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INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY

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"Moisture Meters for Cereal Grain and Oilseeds"

OIML TC17/SC1 Secretariat: China

Participating Nations:

Australia, Austria, China, Cuba, Czech Republic, France,

Germany, Japan, Netherlands, Poland, ,

Russia, United Kingdom, United States of America, Yugoslavia

Observing Nations:

Bulgaria, Egypt, Finland, Hungary, Indonesia, Ireland,

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Foreword

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1. Scope

1.1 This Recommendation specifies the metrological and technical requirements, test methods and maximum permissible errors for metrological control of grain moisture meters used in commercial transactions of cereal grains and oilseeds.

1.2 This Recommendation is primarily written to apply to fully automated digitally indicating grain moisture meters. Instruments that apply conversion factors, look up tables and/or external sample weighing may qualify if permitted by the national responsible bodies and if they perform to the Recommendation's requirements. Suggested additional requirements for security of indirect indicating instruments are contained in Annex A.

1.3 This Recommendation applies to moisture measuring instruments that estimate moisture based on indirect physical means (e.g. electrical or optical sensing). Drying methods or any other direct moisture measurement technology are not specifically covered, but may qualify if they perform to the requirements of the Recommendation.

1.4 This Recommendation applies to grain moisture meters that measure the moisture content of fixed representative-size grain sample and does not apply to devices used for in-motion measurement of grain or seed moisture content.

1.5 This Recommendation specifies instrument performance specifications and is not meant to preclude the application of new technologies to grain moisture measurement.

2. Application

2.1 Moisture content is one of the most critical grain quality measurements because of the direct economic significance of the fraction of the total product weight that is water and because moisture content largely determines the rates at which the grain will degrade during handling and storage. Grain is bought and sold on the basis of weight. Accurate moisture determinations serve as the basis for appropriate price adjustments.

2.2 If the moisture content is above the level that ensures safe storage, the grain must be dried to a suitable level. The energy and handling costs associated with drying grain and the reduction in weight of the grain during drying result in substantially reduced prices for high moisture grain. Concomitantly, overly dry grain is discounted from its weight basis and this dockage is partially justified by the increased susceptibility to breakage during handling for drier grain. The direct discounts assessed for moist grain and the indirect penalty (giving away dry matter) for dry grain are powerful inducements to deliver grain with a moisture content that is very close to the established safe storage level. Because of its significance, moisture content is determined virtually every time grain is bought and sold.

2.3 An air oven method is the most common rapid reference method for grain moisture determinations. National air oven methods vary widely in procedures and results, but all are based on heating a known mass sample for a prescribed period of time (or until the sample no longer loses mass) at a prescribed temperature and measuring the loss of mass. The amount of mass lost is assumed to be the amount of water that was present in the sample. Unfortunately, water is not the only constituent that is driven off by heating. In the "ideal" oven method, the heating times and temperatures would be set so that the amount of nonaqueous material driven off is approximately equal to the amount of water that remains after drying. Those parameters are determined by comparing the air oven method to other more basic (and more difficult) methods such as the phosphorous pentoxide (P_2O_5) method or the Karl Fischer method. Most air oven methods require hours or days to complete. Clearly, grain producers, handlers, and processors need rapid methods to assess moisture content.

2.4 Many technologies have been applied to rapid grain moisture measurement. Rapid indirect methods measure some physical parameter (such as electrical or optical sensing) and predict moisture content using calibration equations or charts. These calibrations can change due to changes in crop varieties planted and seasonal variation in climatic conditions. Invariably, other sample constituents or sample geometry interfere with the signal caused by water. Temperature usually affects both the water signal and the

interfering signals. Therefore, calibration equations attempt to achieve a best fit between the measured parameters and the moisture content as defined by an accepted moisture reference method. Accurate grain moisture measurements depend upon successfully overcoming the effects of interfering factors, such as density, temperature, chemical composition, and impurities.

3. Terminology

3.1 Moisture content and moisture and volatile matter content. The moisture and volatile matter content of a sample of cereal grains or oilseeds (both called moisture content in this Recommendation) is conventionally defined as the amount of mass lost by a sample expressed as a percentage of the original mass, as determined using the reference method defined by the national body.

3.2 The maximum permissible errors (MPE_S).This error covers the sum of maximum value for errors, which could appear on a single measurement, when using the instrument within a defined range of use, irrespective of the point in this range. (adopted from OIML D3 “Legal qualification of measuring instruments.”) The MPES in Section 5.3.1. are errors associated with a meter in use in the market place. The errors for the OIML test procedures are based on Section 5.8.1.

3.2.1 Significant fault

A fault the magnitude of which is greater than the magnitude of the maximum permissible errors in 5.3.1.

NOTE: The following faults are considered not to be significant.

a) Faults implying the impossibility to perform any measurement;

b)Transitory faults being momentary variations in the indication, which cannot be interpreted, recorded or transmitted as a measurement result; and

c) Faults giving rise to variations in the measurement results that are so large as to be noticed by all users of the instruments.

3.3 Kind, variety and type

Kind means the difference of seeds, i.e. corn, rice, soybeans and wheat etc. Variety means the differences within the same kind of seed. Type means differences within processing, e.g. brown rice, paddy or polished rice.

4. Units of Measurement (Moisture content)

The moisture content of a grain or oil seed sample is expressed as the percentage mass loss of the sample as determined using a reference method. Expressed mathematically:

$$MC = \frac{m_0 - m_1}{m_0} \times 100 \ \%$$

where m_0 is the original mass of the sample and m_1 is the final mass of the sample.

5. Metrological requirements

5.1 Reference conditions

During type evaluation, reference environmental conditions for the moisture meter and grain samples shall be as follows:

- ambient temperature of 22 °C ± 5 °C and
- relative humidity (RH) from 30 % to 70 %.

5.2 Reference method for grain moisture content is the method defined by the national responsible bodies.

5.3 Maximum permissible errors (MPE_S)

5.3.1 The maximum permissible errors for grain moisture meters as a function of grain index and moisture content: The maximum value for a given 2 % moisture interval shall be used for all requirements. For consistency of application in the OIML certificate system, it is recommended that each 2 % moisture intervals should begin and end with an even number.

