow of electricity between two pins where the timber acts as an electrical resistor between the pins. The scale on the moisture meter is graduated to read moisture content. Wood temperature affects the readings and for this reason wood temperature above or below 20°C, requires correction to the reading. Temperature correction, if not already taken care of by the meter, is applied before species correction. Species correction is necessary as two different timber species at the same moisture content may not have the same electrical resistance.

Meters are generally set up relative to one species and that is Douglas Fir (Oregon) and species corrections are then applied for other species. There comes a point where the moisture in timber is so low that the resistance is difficult to measure accurately or on the other hand sufficiently high that the resistance does not change greatly and is prone to greater errors. These meters generally provide reliable results between 6% and 25 % moisture content.

Types of meters

A wide variety of meters are available. All have two pins that are used to penetrate the timber but the pins may vary in length from approximately 6 mm up to 50 mm. The longer pins are often insulated up to the pointed ends to prevent surface moisture effects from interfering with core measurements. Those with longer pins are also usually of the 'sliding hammer' type, which provides a means of driving the pins into the timber. The sophistication of the meters varies greatly in terms of features such as inbuilt temperature correction, preprogrammed species calibration and depth indication. Many of the meters now come with a calibration box.

Using resistance meters

- The calibration of the meter should be checked prior to use and this is usually done with a test calibration box that contains electrical resistors that correspond to the moisture contents specified on the test equipment.
- Measurements are then taken in clear timber at least 400 mm from the ends of boards.
- Some meters require measurements to be taken with the pins running down the length of the board while with others the pins are to run across the width of the board (check with the manufacturer's manual).
- The pins are driven to the desired depth to which the moisture content reading is required. As case and core measurements can be significantly different, use of meters with short pins may require boards to be cut and the pins inserted in the end grain to provide a better estimate. In high density timbers, holes may need to be drilled for the pins.
- The pins need to be in firm contact with the timber, otherwise low readings may occur.
- Readings should be recorded to the nearest 0.5% and read shortly after penetration.
- Each reading is to be corrected for wood temperature first (provided this is not done automatically) and then for species (providing the species has not been set on the meter).
- Refer to Table 2 for temperature correction factors and Table 3 for species correction factors for some common commercial species. Additional species correction factors are available in AS 1080.1 and FWPRDC Report PN01.1306.

Limitations, accuracy and precautions when using resistance moisture meters

When using meters a common sense approach is necessary and each reading should be evaluated and if not as expected, then the reasons for this should be investigated. The meters generally provide a reasonable estimate of the moisture content to ± 2% in the measuring range from 8% to 25% and as stated above readings should be recorded to the nearest 0.5%. There are a number of factors that require consideration when using these meters:-

- Measurement necessitates damaging the surface of the timber.
- The method is conducive to only taking a relatively small number of sample readings.
- Readings near the board surface can be significantly different from the core.
- Low battery can cause low readings in high moisture content material.
- Uncertainty over the species can make species corrections difficult.
- Species such as Brush Box have very high species correction factors and are prone to greater error.
- Use for extended periods in high humidity environments can raise meter readings.
- Meters only read the wettest part that the exposed surfaces of the pins are in contact with.
- Surface moisture can provide artificially high readings not reflecting wood moisture content.
- Salt water or any preservative treatment salts can affect meter readings and will usually raise them.
- Electrical wiring in walls can affect the readings.

If meter readings are not in line with what is expected, then this may necessitate oven dry testing to more accurately estimate the moisture content.

CAPACITANCE METER

Principal of operation

These meters measure an electrical property called the 'dielectric constant' and in so doing an electric field produced by the meter, and the presence of the timber on which the meter is positioned, form a 'capacitor' type of arrangement. The electric field can penetrate deep into the timber but meter readings are biased toward moisture in the surface layers. Both the moisture content and the density of the timber affect this electrical property. The effective range of capacitance meters is from approximately 0% to 30% moisture content. The more sophisticated meters can be adjusted for timbers of different densities. Less expensive meters do not have density compensation and for these meters corrections to meter readings must be applied based on the density of the species being tested. Such meters are usually preset to be more suited to softwoods and lower density hardwoods and this can cause limitations with higher density species (i.e. large correction factors are necessary).

