

INTERNATIONAL
RECOMMENDATION

OIML R 59-1
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Moisture meters for cereal grains and oilseeds.

Part 1: Metrological and technical requirements

Humidimètres pour grains de céréales et graines oléagineuses.

Partie 1: Exigences métrologiques et techniques



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Foreword

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This publication – reference OIML R 59-1, Edition 2016 – was developed by Project Group 1 in OIML Technical Subcommittee TC 17/SC 1 *Humidity*. It was approved for final publication by the International Committee of Legal Metrology in 2016 and was submitted to the International Conference on Legal Metrology in 2016 for formal sanction. It supersedes the previous edition of R 59 dated 1984.

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Introduction

¹Moisture 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.

¹If 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.

¹Many 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.

This 2016 edition of OIML R 59 contains significant changes to the 1984 edition, notably to reflect new measuring technologies and aspects of actual grain analysis.

As noted above, grain moisture meters do not measure moisture directly. An electrical or optical response to the moisture in a grain type is measured and moisture is predicted using calibration equations. As such, these instruments must be calibrated to predict the moisture of each grain type used on the instrument. Grains vary from season to season and also grain types may vary widely from country to country; therefore, a program to address calibration updates is needed to ensure that grain moisture meter calibrations represent the current crops. If grain moisture instruments are sold to other countries the calibrations will need to be verified within that country to ensure that the calibrations are representative of the grains within that particular country. This Recommendation does not address an ongoing calibration program for these instruments. Ongoing calibration programs may be subject to metrological controls by the national responsible body.

¹ *An Investigation of the Nature of the Radio Frequency Dielectric Response in Cereal Grains and Oilseeds with Engineering Implications for Grain Moisture Meters, A Dissertation in Physics and Engineering, David B. Funk, Ph.D., D.H.C.*

Moisture meters for cereal grain and oilseeds

Part 1: Metrological and technical requirements

1 Scope

1.1 Requirements and tests

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

1.2 Indications

This Recommendation applies to digitally indicating automatic grain moisture meters that directly display moisture content.

1.3 Application

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 this Recommendation.

1.4 Type of measuring instrument

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

1.5 New technology

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

2 Terminology

2.1 Terminology in OIML V 2-200 *International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM)* [1], and OIML V 1 *International Vocabulary of Terms in Legal Metrology (VIML)* [2]

2.1.1 adjustment [VIM 3.11]

set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

Additional note: A change in the value of any of a device's sealable calibration parameters or sealable configuration parameters.

2.1.2 accuracy; measurement accuracy [VIM 2.13]

closeness of agreement between a measured quantity value and a true quantity value of the measurand

Note 1: The concept of 'measurement accuracy' is not a quantity and is not given a numerical quantity value. A measurement is said to be more accurate when it offers a smaller measurement error.

Note 2: The term “measurement accuracy” should not be used for measurement trueness and the term “measurement precision” should not be used for “measurement accuracy”, which, however, is related to both concepts.

Note 3: ‘Measurement accuracy’ is sometimes understood as closeness of agreement between measured quantity values that are being attributed to the measurand.

2.1.3 calibration [VIM 2.39]

operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

Note 1: A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

Note 2: Calibration should not be confused with adjustment of a measuring system, often mistakenly called “self-calibration”, nor with verification of calibration.

Note 3: Often, the first step alone in the above definition is perceived as being calibration.

2.1.4 certified reference material; CRM [VIM 5.14]

reference material, accompanied by documentation issued by an authoritative body and providing one or more specified property values with associated uncertainties and traceabilities, using valid procedures

2.1.5 maximum permissible measurement error (MPE) (maximum permissible error, limit of error) [VIM 4.26]

extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system

Note 1: Usually the term “maximum permissible errors” or “limits of error” are used, where there are two extreme values.

Note 2: The term “tolerance” should not be used to designate “maximum permissible error”.

Additional note: The MPEs in 4.4.2 of this Recommendation are errors associated with a meter in use in the market place. The errors for the OIML test procedures are based on 4.4.1.

2.1.6 measurement error (error of measurement, error) [VIM 2.16]

measured quantity value minus a reference quantity value

Note 1: The concept of ‘measurement error’ can be used both

- (a) when there is a single reference quantity value to refer to, which occurs if a **calibration** is made by means of a **measurement standard** with a **measured quantity value** having a negligible **measurement uncertainty** or if a **conventional quantity value** is given, in which case the measurement error is known, and true quantity values of negligible range, in which case the measurement error is not known, and
- (b) if a **measurand** is supposed to be represented by a unique **true quantity value** or a set of true quantity values of negligible range, in which case the measurement error is not known.

Note 2: Measurement error should not be confused with production error or mistake.

2.1.7 measurement repeatability (repeatability)[VIM 2.21]

measurement precision under a set of repeatability conditions of measurement

2.1.8 measurement reproducibility (reproducibility) [VIM 2.25]

measurement precision under reproducibility conditions of measurement

Note: Relevant statistical terms are given in ISO 5725-1:1994 and ISO 5725-2:1994.

Additional note: In this Recommendation, the reproducibility of measurements between units of the same type of instrument under reference conditions is assessed by the standard deviation of differences (SDD_p). The reproducibility of measurements from one instrument when select influence factors are varied is assessed by the magnitude of the error shift or fault.

2.1.9 rated operating condition [VIM 4.9]

operating condition that must be fulfilled during measurement in order that a measuring instrument or measuring system performs as designed

Note: Rated operating conditions generally specify intervals of values for a quantity being measured and for any influence quantity.

2.1.10 reference condition [VIM 4.11]

operating condition prescribed for evaluating the performance of a measuring instrument or measuring system or for comparison of measurement results

Note 1: Reference conditions specify intervals of values of the measurand and influence quantities.

Note 2: In IEC 60050-300, item 311-06-02, the term “reference condition” refers to an operating condition under which the specified instrumental measurement uncertainty is the smallest possible.