Basis for determining MPE_S		
Index	Type of grain or seed	MPE_S in percent moisture content (M)
I	Maize, rice, sorghum, sunflower	If 0.05 x M < 0.8 then MPE_S= 0.8; else MPE_S = 0.05 x M
II	All other cereal grains and oilseeds	If 0.04 x M < 0.7 then MPE_S= 0.7; else MPE_S = 0.04 x M

5.4 Specification of grain or oilseed moisture samples used in type evaluation testing:

- naturally occurring grain or seed moisture levels, no moisture conditioning permitted, sample sets should be as homogeneous in moisture as possible
- test sample shall not be spoiled or show evidence of fermentation, and it shall not have impurities, broken, germinated or heated grains or seeds.
- Test sample shall not have been frozen prior to test.
- methods for screening and selection of grain and oilseeds are specified in Annex B.

5.5 Accuracy, repeatability, and reproducibility requirements for type approval at reference conditions: The error of a moisture meter for a given sample of grains or seeds is the algebraic difference between the average of a result of a series of repeat measurements of a grain sample and the conventional true value of the moisture content determined using a method defined as the reference by the national responsible bodies.

5.5.1 Due to the natural variability of grain and oil seeds, grain moisture meters shall be statistically tested for accuracy, repeatability, and reproducibility with natural moisture test samples for all approved grain types. The entire range of moistures will be tested at 2 % moisture intervals. These tests will be carried out under reference environmental conditions (5.1). The two tests for accuracy are moisture error, i.e., $\bar{y}$, average of the difference between meter reading and reference method, and the Standard Deviation of this Difference, SDD, as defined in clause B.2. The standard deviation, SD, of the sample replicates is used as the measure of the repeatability of the instrument and reproducibility between submitted instruments is estimated by calculating the

instrument's standard deviation of differences, SDD_I. Details of the necessary sampling and the mathematical analysis for $\bar{y}$, SDD, SD and SDD_I can be found in Annex B.

5.5.2 The requirements for moisture meter accuracy, Repeatability and reproducibility are:

Accuracy:	$\bar{y}$ and SDD	0.5 x MPE_S in 5.3.1
Repeatability:	SD	0.25 x MPE_S in 5.3.1
Reproducibility between instruments:	SDD_I	0.3 x MPE_S in 5.3.1

5.6 Instrument operating temperature range

5.6.1 A meter shall meet the moisture accuracy specification over a minimum range of 20 ºC. The minimum operating temperature covers 10 ºC to 30 ºC. If the manufacturer specifies a temperature range, the range shall at least cover 20 °C. No moisture value may be displayed when the operating temperature range is exceeded. An appropriate error message shall be displayed when the moisture meter is outside its specified operating range.

5.7 Sample temperature range

5.7.1 The manufacturer shall specify the temperature range for each grain or seed for which the meter is to be used. The minimum sample temperature range for each grain shall be 0 °C to 40 °C. No moisture value shall be displayed when the temperature range is exceeded. An appropriate error message shall be displayed when the temperature of the grain sample exceeds the specified temperature range for the grain. For practical reasons due to ability of accurately determining the reference value of elevated temperature grain samples, the maximum sample temperature for type approval testing shall be 45 °C.

5.7.2 The manufacturer shall specify the maximum allowable difference in temperature between the meter and the sample for which an accurate moisture determination can be made. The moisture meter shall be able to take into account a temperature difference of at

least 5 °C. No moisture value may be displayed when the maximum allowable temperature difference is exceeded. An appropriate error message shall be displayed when the difference in temperature between the meter and the sample exceeds the specified difference.

5.8 Influence factors

5.8.1 During type evaluation, a moisture meter shall be tested for the following influence factors using the applicable reference conditions (5.1). The national responsible body shall select a single well performing grain type and 2 % moisture interval. Meter indicated moisture difference determinations shall be made for each influence factor according to details of the analysis contained in the test procedures in Annex B.

Influence Factor	Test Procedure Section
Power source variation: voltage frequency battery voltage (if applicable)	B.3.3., B.3.3.1., B.3.3.2.
Instrument stability	B.3.1.
Instrument warm-up time	B.3.2.
Instrument leveling	B.3.5., B.3.5.1.
Instrument temperature sensitivity	B.3.7.
Instrument humidity sensitivity	B.3.6
Instrument storage temperature	B.3.4.
Sample temperature sensitivity	B.3.8., B.3.9.

5.8.2 A description of performance tests for influence factors is given in Annex B, test procedures.

5.9 Influence of external disturbances

5.9.1 When subjected individually to the disturbances specified in the immunity tests of IEC 61326 (latest revision) the meter shall not exhibit a significant fault as defined in 3.2.1.

Disturbance	Test Procedure Section
Short time power reduction	B.4.1.
Bursts	B.4.2.
Electrostatic discharges	B.4.3.
Electromagnetic susceptibility	B.4.4.

6. Technical requirements

6.1 Grains and minimum moisture ranges

6.1.1 Due to climatic and crop variability, the national responsible body shall specify a list of kinds and commercially important moisture ranges (at least 6 % moisture) for those kinds and minimum number of kinds (at least three) for which a manufacturer may seek national moisture meter approval. The kinds of grains specified are typically those which:

(1) are of greatest economic importance, and

(2) are significantly different in their physical structure to adequately test the instrumentation (e.g., (a) large grains, (b) small grains, and (c) oil seeds.)

(3) are variable and are typically grown in regions of the national responsible body.

6.1.2 The national responsible body shall specify the required sample of moisture meters (minimum of 2 is highly recommended) to be submitted by the manufacturer for type approval testing.

6.1.3 The manufacturer shall specify the grain and oil seed types and the applicable moisture ranges for type approval, subject to the minimum ranges specified in paragraph 6.1.1.

6.1.4 Moisture meters shall permit the selection of the species of grain or seeds being measured and the selection of the species shall be clearly identified and visible to all parties present.