Types of meters

Meters are imported from overseas and range from those with few features to those with a wider range. Features may include settings for timber density (or specific gravity) and timber thickness as well as the ability to store readings and apply some statistics to the results. It is necessary to ensure that the meter is going to meet your specific needs and if being used with higher density hardwoods, timber density (or specific gravity) adjustment must be seriously considered.

Using capacitance meters

- The appropriate meter settings for density and board thickness etc. should be applied and the meter checked for calibration.
- The density (or specific gravity) is often calculated differently for different reasons (i.e. green density, density at 12% moisture content or basic density). Specific gravity is the density of a material divided by the density of water (approximately 1000kg/m^3). It is necessary to obtain from the meter supplier the relevant figures applicable to the meter being used. Table 3 provides densities at 12 % moisture content.
- Measurements are then taken in clear timber away from knots etc.
- Some meters require measurements to be taken with the meter in a particular orientation on the board (check with the manufacturer's manual).
- The plate of the meter must be in firm contact with the board before a reading is taken.
- Readings should be recorded to the nearest 0.5%. If no density (specific gravity) settings are available, then these meter readings, need correcting.

Limitations, accuracy and precautions when using capacitance moisture meters

Similar to resistance meters, common sense must prevail when using these meters with readings evaluated and investigated if not as expected. Providing the density is accurately assessed then these meters also provide a reasonable estimate of the average moisture content in a board up to approximately 25% moisture content. Again there are a number of aspects that need to be considered when using these meters:-

- Readings can be taken very quickly both within a board or in a number of boards.
- The meters do not damage the surface of the timber that is being measured.
- Within species density variations can be quite high, particularly between mature and young growth material. This can result in significant variation in meter readings.
- Estimating the correct density adjustment can be difficult, particularly if the meter is being used on a wide range of different timbers.
- Density (specific gravity) information for Australian species relating to specific meters is not well documented.
- Difficulties with setting density (specific gravity) adjustment often reduces field measurement accuracy.
- If no timber thickness adjustment is provided then thicker pieces at the same moisture content are likely to read high.
- Any gap between the meter and the board (e.g. a cupped surface) will cause lower readings.
- Framing raises meter readings where exposed timbers cross (e.g. softwood floor over hardwood joists).
- The presence of salts (either from salt water or preservation treatment) will cause readings to be higher.
- Readings are also considered to be less reliable with Brush Box

Again, if meter readings are not in line with what is expected, then this may necessitate oven dry testing to more accurately estimate the moisture content.

MEASURING THE MOISTURE CONTENT OF PLYWOOD AND PARTICLEBOARD

Meters do not provide an accurate and reliable measure of moisture content in these materials. To determine the moisture content of these material the oven dry method should be used.

ASSESSING TIMBER MOISTURE CONTENT FOR CONFORMITY

Australian Standard 1080.1 – Timber – Methods of Test – Method 1: Moisture content - outlines a procedure for moisture content acceptance testing of timber using a resistance moisture meter. For full details the Standard should be referred to. Provided below is a summary of the procedure:-

- Sample at least 1 pack out of every 10, or 1 pack out of every 5 for higher value products (e.g. flooring).
- For each pack assessed (of up to 200 boards per pack) 15 boards are randomly selected and tested.
- The pack is deemed to comply if not more than one test result (after applying temperature and species correction factors) is outside the allowable range. This presumes the result outside the allowable limits is not too different from other results.
- This sampling procedure is based on at least 90% of the samples occurring within the allowable range.

REFERENCES

STANDARDS AUSTRALIA
AS 1080.1 – Timber – Methods of Test – Method 1: Moisture content
AS 4787 – Timber – Assessment of drying quality
FWPRDC Project Report PN01.1306 - The use of hand-held electrical moisture meters with commercially important Australian hardwoods.

For correction factors, refer to Tables 2 and 3 on next page.

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TABLE 2 - TEMPERATURE CORRECTION FACTORS FOR RESISTANCE MOISTURE METERS

(Note that this is wood temperature not air temperature)

Meter reading %	8 %	10%	12%	14%	16%	18%	20%	22%	24%
Wood Temperature	**Temperature correction to be added to or subtracted from meter reading before applying the species correction factor**								
15 °C	Nil	Nil	+1	+1	+1	+1	+2	-	-
20 °C	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	-
25 °C	-1	-1	-1	-1	-1	-1	-1	-1	-
30 °C	-1	-1	-1	-2	-2	-2	-2	-2	-2

TABLE 3 - SPECIES CORRECTION FACTORS FOR RESISTANCE MOISTURE METERS

(Note that this only contains some common species – refer to AS 1080.1 and FWPRDC report PN01.1306 for a more complete list. The tabled figures are based on the Deltron Moisture Meter. Figures may differ for other meters - refer FWPRDC report PN01.1306).