2.1.11 reference quantity value; reference value [VIM 5.18]

quantity value used as a basis for comparison with values of quantities of the same kind

2.1.12 repeatability condition of measurement (repeatability condition) [VIM 2.20]

condition of measurement, out of a set of conditions that includes the same measurement procedure, same operators, same measuring system, same operating conditions and same location, and replicate measurements on the same or similar objects over a short period of time

Note 1: A condition of measurement is a repeatability condition only with respect to a specified set of repeatability conditions.

Note 2: In chemistry, the term “intra-serial precision condition of measurement” is sometimes used to designate this concept.

2.1.13 reproducibility condition of measurement (reproducibility condition) [VIM 2.24]

condition of measurement, out of a set of conditions that includes different locations, operators, measuring systems, and replicate measurements on the same or similar objects

Note 1: Different measuring systems may use different measurement procedures.

Note 2: A specification should give the conditions changed and unchanged, to the extent practical.

2.1.14 type approval [VIML 2.05]

decision of legal relevance, based on the review of the type evaluation report, that the type of a measuring instrument complies with the relevant statutory requirements and results in the issuance of the type approval certificate

Note: See also VIML A.25

2.1.15 type (pattern) evaluation [VIML 2.04]

conformity assessment procedure on one or more specimens of an identified type (pattern) of measuring instruments which results in an evaluation report and/or an evaluation certificate

Note: ‘Pattern’ is used in legal metrology with the same meaning as ‘type’; in the entries below, only ‘type’ is used.

2.1.16 verification of a measuring instrument [VIML 2.09]

conformity assessment procedure (other than type evaluation) which results in the affixing of a verification mark and/or issuing of a verification certificate

Note: See also OIML V2-200:2010, 2.44.

2.2 International Organization of Legal Metrology(OIML) terminology

2.2.1 audit trail [OIML D 31, 3.1.2]

continuous data file containing a time stamped information record of events, e.g. changes in the values of parameters of a device or software updates, or other activities that are legally relevant and which may influence the metrological characteristics

2.2.2 cryptographic means [OIML D 31, 3.1.11]

encryption of data by the sender (storing or transmitting program) and description by the receiver (reading program) with the purpose of hiding information from unauthorized persons. Electronic signing of data with the purpose of enabling the receiver or user of the data to verify the origin of the data, i.e. to prove their authenticity

2.2.3 fault [OIML D 11, 3.10]

[with reference to a certified measurement standard]: difference between the error of indication [during or after exposure to a disturbance] and the mean intrinsic error of a measuring instrument

Note 1: Principally, a fault is the result of an undesired change of data contained in or flowing through an electronic measuring instrument.

Note 2: From the definition it follows that a “fault” is a numerical value which is expressed either in a unit of measurement or as a relative value.

Additional note: If a certified measurement standard is not used, a fault is the difference between a single indication during or after a disturbance, and the mean indication at reference conditions prior to test.

2.2.4 intrinsic error [OIML D 11, 3.8]

error of a measuring instrument, determined under reference conditions

2.2.5 legally relevant [OIML D 31, 3.1.29]

software/hardware/data or part of the software/hardware/data of a measuring instrument which interferes with properties regulated by legal metrology, e.g. the accuracy of the measurement or the correct functioning of the measuring instrument

2.2.6 open network [OIML D 31, 3.1.35]

network of arbitrary participants (electronic devices with arbitrary functions). The number, identity and location of a participant can be dynamic and unknown to the other participants. This is in contrast to a closed network [D 31, 3.1.6] which is a network of a fixed number of participants with a known identity functionality and location

2.2.7 universal computer [OIML D 31, 3.1.54]

computer that is not constructed for a specific purpose but that can be adapted to the metrological task by software. In general this software is founded on an operating system that permits loading and execution of software for specific purposes

2.2.8 (software) validation [OIML D 31, 3.1.56]

confirmation by examination and provision of objective evidence (i.e. information that can be proved true, based on facts obtained from observations, measurement, test, etc.) that the particular requirements for the specific intended use are fulfilled. In the present case the related requirements are those of this Recommendation

2.3 Other terminology

2.3.1 accuracy of a grain moisture calibration; calibration accuracy

performance characteristic of a calibration assessed at reference conditions

Additional note: The assessment requires calculation of \bar{y} , the bias over a set of test samples or the ‘calibration bias’, and the standard deviation of the difference (SDD) between the meter and the reference method for each of the 2 % moisture intervals which is the standard deviation of measurement errors from the same sample set. Refer to R 59-2, A.1.2 for the calculation of \bar{y} and *SDD* from measured values. The limiting values for \bar{y} and *SDD* in column 2, Table 4.4.1 shall be observed in order to deem a calibration as sufficiently accurate.

2.3.2 average error shift

algebraic mean of error shift values calculated from samples of the same grain type with different moisture levels. The resulting ‘average’ value is indicative of the average variation over the encompassed measurement range, as opposed to the variation in measured values at one point of the range

Note: In this Recommendation, reference to a resulting ‘mean’ value is reserved for the mean of replicated measurements, i.e. the mean of measured values on the same test sample (usually taken under repeatability conditions).

2.3.3 auxiliary battery

battery that is

- (a) mounted in, or connected to, an instrument that can also be powered by the mains power, and
- (b) capable of completely powering the instrument for a reasonable period of time.

2.3.4 back-up battery

battery intended to power specific functions of an instrument in the absence of the primary power supply. Example: to preserve stored data

2.3.5 calibration equation; calibration

set of calibration coefficients for one type of grain to convert raw instrument data into a moisture content measurement

Note: Both these terms are used in the same context as ‘calibration function’ in Note 1 of VIM 2.39.

2.3.6 checking facility

facility incorporated in a measuring instrument and which enables significant faults to be detected and acted upon

Note: “Acted upon” refers to any adequate response by the measuring instrument (luminous signal, acoustic signal, prevention of the measurement process, etc.).