6.1.5 Meters shall be designed to measure the moisture content of representative size grain samples. The minimum allowable sample size used in analysis shall be 100g or 400 kernels or seeds，which ever is smaller.

6.2 Instrument warm up period:

When a meter is turned on it shall not display or record any usable values until the operating temperature necessary for accurate determination has been attained. This performance may not be necessary for the meters, which do not require any warm up time.

6.3 Digital display and recording elements.

6.3.1 Meters shall be equipped with a digital indicating element.

6.3.2 The minimum height for the digits used to display moisture content shall be 10 mm.

6.3.3 Meters shall be equipped with a communication interface that permits interfacing with a recording element and transmitting the date, grain type, grain moisture results, and calibration version identification. Correspondence between displayed information and remote recording element shall be verified.

6.3.4 A digital indicating element shall not display, and a recording element shall not record, any moisture content values before the end of the measurement cycle.

6.3.5 Moisture content results shall be displayed as percent moisture, wet basis and if recorded, recorded as percent moisture content, wet basis. Subdivisions of this unit shall be in terms of decimal subdivisions (not fractions).

6.3.6 The display shall permit moisture value determination to 0.1 % resolution. The 0.1 % resolution is for commercial transactions; at the manufacturers option the display and printout may also permit 0.01 % resolution for type evaluation only.

6.3.7 On multi-constituent meters (e.g., meters which also measure grain protein), provision shall be made for displaying and recording the constituent label (such as moisture, protein, etc.) to make it clear which constituent is associated with each of the displayed and recorded values.

6.4 Meter construction

6.4.1 Moisture meters and all accessory equipment shall be of such materials, design, and construction as to make it probable that, under normal service conditions (a) accuracy will be maintained, (b) operating parts will continue to function as intended, and (c) adjustments will remain reasonably permanent. Undue stresses, deflections, or distortions of parts shall not occur to the extent that accuracy or permanence is detrimentally affected.

6.4.2 The housing of moisture meters shall be constructed so that the main components of the instrument are protected from dust and moisture.

6.4.3 The measured quantity may be a quantity or a function of various quantities such as: mass, volume, temperature, electrical resistance, spectral data or capacitance.

6.4.4 When the principle of measurement of a moisture meter requires the use of a grinding mill, the mill shall be considered an integral part of the moisture determining process. Its design, method of use and integration with the moisture meter shall be appropriate and complete for the measurement.

6.5 Marking

6.5.1 General marking

Each moisture meter shall bear the following markings:

(a) identification of trade-mark of the manufacturer,

(b) designation of instrument type and serial number, given by the manufacturer

(c) type approval mark, if instrument is approved.

6.6 Operating ranges

A meter shall automatically and clearly indicate when the operating range of the meter has been exceeded by either an error indication, or blanking the display.

- Moisture Range of Grain and Seed: A meter shall not display or record any moisture content values when the moisture content of the grain sample is beyond the operating range of the device, unless the moisture representation includes a clear error indication (and recorded error message with the recorded representation).

- Temperature Range: A meter shall not display or record any moisture content values and an appropriate error message must be displayed when the temperature range of the meter, temperature range of the grain and seed and the maximum allowable difference in temperature between the meter and sample are exceeded. If the moisture meter is not able to measure the sample temperature then the operating procedure shall be defined by national responsible bodies.

6.7 Provision for Sealing and Calibration Security

Provision shall be made for applying a security seal in a manner that requires the security seal to be broken, or for using an audit trail, or other approved means of providing security, before any change that affects the metrological integrity of the device can be made to any mechanism.

Note: Zero-setting and test point adjustments are considered to affect metrological characteristics and must be sealed.

If calibration constants are digitally stored in an electronically alterable form, the meter shall be designed to make automatic checks to detect corruption *due to adjustment or changing* calibration constants. An error message must be displayed if calibration constants have been electronically altered and no further measurement shall be possible.

6.8 Manufacturers shall provide a manual that describes the installation, operation, and routine maintenance of the moisture meter and its accessories. In addition, the manual must include the following information:

(1) name and address of the manufacturer;

(2) the type or pattern of the meter with which it is intended to be used;

(3) date of issue;

(4) the kind or varieties of grain for which the meter is designed to be used;

(5) the limitations of use, including, but not confined to the moisture measurement range, grain or seed temperature, maximum allowable temperature difference between grain sample and meter, meter operating temperature range, voltage and frequency ranges, electromagnetic interferences and electromagnetic compatibility.

In addition the manual shall be written in the official language(s) of the countries where it is used or in a language accepted by the national responsible body.

6.9 Place of installation and environment

The moisture meter shall be installed in conformity with the requirements given in the manual provided by the manufacturer.

6.10 Visibility of the moisture meter and of the measurement operations

Moisture meters in service shall be so placed that all parties present have the possibility of seeing simultaneously all the measurement operations. The indicating or recording device should be seen at the same time, and all necessary steps shall be taken to eliminate any possibility of error or fraud.

6.11 Battery-operated instruments shall not indicate or record values outside the applicable tolerance limits when battery power output is excessive or deficient.

7. Practical instructions

7.1 Type approval samples should be natural; that is, the moisture should not be adjusted by soaking in water or by spraying water. Sufficient sample should be available to complete the tests, and satisfy the minimum allowable sample size requirements for the meter.

7.2 Sample records

The sample records should include: the identification number assigned, the date received, source, grain type, moisture, and other pertinent information. Upon receipt the integrity of the sample enclosure should be checked and the new enclosure used if necessary. Heat-sealed polyethylene bags (e.g. 0.15 mm thickness) are commonly used as enclosures. Samples are to be stored at 2 °C to 8 °C prior to use, unless tested within 24 hours of receipt.

7.3 Prior to testing, samples are removed from cold storage and equilibrated overnight to room temperature. Samples over 18 % moisture content are equilibrated to room temperature over a time period of at least 4 hours on the day of testing.

7.4 The sample must be clean. The condition of the sample (odor, appearance, damage, remaining foreign material, etc.) is recorded on the sample record. The sample is mixed.