Meter reading %	8 %	10%	12%	14%	16%	18%	20%	22%	24%	Density
Species	**Resistance meters are generally calibrated to Oregon (Douglas Fir), therefore other species require readings to be corrected after applying the temperature correction factor**									**@12% MC**
Oregon (Douglas Fir)	0	0	0	0	0	0	0	0	0	550
Australian Hardwoods										
Yellow Stringybark (NSW)	+4	+4	+3	+3	+2	+2	+1	+1	0	900
Red Ironbark Broad Leaved & Red (mainly NSW)	+4	+3	+3	+3	+2	+2	+2	+1	+1	1100
Grey Ironbark (Qld)	+3	+2	+2	+2	+2	+2	+2	+2	+1	1105
Forest Red Gum - Blue Gum (Qld)	+3	+2	+2	+2	+2	+1	+1	+1	0	1000
White Mahogany – Honey Mahog. (Qld)	+2	+2	+2	+2	+2	+2	+2	+2	+2	1000
Rose Gum - Flooded Gum (Qld & NSW)	+2	+2	+2	+1	+1	0	0	0	0	750
Sydney Blue Gum (NSW)	+2	+2	+1	+1	0	0	-1	-1	-1	850
Blackbutt (Qld & NSW)	+1	+1	+1	+1	+1	+1	+1	+1	+1	900
Turpentine (Qld & NSW)	+1	+1	+1	+1	+1	+1	+1	+1	0	950
Blackbutt (NSW regrowth)	+1	+1	+1	+1	+1	0	0	0	0	900
Grey Ironbark (NSW)	+1	+1	+1	+1	0	0	0	0	0	1100
Red Ironbark Narrow Leaved (mainly Qld)	+1	+1	+1	0	0	0	0	0	0	1090
Spotted Gum (Qld Citridora)	+1	0	-1	-1	-2	-3	-3	-4	-5	1100
Jarrah (WA regrowth)	0	0	+1	+1	+1	+1	+1	+1	+1	780
Grey Gum (Qld & NSW)	0	0	0	0	0	0	0	0	0	1050
Tallowwood (Qld & NSW)	0	0	0	0	0	0	0	0	0	1000
Messmate (Vic & Tas regrowth)	0	0	0	0	-1	-1	-1	-1	-2	750
Alpine Ash (Vic & Tas regrowth)	0	0	0	0	0	0	-1	-1	-1	650
Mountain Ash (Vic & Tas regrowth)	0	0	0	0	0	0	-1	-1	-1	650
Spotted Gum (NSW Regrowth *Maculata*)	0	-1	-1	-2	-3	-4	-5	-5	-6	1100
Manna Gum - Satin Ash (NSW)	-1	-1	-1	-1	-2	-2	-2	-2	-3	800
Imported Hardwoods										
European Beech	+3	+3	+3	No data	No data	No data	No data	No data	No data	
Kwila Merbau (Malaysia)	+2	+2	+2	+2	+1	+1	+1	+1	+1	850
Yellow Balau (Malaysia)	0	0	-1	-2	-2	-2	-2	-2	No data	900
New Guinea Rosewood (PNG)	0	-1	-2	-2	-3	-3	-4	-5	-5	
Sugar Maple (Nth America)	-1	0	+1	+1	+1	+1	+1	+1	No data	
Softwoods										
Araucaria - Hoop Pine (Qld & NSW)	+3	+2	+2	+2	+1	+1	+1	0	0	550
Radiata Pine (Vic)	+2	+2	+2	+2	+2	+2	+2	+2	+2	550
Cypress (Qld & NSW)	+2	+1	+1	+1	+1	+1	+1	0	0	700
Slash Pine (Qld)	+1	+1	+1	+1	+1	0	0	0	0	650

Notes:

· No correction factors are published for Gympie Messmate, New England Blackbutt, Silvertop Stringybark or Northern Box. Oven dry testing is the preferred method for Brush box.

· The names Keruing, Meranti and Taun refer either to a group of species or the material is from different sources with different correction factors. Refer to AS 1080.1.