2.3.7 enabling/inhibiting sealable hardware

physically sealable hardware, such as a two-position switch, located on a remotely configurable device, that enables and inhibits the capability to receive adjustment values or changes to sealable configuration parameters from a remote device

2.3.8 error shift

with reference to a certified measurement standard: difference between the mean error of indication while one or more influence quantities are varied within the rated operating conditions and the mean intrinsic error of a measuring instrument. See 4.4.1 for the error shifts associated with grain moisture meter testing

Note: If a certified measurement standard is not used, the error shift is the difference between two measured values: the indication under rated operating conditions and the mean indication at reference conditions prior to test.

2.3.9 grain

for the purpose of this Recommendation grain means oil seeds, pulses and cereal grains

2.3.10 integrity of programs, data or parameters

assurance that the programs, data or parameters have not been subjected to any unauthorized or unintended changes during their use, transfer, storage, repair or maintenance

2.3.11 moisture content wet-basis

ratio of moisture to the total mass of the grain sample

2.3.12 moisture meter

instrument that measures a parameter (electrical, optical, etc.) to predict the moisture content of a grain within specified error limits

2.3.13 sample temperature sensitivity (STS)

measurement variation (relative to the moisture values obtained at reference conditions) resulting from the range of grain sample temperatures permitted in commercial measurements

Note: STS is controlled in approved moisture calibrations. During assessment, a limit is placed on the value of the average error shift caused by allowable temperature variations.

2.3.14 significant fault [VIML 5.14]

fault greater than the value specified in this Recommendation (see 4.4.1)

Note: The relevant Recommendation may specify that the following faults are not significant, even when they exceed the value defined in 4.4.1:

- (a) faults arising from simultaneous and mutually independent causes (e.g. EM fields and discharges) originating in a measuring instrument or in its checking facilities;
- (b) faults implying the impossibility to perform any measurement;

- (c) transitory faults being momentary variations in the indication, which cannot be interpreted, memorized or transmitted as a measurement result;
- (d) faults giving rise to variations in the measurement result that are serious enough to be noticed by all those interested in the measurement result; the relevant Recommendation may specify the nature of these variations.

2.4 Abbreviations and acronyms

AC	alternating current
DC	direct current
EM	electromagnetic
EMC	electromagnetic compatibility
e.m.f.	electromotive force
ESD	electrostatic discharge
EUT	equipment under test
IEC	International Electrotechnical Committee
ISO	International Organization for Standardization
M	reference moisture
MPE	maximum permissible error
OIML	International Organization of Legal Metrology
RF	radio frequency
RH	relative humidity
SD:	standard deviation [See R 59-2, A.1.3]
SDD	standard deviation of differences [See R 59-2, A.1.2]
STS	sample temperature sensitivity [See R 59-2, A.3]
t	actual temperature during a test
t_{ref}	reference temperature during a test
Δt	magnitude of the temperature difference between a sample and an instrument at T_{ref}
t_{C}	minimum environmental temperature specified by the national responsible body for type testing
t_{H}	maximum environmental temperature specified by the national responsible body for type testing
\bar{y}	average of the difference between meter reading and reference method (see R 59-2, 2.3.1 and R 59-2, 3.13.11)

2.5 Additional symbols and subscripts used in equations

Additional subscript and symbols are defined in R 59-2, Annex A *Test procedures* for each equation associated with each test.

3 Units of measurement

3.1 Moisture content

The unit of measurement for the moisture content of a grain sample, which is to be displayed on a moisture meter, is the % moisture by mass. Reference moisture (M) is expressed as the percentage mass loss of the sample as determined by the reference method. The equation below represents wet-basis moisture content:

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

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

4 Metrological requirements

4.1 Influence quantities

4.1.1 Reference conditions

- (a) Ambient temperature: 20 °C to 27 °C
- (b) Relative humidity: 30 % to 70 %
- (c) Atmospheric pressure: 86 kPa to 106 kPa
- (d) Power voltage: nominal mains or test voltage, V_{nom} or U_{nom}
- (e) Power frequency: nominal frequency, F_{nom}
- (f) Instrument tilt position: level at $0^\circ \pm 0.1^\circ$

Note: During each test, the t_{ref} and RH_{ref} shall not vary by more than $\pm 2^\circ\text{C}$ and $\pm 10\%$ respectively within the allowable ranges.

4.1.2 Disturbance test ranges

- (a) AC mains voltage dips, short interruptions and voltage variations: reduction to 0 % (0.5 cycle), reduction to 0 % (1 cycle), reduction to 70 % (25 / 30(1) cycles), reduction to 0 % (250 / 300⁽¹⁾ cycles).
- (b) Bursts (transients) on AC mains: Amplitude 1 kV, repetition rate 5 kHz
- (c) Radiated radio-frequency fields, electromagnetic fields: 26 MHz – 2 GHz, 10 V/m
- (d) Conducted radio-frequency fields: 0.15 MHz – 80⁽²⁾ MHz, 10 V (e.m.f.)
- (e) Electrostatic discharge – direct application: Up to 6 kV contact discharge
- (f) Electrostatic discharge – indirect application: Up to 8 kV air discharge
- (g) Storage temperature (extreme shipping conditions): -20°C to 50°C or greater as specified by the national responsible body.

Note 1: The cycle counts apply for 50 Hz / 60 Hz respectively

Note 2: Testing up to 26 MHz is permitted. Refer to R 59-2, A.4.4 for conditions.

4.2 Rated operating conditions

Measuring instruments shall be designed and manufactured such that their errors do not exceed the MPEs for initial verification as defined in 4.4.2 when operated within the operating conditions defined below:

- | | |
|---|--|
| (a) Ambient temperature: | 10 °C to 30 °C ⁽¹⁾ |
| (b) Relative humidity: | up to 85 % no condensation |
| (c) Atmospheric pressure: | 86 kPa to 106 kPa (or as specified by the national responsible body) |
| (d) Power voltage: | -15 % to +10 % of mains or test voltage |
| (e) Power frequency: | nominal frequency, F_{nom} |
| (f) Instrument tilt position: | 5 % or maximum allowable on level indicator where indicator is present |
| (g) Grain sample temperature: | 2 °C to 40 °C ⁽²⁾ |
| (h) Sample and instrument temperature differential: | 10 °C ⁽³⁾ |
| (i) Grain sample moisture range: | Specified by the manufacturer (See 5.1) |

⁽¹⁾ This is the minimum range. The manufacturer or national responsible body may specify a wider range (see 4.6).