7.5 The sample is then divided into representative portions slightly in excess of the amounts needed for the meter plus reference method analysis.

8. Metrological controls

8.1 Type approval

8.1.1 Manufacturers shall provide the national responsible body with an operating manual for the grain moisture meter. A manufacturer may also provide data and other information that support a determination of whether the performance of the instrument meets requirements according to this Recommendation.

8.1.2 The national responsible body shall review the operating manual for its completeness and clarity of operating instructions and shall visually inspect the instrument in conjunction with a review of its specifications by the manufacturer to determine that the technical requirements in clause 6 are met.

8.1.3 The national responsible body shall carry out the following performance tests, to confirm acceptable performance for the following moisture meter tests:

- accuracy, repeatability, and reproducibility
- power source variation: voltage and frequency; battery voltage (if applicable)
- instrument stability
- instrument warm-up time
- instrument leveling
- instrument temperature sensitivity
- instrument humidity sensitivity
- instrument storage temperature
- grain temperature sensitivity
- Short time power reduction
- Bursts
- Electrostatic discharges
- Electromagnetic susceptibility

8.2 The report on the grain moisture meter tests carried out at type approval shall contain, as a minimum, the items of information according to the format provided in Annex C. A specific form may be developed according to national preference. The manufacturer shall be provided specific comments about any test failures.

9. Bibliography

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(4) IEC/TR3 61000-2-1 Electromagnetic compatibility(EMC) Part 2 Environment Section 1: Description of the environment-Electromagnetic environment for low-frequency conducted disturbances and signaling in public power supply systems

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ANNEX A

SPECIFICATIONS FOR INDIRECT INDICATING AND/OR
NON-AUTOMATED MOISTURE METERS
(INFORMATIVE)

A.1. Indirect indicating and/or non-automated moisture meters are not within the scope of this recommendation. However, this annex is retained for informative purposes. The purpose of these tests is to provide a means of verifying the overall performance of the moisture meter to the metrological and technical requirements.

A.2. Terminology

A.2.1 Conventional scale

If the use of conversion tables to obtain the moisture content, is necessary, the indicating scale of the moisture meter is called the “conventional scale”. The values indicated on this scale are dimensionless.

A.2.2 Conversion tables

Any chart, table, graph, slide rule, or other external device used to determine the moisture content from the value indicated by the moisture meter when the indicated value is altered by a parameter not automatically corrected for in the moisture meter (for example, grain type, temperature and/or test weight).

A.2.3 Zero setting

The value 0 % mass can, in practice, never be reached by the quantity that represents the moisture content of a sample of grains or seeds. However, moisture meters may give a (zero) indication. This zero is mechanical or electrical according to the principle of measurement of the instrument. For moisture meters with direct indication of the moisture content that is to say not requiring the use of conversion tables - zero may represent the result of a measurement when the measuring cell is empty or the indication

of the instrument when the measuring operations have not yet been initiated. For moisture meters provided with conversion tables, zero may also represent the indication appearing on the conventional scale when the value of the measured quantity is zero.

A.2.4 Test Value

A device enabling the determination of a test value is a device aiming at verifying the smooth running of the measuring part. It must be possible to use the device without the operator having at his disposal a sample of grain. The test value is obtained by one or more indications of the indication device, which are the results of a measurement simulation. This simulation shall correspond to the operation of those elements which determine the parameters having a critical effect on the measurement.

A.3. Design of Indicating and Recording Elements and of Recorded Representations.

A.3.1 A meter shall be equipped with a primary indicating element and may also be equipped with a primary recording element. If the meter indicates directly and/or is equipped to record, the meter shall indicate and/or record its measurements in terms of percent moisture content, wet basis. Subdivisions of this unit shall be in terms of decimal subdivisions (not fractions). If the meter indicates in the conventional scale and requires conversion or correction tables, the resulting values after use of such tables shall be in terms of percent moisture content, wet basis. Subdivisions of this unit shall be in terms of decimal subdivisions (not fractions).

A.3.2 Digital indications

A.3.2.1 A digital indicating element shall not display any values (either moisture content or conventional scale) before the end of the measurement cycle.

A.3.3 Scale graduations

A.3.3.1 Length.

Graduations shall be so varied in length that they may be conveniently read.

A.3.3.2 Width

In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and the width of the main graduations shall be not more than 50 % greater than the width of subordinate graduations. Graduations shall in no case be less than 0.2 mm in width.

A.3.3.3 Clear Interval Between Graduations

The clear interval shall be not less than 0.75 mm between graduations. If the graduations are not parallel, the measurement shall be made:

- along the line of relative movement between the graduations at the end of the indicator, or
- if the indicator is continuous, at the point of widest separation of the graduations.

A.3.4 Indicators

A.3.4.1 Symmetry

The index of an indicator shall be symmetrical with respect to the graduations, at least throughout that portion of its length associated with the graduations.

A.3.4.2 Length

The index of an indicator shall reach to the finest graduations with which it is used, unless the indicator and the graduations are in the same plane, in which case the distance between the end of the indicator and the ends of the graduations, measured along the line of the graduations, shall be not more than 1.0 mm.

A.3.4.3 Width

The width of the index of an indicator in relation to the series of graduations with which it is used shall be not greater than:

(1) width of the widest graduation, nor

(2) width of the minimum clear interval between graduations.

When the index of an indicator extends along the entire length of a graduation, that portion of the index of the indicator that may be brought into coincidence with the graduation shall be of the same width as the graduation throughout the length of the index that coincides with the graduation.

A.3.4.4 Clearance

The clearance between the index of an indicator and the graduations shall in no case be more than 1.5 mm.

A.3.4.5 Parallax

Parallax effects shall be reduced to the practicable minimum.

A.3.5 Recording Elements

If a meter is equipped with a recording element, it shall record in terms of percent moisture content, wet basis only, and not in terms of conventional scale.

- A recording element shall not record any values before the end of the measurement cycle.
- A recording element shall not record any values when the moisture content of the grain sample is beyond the operating range of the device.