⁽²⁾ This is the minimum grain sample temperature range. The manufacturer shall specify the temperature range for each grain or seed for which the meter is to be used (see 4.7).

⁽³⁾ This is the minimum differential. The manufacturer may specify a larger differential. If the instrument is unable to measure sample temperature then the operating procedure shall be defined by the national responsible body (see 4.7).

4.3 Reference method

¹An air oven method is the most common rapid reference method for grain moisture determination. 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 non-aqueous 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.

The reference method for grain moisture content is the method defined by the national responsible body.

¹ *An Investigation of the Nature of the Radio Frequency Dielectric Response in Cereal Grains and Oilseeds with Engineering Implications for Grain Moisture Meters, A Dissertation in Physics and Engineering*, David B. Funk, Ph.D., D.H.C.

4.4 Maximum permissible errors (MPEs)

For type evaluation the maximum permissible error for grain moisture meters as a function of the grain type and moisture content is half the MPE that is applied at verification or in-field inspection: The maximum value within a given interval of moisture content shall be used as the reference moisture content for all requirements in calibration/testing. For consistency of application in testing laboratories in different countries, it is recommended that each of the 2 % moisture intervals should begin *and end with an even number of moisture* (e.g. within a moisture interval of 10 % to 12 % the MPE will be calculated based on 12 % moisture).

4.4.1 MPEs for type evaluation

MPEs for type evaluation				
(1) Grain type	(2) MPEs in percent moisture content (M) %	(3) Average Error shift	(4) Repeatability SD %	(5) Reproducibility SDD ₁ %
Corn, oats, pulses, rice, sorghum, sunflower	If $0.025 \times M < 0.4$ then MPEs = 0.4; else MPEs = $0.025 \times M$ (e.g. If $M < 16$ then MPEs = 0.4; else MPEs = $0.025 \times M$)	$0.5 \times$ column 2	$0.5 \times$ column 2	$0.6 \times$ column 2
All other grains and oil seeds	If $0.02 \times M < 0.35$ then MPEs = 0.35; else MPEs = $0.02 \times M$ (e.g. If $M < 17.5$ then MPEs = 0.35; else MPEs = $0.02 \times M$)	$0.5 \times$ column 2	$0.5 \times$ column 2	$0.6 \times$ column 2

4.4.2 MPEs at verification/ in-field inspection

MPEs at verification/ in-field inspection	
Type of grain or seed	MPE _s in percent moisture content (M)
(I) Corn, oats, pulses, rice, sorghum, sunflower	If $0.05 \times M < 0.8$ then MPEs = 0.8; else MPEs = $0.05 \times M$
(II) All other cereal grains and oilseeds	If $0.04 \times M < 0.7$ then MPEs = 0.7; else MPEs = $0.04 \times M$

4.5 Accuracy and precision requirements

The error of a moisture meter for a given sample of grains or seeds is the 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 body.

4.6 Instrument environmental operating temperature range

A meter shall meet the moisture accuracy specification over a minimum environmental operating range of 20 °C. The minimum environmental operating temperature range is 10 °C to 30 °C. No moisture value may be displayed when the instrument's environmental operating temperature range is exceeded. An appropriate error message shall be displayed when the moisture meter is outside its specified environmental operating temperature range.

The manufacturer may specify a wider temperature range than the t_C to t_H required by the national responsible body in order to meet international requirements. The manufacturer may request type testing and approval over the wider environmental operating temperature range (i.e. for that particular type approval application, the manufacturer's specified ranges are adopted as t_C to t_H).

4.7 Sample temperature range

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 2 °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. 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 10 °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. If the instrument is not able to measure sample temperature, then the operating procedure shall be defined by the national responsible body.

5 Technical requirements

5.1 Grains and minimum moisture ranges

Due to climatic and crop variability, the national responsible body shall specify a list of grains and commercially important moisture content ranges (at least 6 % moisture) for the grain types for which a manufacturer may seek national approval. For meters designed to be used on a number of different grain types, at least three calibrations shall be submitted for national moisture meter examination. The grains specified are typically those which

- (a) are of greatest economic importance, and
- (b) are significantly different in their physical structure to adequately test the instrumentation (e.g. large grains, small grains, and oil seeds), and
- (c) are variable and are typically grown in regions of the national responsible body.

The manufacturer shall specify the grain and oil seed types and the applicable moisture range for the meter, subject to the minimum ranges specified in 4.1.1.

5.2 Selection of grain on the instrument

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

5.3 Minimum sample size

The minimum allowable sample size used in analysis shall be 100 g or 400 kernels or seeds, whichever is smaller, except where the national responsible body determines otherwise.

5.4 Determination of quantity and temperature

The moisture meter system shall not require the operator to judge the precise volume or weight and temperature needed to make an accurate moisture determination. External grinding, weighing and temperature measurement operations are not permitted.

5.5 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 requirement may not be necessary for instruments which do not require any warm-up time.

5.6 Digital display and recording elements

Meters shall be equipped with a digital indicating element.

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

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).

The display shall permit moisture value determination to 0.1 % resolution. The 0.1 % resolution is for commercial transactions; at the national responsible body's option the display and printout shall also permit 0.01 % resolution for type evaluation only.

The national responsible body may require meters to be equipped with an internal recording device and/or a communication interface that permits interfacing with an external recording device. Correspondence between the displayed information and the recording device shall be verified.

The measurement records shall include at least the date, grain type, sample I.D., grain moisture results, calibration version identification and, as appropriate, error messages.

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

Especially on multi-constituent meters (e.g. meters which also measure grain protein), provision shall be made to ensure an unambiguous relation between the displayed/recorded values and the constituents.

5.7 Data storage

If data storage is required, the measurement data must be stored automatically when the measurement is concluded. The storage device must have sufficient permanency to ensure that the data are not corrupted under normal storage conditions. There shall be sufficient memory storage for any particular application.

The measurement value stored shall be accompanied by all relevant information necessary for future legally relevant use. The measurement records shall include as a minimum: unambiguous identifier of the measurement, measurement date, unique identification of the instrument, grain type, moisture results and units, calibration version identification, error messages and constituent labels (on multi-constituent meters). Acceptable examples of a measurement identifier include consecutive numbers enabling assignment to values printed on an invoice, or a test sample ID.

5.8 External data storage

When external stored data are considered as legally relevant, the following additional requirements have to be fulfilled:

- The data shall be protected by software means to guarantee its authenticity and integrity. The software that displays or further processes the measurement values and accompanying data shall check the time of measurement, authenticity and integrity of the data after having read them from the insecure storage or after having received them from an insecure transmission channel. If an irregularity is detected, the data shall be discarded or marked unusable. For instruments using an open network, a higher severity level according to D 31 is required.

Note: Software modules that prepare data for storing or sending, or that check data after reading or receiving, belong to the legally relevant software part.

- The measurement shall not be inadmissibly influenced by a transmission delay.
- If a transmission interruption occurs because the network services become unavailable, no measurement data shall be lost. The measurement process shall be stopped to avoid the loss of measurement data.

Note: General national regulations (for instance for tax purposes) may contain strict limitations for deleting stored measurement data.

5.9 Meter construction

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.

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

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

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.

5.10 Marking

5.10.1 General marking

Each moisture meter shall be clearly and permanently marked for the purposes of identification with the following information:

- (a) manufacturer's name or trademark;
- (b) designation of the instrument type (model number) and serial number, given by the manufacturer; and
- (c) type approval mark, if the instrument is approved.

5.10.2 Location of marking

The required information shall be so located that it is readily observable without the need to disassemble parts, requiring the use of any means separate from the device.

5.10.3 Marking operational controls, indications, and features

All operational controls, indications and features indicating switches, light displays and push buttons shall be clearly identifiable. However, keys necessary only to the operator shall be marked to the extent that a trained operator can understand the function of each key.

5.11 Ambient temperature 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 by blanking the display.

5.11.1 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).

5.11.2 Temperature range

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

5.12 Provision for sealing and calibration security

Provision shall be made for appropriate sealing by mechanical, electronic and/or cryptographic means, making any change that affects the metrological integrity of the instrument impossible or evident. Calibrations, zero-setting and test point adjustments are considered to affect metrological characteristics and shall be sealed.

Examples of appropriate sealing means are: mechanical sealing, event counter, audit trail, and access only via interfaces protected by cryptographic means.

After securing and/or verification, the software of an instrument shall not be modifiable or uploadable via any interface or by other means without breaking the seal.

Refer to Annex C which contains practical guidance for sealing moisture measuring instruments, including consideration of sealable parameters and details of sealing mechanisms, e.g. metrological audit trails.

5.13 Manufacturer's manual

With each instrument, the manufacturer 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:

- (a) name and address of the manufacturer;
- (b) type or pattern of the meter with which it is intended to be used;
- (c) date of issue;
- (d) kind or varieties of grain for which the meter is designed to be used; and
- (e) limitations of use, including, but not confined to the moisture measurement range, grain or seed temperature, maximum allowable temperature difference between the grain sample and

the meter, meter operating temperature range, voltage and frequency ranges, electromagnetic interferences and electromagnetic compatibility. In addition, the manual shall be supplied to the owner/user of the instrument in the official language(s) of the countries in which it is used or in a language accepted by the national responsible body.

5.14 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 simultaneously seeing 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.

5.15 Power supply

A meter that uses alternating current must perform within applicable limits when tested in accordance with R 59-2, A.2.4.1

5.16 Battery-operated instruments

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

5.16.1 Non-rechargeable batteries

Instruments powered by non-rechargeable batteries or by rechargeable batteries that cannot be (re)charged during the operation of the measuring instrument shall comply with the following requirements:

- (a) an instrument provided with new or fully charged batteries of the specified type shall comply with the metrological requirements; and
- (b) as soon as the battery voltage has dropped to a value specified by the manufacturer as the minimum value of voltage at which the instrument complies with metrological requirements, this shall be detected and acted upon by the instrument.

For these instruments, no special tests for disturbances associated with the “mains” power (R 59-2, A.4.1 and R 59-2, A.4.2) have to be carried out.

In the criteria for (categories of) instruments, a minimum period of time shall be stated during which the instrument shall function correctly without renewing or recharging the batteries and (in particular for continuous totalizing measuring equipment) provisions may be prescribed that prevent the loss of stored data.

5.16.2 Rechargeable auxiliary batteries

Instruments powered by rechargeable auxiliary batteries that are intended to be (re)charged during the operation of the measuring instrument shall both

- (a) comply with the requirements of 5.16.1 with the mains power switched off, and
- (b) comply with the requirements for AC mains powered instruments with the mains power switched on.

5.16.3 Backup batteries

Instruments powered by the mains power and provided with a backup battery for data-storage only shall comply with the requirements for AC mains powered instruments.

A minimum period of time shall be stated during which the relevant function of the instrument shall function properly without renewing or recharging the batteries.

The provisions of 5.16.1(b) and 5.16.2 do not apply for backup batteries.

5.17 Level indicating means

A meter shall be equipped with a level indicator and leveling adjustment if its performance is changed by an amount greater than the applicable tolerance when the meter is moved from a level position to a position that is out of level in any direction up to 5 % from its normal operating position. The level indicating means shall be readable without removing any meter parts requiring a tool.

5.18 Software-controlled electronic devices and security

The requirements of OIML D 31 shall be fulfilled. In general, for moisture meters the severity level I, examined with validation procedure A, is required.

Note: The severity levels describe different protection levels of the software, depending on the risk of fraud or on the level of conformity. The validation procedures define the level of examination for type approvals.