A.3.6 Design of Direct Reading Grain Moisture Meters.

A.3.6.1 Grain or Seed Kind and Class Selection and Recording

Provision shall be made for selecting and recording, if equipped to record, the kind and class (as appropriate) of grain or seed to be measured. The means to select the kind and class of grain or seed shall be readily visible and the kind and class of grain or seed selected shall be clearly and definitely identified.

A.3.6.2 Operating Range

A meter shall automatically and clearly indicate when the operating range of the meter has been exceeded or the manufacturer shall:

(1) clearly and conspicuously mark the operating ranges on the meter; or

(2) furnish the operating ranges of the meter and the means to clearly and conspicuously display this information on or immediately adjacent to the device.

A.3.6.3 The operating range shall specify the following:

(1) temperature range over which the meter may be used and still comply with the applicable requirements;

(2) the moisture range for each grain or seed for which the meter is to be used;

(3) the temperature range for each grain or seed for which the meter is to be used; and

(4) the maximum allowable difference in temperature between the meter and the sample for which an accurate moisture determination can be made.

Examples of clearly indicating these conditions include an error indication, or blanking the display.

A.3.6.4 Value of Smallest Unit.

The value of the minimum indicated or recorded moisture indication shall not be greater than 0.1 %.

A.4. Design of Measuring Elements.

A.4.1 Zero-Setting and Test Point Mechanisms

If a grain moisture meter is equipped with a zero setting and/or test point mechanism(s), this (these) mechanism(s) shall be adjustable only with a tool outside and entirely separate from this mechanism or enclosed in a cabinet. This requirement shall not apply to manual operations that the operator must make (following operating instructions) in order to obtain a meter reading on a grain sample.

A.4.2 Provision for Sealing

Provision shall be made for applying a security seal in a manner that requires the security seal to be broken before an adjustment can be made to any component of the grain moisture meter that is set by the manufacturer or authorized service representative and not intended to be adjusted by the user.

A.5. Accessory Equipment

When the operating instructions for a moisture meter require accessory equipment separate from and external to the moisture meter, such equipment shall be appropriate and complete to achieve the metrological requirements addressed in Section 5.

A.6. Conversion and Correction Tables

A.6.1 When a moisture meter requires the use of conversion or correction tables, they shall be appropriate and correct for the moisture meter being used and the following general requirements apply:

(1) The national responsible body shall approve these tables.

(2) The manufacturer shall provide on a visible part of the moisture meter, next to the indicating device, written instruction indicating the necessity for the use of this (these) table(s).

(3) The moisture meter shall be provided with clear and detailed operation instructions for the final calculation of percent moisture.

A.6.2 Conversion and correction tables, charts, graphs, slide rules, or other apparatus to convert the conventional scale values read from a moisture meter to moisture content values shall be marked with the following information:

(1) name and address or trademark of the manufacturer;

(2) designation of type, given by the manufacturer, and serial number, with which it is intended to be used;

(3) date of issue and calibration version number;

(4) the kind or classes of grain or seed for which the device is designed to measure moisture content;

(4) the limitations of use, including but not confined to the moisture measurement range, grain or seed temperature, kind or class of grain or seed, moisture meter temperature, voltage and frequency ranges, electromagnetic interferences, and necessary accessory equipment; but values exceeding any measurement range shall not be included.

A.7. Operating instructions and use limitations

The manufacturer shall furnish with each device, operating instructions (manual) containing all of the information required by paragraph A.6.2. The manual shall include a list of all accessory equipment, conversion and correction charts necessary to obtain moisture content values. The manual shall also contain the operating ranges and the kinds of grain or seed to be measured with the moisture meter. In addition the manual shall contain complete information and instructions concerning the accuracy, sensitivity, and use of accessory equipment (e.g., grinders, test weight equipment, thermometer, etc.) necessary for obtaining accurate moisture results.

ANNEX B

TEST PROCEDURES (MANDATORY)

Grain and seed types for instrument influence factor and disturbance tests Testing laboratory shall chose well performing moisture-stable grain samples comprising adjacent 2 % moisture intervals (e.g. 10 % to 12 %, 12 % to 14 %, 14 % to 16 %) for conducting type approval testing. Grain and seed types chosen should be economically important and significantly different in their physical structure to adequately test the instrumentation. Variable grains and seed types that are typically grown in regions of the national responsible body shall be used for conducting testing. Moisture intervals selected should bracket commercially important moisture levels for the grain type. For uniformity of application, each 2 % moisture intervals should begin and end with an even number. The maximum value calculated for a given 2 % moisture interval (i.e 10 % to 12 %, 12 % to 14 %, 14 % to 16 %) shall be used for all requirements (see 5.3.1). Sample sets shall be selected according to the criteria in 5.4 and B.1.2. Unless test conditions call for different environmental conditions, all type approval tests shall be carried out under reference conditions 5.1.

B.1.1 Grain or oilseed sample sets will be prescreened for moisture homogeneity by comparing an approved moisture meter result to the result of determinations using the reference moisture method. No accuracy set will be used where the standard deviation of the differences (*SDD*) between the approved moisture meter and reference method for the samples in any of the 2 % moisture intervals exceed 0.5 times the MPES (5.3.1) minus 0.1. A minimum of ten samples shall be selected with variable moisture levels within each 2 % moisture interval.

B.2 Accuracy, repeatability, and reproducibility

B.2.1 The two tests for accuracy are moisture error, $\bar{y}$, (meter reading versus reference method) and the Standard Deviation of the Differences, *SDD*, between the meter and the

reference method for each of the 2 % moisture intervals. One instrument (The testing of two instruments is highly recommended and is at the discretion of the national body) [Editors Note: This effects B.2.3 Reproducibility in which two instruments are needed] will be individually tested. The equations for $\bar{y}$ and *SDD* follow:

$$\bar{y} = \frac{\sum_{i=1}^{n} (\overline{x_i} - r_i)}{n}$$

where,

$\bar{y}$ = average over all y_i

y_i = $\overline{x_i} - r_i$

$\overline{x_i}$ = average meter moisture value for sample i (3 replicates)

r_i = reference moisture value for sample i

n = number of samples per 2 % moisture interval (n = 10)

$$SDD = \sqrt{\frac{\sum_{i=1}^{n} \left(y_i - \bar{y}\right)^2}{n-1}}$$

Accuracy acceptance requirements for both $\bar{y}$ and *SDD* shall be 0.5 x MPE_S (5.3.1) for the appropriate 2 % moisture intervals. Reference method portions shall be cut off from each sample and submitted to the reference procedure before and after the above tests and the results recorded.

B.2.2 The repeatability of a meter is defined as the Standard Deviation, *SD*, of the three replicates. It shall be calculated for each sample in a 2 % moisture interval and pooled across samples. Each instrument is to be tested individually. The equation used to calculate *SD* is:

$$SD = \sqrt{\frac{\sum_{i=1}^{n} \sum_{j=1}^{3} \left(x_{ij} - \overline{x_i}\right)^2}{2n}}$$

where,

x_{ij} = meter moisture value for sample i and replicate j,

$\overline{x_i}$ = average of the three moisture values for sample i,

n = number of samples per 2 % moisture interval (n = 10)

Repeatability requirements for *SD* are 0.25 x MPE_S (5.3.1) for the appropriate 2 % moisture interval.

B.2.3 Reproducibility between submitted instruments is estimated by calculating the standard deviation of differences, SDD_I . The equation used to calculate instrument reproducibility is:

$$SDD_I = \sqrt{\frac{\sum_{i=1}^{n}\left(d_i - \overline{d}\right)^2}{n-1}}$$

where,

$d_i = \overline{x}_i^{(1)} - \overline{x}_i^{(2)}$

$\overline{x}_i^{(1)}$ = mean of three replicates for sample i on instrument 1

$\overline{x}_i^{(2)}$ = mean of three replicates for sample i on instrument 2

$\overline{d}$ = mean of the d_i

n = number of samples in all 2 % moisture ranges

Reproducibility requirements are 0.3 $\times$ MPE_S (5.3.1) for the 6 % moisture range.

B.3 Influence factor tests

Throughout the influence factor testing, portions of the grain or seed samples shall be tested by the reference moisture method. These reference moisture method tests are to determine that the moisture content is appropriate for the test and that the sample was stable throughout the test. The values to be compared to the permitted differences from reference conditions (5.8.1) are the simple subtractive differences in the means of the meter indications at the test appropriate reference condition from the meter indications at the extremes of the influence factor being tested.

B.3.1 Instrument stability

One grain or seed type

Three 2 % moisture interval samples (e.g. 10 % to 12 %, 12 % to 14 %, 14 % to 16 %)
Number of repetitions = 5

Minimum time period for assessing instrument stability shall be four weeks. A set of three samples, one from each of the three 2 % moisture intervals will be selected for testing. These samples may be a subset of the test set for accuracy, repeatability, and reproducibility tests. Each of the 3 samples will be measured 5 times through all of the meters submitted for type approval, prior to running any other type evaluation tests. The mean moisture content obtained for the 15 observations (3 samples x 5 replicates) will be recorded. The 3 samples shall be stored and retested once all other type evaluation testing has been completed. (within 4 to 6 weeks).

The maximum permitted difference between the means of the two tests is 0.25×MPE.

Reference method portions shall be cut off from the bulk sample and submitted to the reference procedure before and after the above tests and the results recorded.

B.3.2 Instrument warm-up time

One grain or seed type

Single 2 % moisture interval sample (e.g. 12 % to 14 %)

Number of repetitions = 5

The following test procedures will be used to check warm-up times recommended by the manufacturer. If the manufacturer does not recommend a warm-up time, assume that turning the instrument power on will immediately provide accurate results.

Test Sequence:

(1) instrument powered off and stabilized at reference conditions (overnight).

(2) instrument powered on, wait specified warm-up time TEST

(3) wait one hour or twice the manufacturer recommended warm-up time, which is greater TEST

For an instrument where no warm-up time is specified, the sample would be tested immediately upon the instrument being powered on and then again after 1 hour. Reference method portions shall be cut out from the bulk sample and submitted to the

reference procedure before and after the above tests and the results recorded. The maximum permitted difference between the means of the two tests is 0.25×MPE.

B.3.3 Instrument power supply

B.3.3.1 Main voltage and frequency variation

One grain or seed type

Single 2 % moisture interval sample (e.g. 12 % to 14 %)

Number of repetitions = 10

Applicable standards: IEC/TR3 61000-2-1, IEC 61000-2-2, IEC 61000-4-1

Voltage variation nominal voltage (U_{nom}) U_{nom} - 15 %, U_{nom} + 10 %

Frequency variation nominal frequency (f_{nom}) f_{nom} - 2 %, f_{nom} + 2 %

Voltage and frequency will be varied independently to the above stated levels. Voltage settings shall be determined and recorded to ± 0.1 V, and the frequency settings determined and recorded to ± 0.1 Hz. The difference between the mean moisture indication at the nominal voltage or frequency and mean moisture indication at the tested extremes of voltage or frequency shall be evaluated. Reference method portions shall be cut out from the bulk sample and submitted to the reference procedure before and after both the voltage and frequency tests and the results recorded.

The maximum permitted difference between the mean moisture meter value at nominal voltage or frequency and the mean value determined at the high and low voltage frequency test points is ± 0.2 %. The maximum allowable standard deviation of 10 repeat measurements at any of the voltage or frequency levels is 0.10 %.

After each change in the voltage and frequency, allow the meter to stabilize for 30 minutes before testing.

B.3.3.2 Battery power supply

One grain or seed type

Single 2 % moisture interval sample (e.g. 12 % to 14 %)

Number of repetitions = 10

The instrument will be tested for its performance at the extremes of the manufacturer's specified voltage range relative to its performance at nominal battery voltage(U_{nom}, U_{hi}, U_{lo}).