5.18.1 Specifications of the software requirements

For instruments and modules operated by software, the manufacturer shall describe or declare how the software is implemented within the instrument or module, i.e. if it is installed in a fixed hardware and software environment (embedded) or on a universal computer system (implemented into the housing or external).

Legally relevant software shall be clearly identifiable via a unique software version or a checksum. In the normal operation mode of the instrument, the software version or the checksum shall be displayed or printed out on command or shall be displayed during the start-up procedure of the instrument.

Legally relevant measuring algorithms and functions shall be appropriate and functionally correct as evidenced by the instrument correctly displaying and recording the measurement result and the required accompanying information. It shall be possible to validate algorithms and functions where required by metrological tests.

The conformity of the legally relevant software on each instrument to that in the approved type shall be at level (b) described in D 31, 5.2.5. In types where selected functions or parts of the source code can be modified, it shall be possible to detect software variations, e.g. via checksum values.

Further measurements shall not be possible when a significant fault is detected.

If the software of the instrument is separated into legally relevant and non-relevant parts, the requirements of D 31, 5.2.1.2 shall be fulfilled.

For instruments/measuring systems using an internal or external universal computer, the legally relevant software shall be operated only in the environment specified for its correct functioning. If necessary to secure the correct functioning of the legally relevant software, the operating system shall be fixed to a defined invariant configuration.

Note: A fixed environment for software is also required for instruments where cryptographic data protection is implemented or when software changes on a verified instrument are permitted without an appointed verifier onsite (i.e. the ‘Traced updates’ described in D 31, 5.2.6.3).

The national responsible body may apply the requirements in 5.8 if measurement data has to leave the measuring instrument and be stored or transmitted in an insecure environment before it is used for commercial purposes.

5.18.2 Acceptable solutions for software identification

The software identification is provided in the normal operation mode by either

- a clearly identified operation of a physical or soft key, button, or switch, or
- a continuously displayed version number or checksum, etc.,

accompanied in both cases by clear instructions on how to check the actual software identification against the reference number (as listed in the OIML certificate) marked on or displayed by the instrument.

5.18.3 Software documentation

In addition to the documentation required in R 59-2, 2.2, the manufacturer shall submit the following documentation:

- a) description of the legally relevant software and how the requirements of 5.18.1 are met;
- b) description of suitable system configuration and minimal required resources;
- c) description of security means of the operating system (password, etc. if applicable);
- d) description of the (software) sealing method(s);
- e) overview of the system hardware, e.g. topology block diagram, type of computer(s), type of network, etc. – where a hardware component is deemed legally relevant or where it performs legally relevant functions, this should also be identified;
- f) description of the accuracy of the algorithms (e.g. filtering of A/D conversion results, price calculation, rounding algorithms, etc.);
- g) description of the user interface, menus and dialogues;
- h) description of the software identification which has to be clearly assigned to the legally relevant functions including the description of all encryption means (if any);
- i) clear instructions on how to check the actual software identification against the reference number as listed in the type approval certificate. This reference may additionally be marked on or displayed by the instrument;
- j) list of commands of each hardware interface of the measuring instrument / electronic device / sub-assembly including a statement of completeness;
- k) list of durability errors that are detected by the software and if necessary for understanding;
- l) description of the detecting algorithms;
- m) description of data sets stored or transmitted;
- n) if fault detection is realized in the software, a list of faults that are detected and a description of the detecting algorithm; and
- o) operating manual.

5.18.4 Grain calibrations and integrity

Grain moisture meters measure the effect of moisture on certain electrical or optical properties of grain. So, as the grain crop changes, the effect of moisture on these physical properties of the grain may change based on the crop year. The national responsible body may authorize updates on calibrations based on grain data collected during the current and/or recent years to accommodate for the seasonal and crop year variations. The national responsible body may also require retention of the data that is used to adjust the grain calibration. In many cases the grain calibration data are downloaded to the instrument using a communication interface. These are not considered software changes that would require a change to the software identification. Changes to the grain calibrations of the device shall be recorded in an audit trail or event logger.

5.18.4.1 Calibration version

A meter shall be capable of displaying calibration constants, a unique calibration name, or a unique calibration version number for use in verifying that the latest version of the calibration is being used to make moisture content determinations.

5.18.4.2 Calibration protection

If calibration constants are digitally stored in an electronically alterable form, the meter shall be designed to make automatic checks to detect unauthorized modification. An error message shall be displayed if calibration constants have been electronically corrupted and no further measurement shall be possible.

5.18.4.3 Calibration transfer

The instrument hardware/software design and calibration procedures shall permit calibration development and the transfer of calibrations between instruments of like models without requiring user slope or bias adjustments.

5.18.5 Correctness of algorithms and functions

The measuring algorithms and functions of a measuring device shall be functionally correct.

The measurement result and any accompanying information shall be displayed, recorded and printed correctly.

It shall be possible to validate algorithms and functions by metrological tests.

5.18.6 Software protection

5.18.6.1 Prevention misuse

A measuring instrument, and especially the software, shall be constructed in such a way that possibilities for unintentional, accidental or intentional misuse are minimal.

5.18.6.2 Fraud protection

For protection against fraudulent use, the following requirements shall be fulfilled:

- the legally relevant software shall be secured against unauthorized modification, loading, or changes by swapping the memory device. In addition to mechanical sealing, technical means may be necessary to secure measuring instruments having an operating system or an option to load software. Only clearly documented functions are allowed to be activated by the user interface, which shall be realized in such a way that it does not facilitate fraudulent use; and
- parameters that fix the legally relevant characteristics of the measuring instrument shall be secured against unauthorized modification. If necessary for the purpose of verification, it shall be possible to display or print the current parameter settings.

5.18.7 Fault detection

Appropriate fault detection criteria (i.e. operating ranges) are included in the relevant sections of this Recommendation.

6 Bibliography

At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and the users of this Recommendation are encouraged to apply the most recent editions of the normative documents indicated below. Members of the IEC and ISO maintain registers of currently valid International Standards.