Reference method portions shall be cut out from the bulk sample and submitted to the reference procedure before and after the battery voltage tests and the results recorded. The maximum allowable difference from U_{nom} performance is $\pm 0.15 \times$ MPE. Mean values shall be used for these determinations. If the instrument can also be operated with an AC adapter the tests in B.3.3.1 apply as well. The instrument shall not indicate or record values outside the applicable tolerance limits when the battery power output is excessive or deficient.

B.3.4 Instrument storage temperature.

One grain or seed type

Single 2 % moisture interval sample (e.g. 12 % to 14 %)

Number of repetitions = 10

A single sample is analyzed (n=10) at reference conditions (5.1) prior to temperature cycling. Reference method portions shall be cut out from the bulk sample and submitted to the reference procedure before and after the storage temperature tests and the results recorded. The instrument is then powered down and placed in the environmental chamber. The chamber temperature is then increased to 55 °C over a 1-hour period and maintained at that temperature for 3 hours. Chamber temperature is then decreased to -20 °C over a 1-hour period and maintained at that temperature for 3 hours. Repeat the temperature cycle. Instrument is equilibrated at reference conditions (5.1) for at least 12 hours unpowered. The instrument is turned on for the specified warm-up period and the test sample analyzed a second time (n=10).

The mean of each replicate measurement is to be determined before and after temperature cycling. The maximum allowable difference in the mean values due to temperature cycling is $\pm 0.25 \times$ MPE.

B.3.5 Instruments without level indicators

One grain or seed type

Single 2 % moisture interval sample (12 % to 14 %)

Number of repetitions = 5

Reference tilt condition: instrument leveled to 0.1°

Degree of tilt: 5% front to back and left to right (minimum of 2 orientations of tilt)

The test procedure is to measure the single sample with the instrument mounted on a level surface (reference alignment); then in each of the four orientations of tilt; returning to the reference alignment for the final test. Reference method portions shall be cut out from the bulk sample and submitted to the reference procedure before and after the instrument level tests and the results recorded.

The mean of each replicate measurement is to be determined for each orientation. The maximum allowable difference in the mean values of each tilt orientation from the mean of the two reference orientations is ±0.25×MPE.

B.3.5.1 Instruments with level indicators

Meters equipped with leveling indicators will be tested at the indicated limits of the level indicator (front to back and left to right) rather than the specified tilt in B.3.5 Orientations similar to those in B.3.5 shall be applied with the same performance requirements.

B.3.6 Humidity

One grain or seed type

Single 2 % moisture interval sample (12 % to 14 %)

Number of repetitions = 10

Instruments (power on) shall be placed in an environmental chamber at 22 °C and a relative humidity of 30 % for 16 hours. Samples shall be stored sealed at reference conditions. After equilibration the sample will then be analyzed in the chamber. The relative humidity will be raised to 70 % (22 °C) and, after the instrument has equilibrated at this humidity for at least 16 hours, the sample will again be analyzed. Reference method portions shall be cut out from the bulk sample in the laboratory and submitted to the reference procedure before and after the humidity level tests and the results recorded.

The mean of each replicate measurement is to be determined for each humidity level.

The maximum allowable difference in the mean values between the two humidity levels is ±0.25×MPE.

B.3.7 Instrument Temperature Sensitivity.

One grain or seed type

Three 2 % moisture interval samples (i.e 10 % to 12 %, 12 % to 14 %, 14 % to 16 %)
Number of repetitions = 3

Instruments are to be tested in an environment chamber at:

(1). reference temperature, T_R, (5.1), 65 % RH

(2). the lower operating temperature (T_1), 65 % RH

(3). the upper operating temperature (T_2), constant humidity ratio of 0.011 kg of water per kg of dry air.

Manufacturer is to declare T_1 and T_2, as the instruments operating range, if the operating range is not declared then the minimum operating temperature range from 10 ºC to 30 ºC will apply.

Instrument temperature sensitivity tests will be run using three moisture level samples. Each sample will be cut into 3 portions for testing at T_R, at T_1, and at T_2. Instruments will remain in the chamber throughout cycling to the appropriate temperatures; the sample will be placed in the test chamber to the test temperature for at least 4 hours in a covered moisture inert container before instrument moisture measurements. Instruments shall be equilibrated to the new environmental conditions at least four hours prior to sample testing. Reference method portions shall be cut out from the sample portions in the laboratory prior to placement of moisture samples in the test chamber and submitted to the reference procedure before and after the humidity level tests and the results recorded.

The mean of each replicate measurement is to be determined for each temperature level. The maximum allowable difference in the mean values between T_R, and T_1 and T_R, at T_2 is ±0.40×MPE for all moisture levels.

Note: To facilitate testing of instrument temperature sensitivity, manufacturers shall provide a means of disabling the instrument feature for suppressing the display of moisture results when temperature ranges are exceeded.

B.3.8 Sample Temperature Sensitivity:

Three grain or seed types

Three 2 % moisture interval samples: (e.g. 10 % to 12 %, 12 % to 14 %, 14 % to 16 %)

Number of Samples: (3 grain types, 3 moisture levels, duplicate samples at each moisture level)

Number of repetitions = 3

Instruments temperature: at reference conditions (5.1), reference temperature (T_{ref})

Grain or seed temperatures: reference temperature (T_{ref}), manufacturer declared $T_{ref} \pm \Delta T$ or minimum ΔT of ± 5 °C in case of no separate specification.

Additional testing is required to verify that accurate results are provided when the sample and instrument are at different temperatures. This will be referred to as the sample temperature sensitivity test. The purpose of this test is to verify that the instrument provides accurate results when the*re is a* difference in temperature between the sample and the instrument. . The sample temperature sensitivity test will be conducted using the three grain or seed types comprising three 2 % moisture intervals.