The actual status of the Standards referred to can also be found on the Internet:

- IEC Publications: http://www.iec.ch/searchpub/cur_fut.htm
- ISO Publications: http://www.iso.org/iso/iso_catalogue.htm
- OIML Publications: <http://www.oiml.org/en/publications/recommendations>
(with free download of PDF files).

In order to avoid any misunderstanding, it is highly recommended that all references to Standards in OIML Recommendations and Documents be followed by the version referred to (generally the year or date).

Ref.	Standards and reference documents	Description
[1]	ISO/IEC Guide 99; OIML V 2-200: 2012 <i>International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM)</i>	An international agreement on terminology, prepared as a collaborative work of experts appointed by the BIPM, IEC, IFCC, ISO, IUPAC, IUPAP and OIML. This vocabulary covers subjects relating to measurement and includes information on the determination of physical constants and other fundamental properties of materials and substances. In practice, these publications are usually referred to as the “VIM”.
[2]	OIML V 1:2013 <i>International Vocabulary of Terms in Legal Metrology (VIML)</i>	No abstract available.
[3]	OIML D 11:2013 <i>General requirements for electronic measuring instruments</i>	Guidance for establishing appropriate metrological performance testing requirements for influence quantities that may affect the measuring instruments covered by International Recommendations.
[4]	OIML D 31:2008 <i>General requirements for software controlled measuring instruments</i>	Specifies the general requirements applicable to software related functionality in measuring instruments and gives guidance for verifying the compliance of an instrument with these requirements.
[5]	ISO/DIS 7700-2: 20XX <i>Check of the calibration of moisture meters in use - Part 2:moisture meters for oilseeds</i>	Specifies a method for checking the performance of meters in service for measuring the moisture content of oilseeds.
[6]	IEC/TR 61000-2-1: 1990-05 <i>Electromagnetic compatibility (EMC) Part 2 Environment Section 1: Description of the environment-Electromagnetic environment for low-frequency conducted disturbances</i>	Provides information on the various types of disturbances that can be expected on public power supply systems.

	<i>and signaling in public power supply systems</i>	
[7]	IEC 61000-2-2: 2002 <i>Electromagnetic compatibility (EMC) Part 2-2: Environment- Compatibility levels for low-frequency conducted disturbances and signaling in public power supply systems</i>	This standard is concerned with conducted disturbances in the frequency range from 0 kHz to 9 kHz, with an extension up to 148.5 kHz specifically for mains signaling systems.
[8]	IEC 61000-4-1: (2000-04) <i>Basic Electromagnetic compatibility (EMC) Part 4-1: Testing and measurement techniques-Overview of IEC 61000-4 series</i>	Provides EMC standards on testing and measurement techniques and provides general recommendations concerning the choice of relevant tests.
[9]	IEC 61326-1: 2005 <i>Electrical equipment for measurement, control and laboratory use-EMC requirements</i>	Specifies minimum requirements for immunity and emissions regarding electromagnetic compatibility (EMC) for electrical equipment, operating from a supply of less than 1000 V a.c. or 1500 V d.c.
[10]	National Conference on Weights and Measures, Publication 14, <i>Grain moisture meters and near infrared grain analyzers: 2014</i>	U.S. type evaluation procedures for grain moisture meters and protein, starch and oil analyzers.
[11]	<i>An investigation of the nature of the radio frequency dielectric response in cereal grains and oilseeds with engineering implications for grain moisture meters, a dissertation in physics and engineering, David B. Funk, Ph.D. H.C: 2001</i>	A dissertation in physics and engineering.
[12]	OIML D 3:1979 <i>Legal qualification of measuring instruments</i>	This Document deals with official actions which may be undertaken by a State for the purpose of attributing a “legal” quality to measuring instruments. Every effort has been made to consider all possible methods involved in these official actions.
[13]	ISO 650:1977 <i>Relative density 60/60 degrees F hydrometers for general purposes</i>	The requirements for five series of glass hydrometers concerning reference levels for adjustment and reading, materials, dimensions, form, scale and handling.
[14]	OIML R 76-1:2006 <i>Non-automatic weighing instruments</i>	This Recommendation specifies the metrological and technical requirements for non-automatic weighing instruments that are subject to official metrological control. It is intended to provide standardized requirements and testing procedures to evaluate the metrological and technical characteristics in a uniform and traceable way.

[15]	<p>ISO 7700-1:2008</p> <p>Food products—Checking the performance of moisture meters in use—Part 1:Moisture meters for cereals</p>	<p>Food products – checking the performance of moisture meters in use part 1: moisture meters for cereals</p>
[16]	<p>IEC 61000-4-6 (2003-05) with amendment 1 (2004-10)</p> <p><i>Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques Section 6: Immunity to conducted disturbances, induced by radio-frequency fields</i></p>	<p>Relates to the conducted immunity requirements of electrical and electronic equipment to electromagnetic disturbances emanating from intended radio-frequency (RF) transmitters in the frequency range 9 kHz up to 80 MHz. Equipment not having at least one conducting cable (such as mains supply, signal line or earth connection), which can couple the equipment to the disturbing RF fields is excluded. This standard does not intend to specify the tests to be applied to particular apparatus or systems. Its main aim is to give a general basic reference to all concerned product committees of the IEC. The product committees (or users and manufacturers of equipment) remain responsible for the appropriate choice of the test and the severity level to be applied to their equipment.</p>
[17]	<p>IEC 61000-4-2 Edition 2.0 (2008-12)</p> <p>Basic EMC Publication</p> <p><i>Electromagnetic compatibility (EMC) - Part 4-2 Testing and measurement techniques - Electrostatic discharge immunity test</i></p>	<p>This publication is based on IEC 60801-2 (second edition: 1991). It relates to the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges, from operators directly, and to adjacent objects. It additionally defines ranges of test levels which relate to different environmental and installation conditions and establishes test procedures. The object of this standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to electrostatic discharges. In addition, it includes electrostatic discharges which may occur from personnel to objects near vital equipment.</p>
[18]	<p>IEC 61000-4-11 (2004-03)</p> <p><i>Electromagnetic compatibility (EMC) - Part 4-11: Testing and measuring techniques - Voltage dips, short interruptions and voltage variations immunity tests</i></p>	<p>Defines the immunity test methods and range of preferred test levels for electrical and electronic equipment connected to low-voltage power supply networks for voltage dips, short interruptions, and voltage variations. This standard applies to electrical and electronic equipment having a rated input current not exceeding 16 A per phase, for connection to 50 Hz or 60 Hz AC networks. It does not apply to electrical and electronic equipment for connection to 400 Hz AC networks. Tests for these</p>