B.3.9 Grain or seed test temperatures shall be per manufacturers specification or if there is no separate specification, the minimum temperature difference requirement shall be ± 5 °C from reference temperature. Tests will be conducted with the instrument at reference temperature (T_{ref} , see 5.1) and the sample temperature varying from $T_{ref} - \Delta T_C$ to $T_{ref} + \Delta T_H$, where T_{ref} is the : reference temperature. T_{ref}. The manufacturer specified sample temperature for the sample above the instrument temperature is represented as $T_{ref} + \Delta T_H$ and below as $T_{ref} - \Delta T_C$. The two temperature differences need not be equal. In no case will $T_{ref} + \Delta T_H$ be allowed to exceed 45 °C for the test.

B.3.10 Three moisture level analyses will be made for each grain sample at each of the three test temperatures. The means for the 18 observations (2 samples x 3 moisture intervals x 3

replicates) of each grain or seed type shall be determined. The maximum permitted difference at the sample temperature extreme from moisture levels measured at reference sample temperature is ± 0.45 % for grains or seed types of Index I from 5.3.1, otherwise ± 0.35 % grains or seed types of Index II.

B.4.1 Short time power reductions: The equipment under test(EUT) shall be exposed to mains voltage interruptions from nominal voltage to zero voltage, for a duration equal to a half cycle of line frequency (severity level 1a), and to mains voltage reductions from nominal voltage to 50 % of nominal voltage, for a duration equal to one cycle of line frequency (severity level 1b).

At least ten interruptions and ten reductions are applied, with a time interval of at least ten seconds between tests. The interruptions and reductions are repeated throughout the time necessary to measure the error (of indication) of the EUT; therefore more than ten interruptions and reductions may be necessary.

The difference between the intrinsic error and the error (of indication) measured whilst the EUT is subjected to mains voltage interruptions and reductions, at the same reference conditions, shall not exceed the maximum permissible error in the specified operating range (or significant faults are detected and acted upon by means of a checking facility).

B.4.2 Bursts: The equipment under test is subjected to electrical bursts superimposed on the mains supply voltage. The EUT is subjected to bursts of double exponential waveform transient voltages with a peak amplitude of 1000 V (for electromagnetic environment E1) and 2000 V (for electromagnetic environment E2).

Each voltage spike shall have a rise time of 5 ns and a one half amplitude duration of 50 ns. The burst length shall be 15 ms and the burst period (repetition time interval) shall be 300 ms. All bursts shall be applied asynchronously, in asymmetrical mode (common mode). The bursts shall be applied for at least one minute during the measurement, or simulated measurement, for each polarity.

The error (of indication) of the EUT shall be measured during the application of the mains voltage bursts. The difference between the intrinsic error and the error (of indication) measured whilst the EUT is subjected to mains voltage bursts, at the same

reference conditions, shall not exceed the maximum permissible error in the specified operating range (or significant faults are detected and acted upon by means of a checking facility).

B.4.3. Electrostatic discharge: The error (of indication) of the equipment under test shall be measured while the EUT is subjected to electrostatic discharges at a severity level of 6 kV for contact discharges and of 8 kV for air discharges.

At each test location, at least ten discharges shall be applied with intervals of at least 10 seconds between discharges, throughout the period of the error (of indication) measurement. Air discharges shall only be applied where contact discharges cannot be applied. For indirect discharges, a total of ten discharges shall be applied on the horizontal coupling plane and a total of ten discharges for each of the various positions of the vertical coupling plane. The difference between the intrinsic error and the error (of indication) measured whilst the EUT is subjected to electrostatic discharges, at the same reference conditions, shall not exceed the maximum permissible error in the specified operating range (or significant faults are detected and acted upon by means of a checking facility).

B.4.4. Electromagnetic susceptibility – electromagnetic fields: The equipment under test is subjected to 20 discrete frequency bands of electromagnetic radiation in the frequency range 26 MHz to 1000 MHz, at a field strength of either 10 V/m (for electromagnetic environment E1) or 10 V/m (for electromagnetic environment E2).

The difference between the intrinsic error and the error (of indication) measured whilst the EUT is subjected to the electromagnetic radiation, at the same reference conditions, shall not exceed the maximum permissible error in the specified operating range (or significant faults are detected and acted upon by means of a checking facility).

ANNEX C

Test Report Format

Note: This Annex is informative with regard to implementation of this Recommendation in national regulations; however, use of the Test Report Format is mandatory for the application of the Recommendation within the *OIML Certificate System for Measuring Instruments*.

Report on testing a resistance thermometer

Reference: OIML R 84 (2003) No. of report:.....

Type of thermometer: .....

Serial number: .....

Temperature range:.....

Tolerance class: .....

Measuring current: .....

Manufacturer:.....

Address: .....

Customer: .....

Address: .....

Additional parameters (if specified by the manufacturer):.....

SUMMARY OF TEST REPORT

clause	Tests	passed	Failed	Remarks
5.5 B.2.1	Accuracy			
5.5 B.2.2	Repeatability			
5.5 B.2.3	Reproducibility			
5.6	Instrument operating temperature range			
5.7	Sample temperature range			
5..8	Influence factors			
B.3.3	Instrument power supply variation			
B.3.1	Instrument stability			
B.3.2	Instrument warm-up time			
B.3.5	Instrument leveling			
B.3.7	Instrument temperature sensitivity			
B.3.6	Instrument humidity sensitivity			
B.3.4	Instrument storage temperature			
B.3.8	Sample temperature sensitivity			
5.9	Influence of external disturbances			
B.4.1	Short time power reduction			
B.4.2	Bursts			
B.4.3	Electrostatic discharges			
B.4.4	Electromagnetic susceptibility			
6.1	Grains and minimum moisture ranges			
6.2	Instrument warm up period			
6.3	Digital display and recording elements			
6.6	Operating ranges			
6.7	Provision for sealing and security			
8.1	Manual			

CHECKLEST FOR SAMPLE

Inspection for sample				
clause	**requirement**	**Positive(+)**	**Negative(-)**	**Remarks**
5.4	Specification of sample			
7.1	Type approval sample			
7.2	Sample records			
7.3	Sample equilibrated to room temperature			
7.4	The condition of the sample			
7.5	Portions of the sample			
B.1	Grain and seed types and moisture intervals			
B.1.2	Homogeneity of sample			