		networks will be covered by future IEC standards. The object of this standard is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to voltage dips, short interruptions and voltage variations. It has the status of a Basic EMC Publication in accordance with IEC Guide 107.
[19]	IEC 61000-6-1 (1997-07) <i>Electromagnetic compatibility (EMC) - Part 6: Generic standards - Section 1: Immunity for residential, commercial and light-industrial environments</i>	Defines the immunity test requirements in relation to continuous and transient, conducted and radiated disturbances, including electrostatic discharges, for electrical and electronic apparatus intended for use in residential, commercial and light-industrial environment, and for which no dedicated product or product-family standard exists. Immunity requirements in the frequency range 0 kHz to 400 GHz are covered and are specified for each port considered. This standard applies to apparatus intended to be directly connected to a low voltage public mains network or connected to a dedicated DC source which is intended to interface between the apparatus and the low-voltage public mains network.
[20]	IEC 61000-6-2 (1999-01) <i>Electromagnetic compatibility (EMC) - Part 6-2: Generic standards – Immunity for industrial environments</i>	Applies to electrical and electronic apparatus intended for use in industrial environments, for which no dedicated product or product-family immunity standard exists. Immunity requirements in the frequency range 0 Hz to 400 GHz are covered, in relation to continuous and transient, conducted and radiated disturbances, including electrostatic discharges. Test requirements are specified for each port considered. Apparatus intended to be used in industrial locations are characterized by the existence of one or more of the following: <ul style="list-style-type: none"> – a power network exists powered by a high or medium voltage power transformer dedicated for the supply of an installation feeding a manufacturing or similar plant; – industrial, scientific and medical (ISM) apparatus; – heavy inductive or capacitive loads are frequently switched; and – currents and associated magnetic fields are high.

[21]	IEC 61000-4-4 (2004-07) <i>Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test</i>	Establishes a common and reproducible reference for evaluating the immunity of electrical and electronic equipment when subjected to electrical fast transient/burst on supply, signal, control and earth ports.
[22]	IEC 61000-4-3 Consolidated Edition 2.1 (2002-09) with amendment 1 (2002-08) <i>Electromagnetic compatibility (EMC) - Part 4: Testing and measurement Techniques Section 3: Radiated, radio-frequency, electromagnetic field immunity test</i>	Applies to the immunity of electrical and electronic equipment to radiated electromagnetic energy. Establishes test levels and the required test procedures. Establishes a common reference for evaluating the performance of electrical and electronic equipment when subjected to radio-frequency electromagnetic fields.
[23]	ISO 24333: 2009 <i>Cereals and cereal products – Sampling</i>	Specifies requirements for the dynamic or static sampling, by manual or mechanical means, of cereals and cereal products, for assessment of their quality and condition.
[24]	ISO 6540:1980 <i>Maize – Determination of moisture content (on milled grains and on whole grains)</i>	Section one specifies the reference method. It consists of grinding of sample, if necessary, after pre-conditioning, if required, then drying a test portion at a temperature between 130 and 133 °C under conditions which enable a result to be obtained which is in agreement with that obtained by the absolute method (prescribed in the annex). Section two specifies the routine method on whole grains. It consists of drying whole grains for 38 h at a temperature between 130 and 133 °C. <i>Note:</i> The reference method for grain moisture content is the method defined by the national responsible body.
[25]	ISO 712:2009 <i>Cereals and cereal products – Determination of moisture content – Reference method</i>	Specifies a routine reference method for the determination of the moisture content of cereals and cereal products. <i>Note:</i> The reference method for grain moisture content is the method defined by the national responsible body.

Annex A

Principles for sealing

(Informative)

This Annex highlights considerations for determining which parameters of a grain moisture measuring instrument require sealing. It also provides examples of sealing methods, such as metrological audit trails, and the minimum requirements for an effective seal.

A.1 Terminology specific to this Annex

A.1.1 adjustment mode

operational mode of a measuring instrument which enables the user to make adjustments to sealable parameters, including changes to configuration parameters

A.1.2 adjustment

change in the value of the sealable calibration parameters or the sealable configuration parameters of an instrument

A.1.3 audit trail

electronic count and/or information record of the changes to the values of the calibration or configuration parameters of a measuring instrument

A.1.4 enabling/inhibiting sealable hardware

physically sealable hardware, such as a two-position switch located on a remotely configurable instrument, that enables and inhibits the sealable parameters of the instrument from being changed from a remote device

A.1.5 event

while in adjustment mode, an action in which

- one or more changes are made to configuration parameters, or
- adjustments are made to one value (or values for a set of values) for a calibration parameter (e.g. adjustments for a set of calibration factors to linearize device output)

If no adjustment is made, then there is no event. In the case of a centralized audit trail, the same values for the same parameter sent to multiple devices shall be considered to be the same event. In the case of a centralized event logger, the event logger must identify both the device and the parameter that was changed.

A.1.6 event counter

non-resettable counter that increments once each time the mode that permits changes to sealable parameters is entered and one or more changes are made to sealable parameters of the instrument

A.1.7 event logger

form of audit trail containing a series of records where each record contains the number from the event counter corresponding to the change to a sealable parameter, the identification of the parameter that was changed, the time and date on which the parameter was changed, and the new value of the parameter

A.1.8 physical seal

physical means, such as lead and wire, used to seal a device to detect access to those adjustable features that are required to be sealed

A.1.9 remote configuration capability

ability to adjust a measuring instrument or change its sealable parameters from or through some other device that is not itself necessary for the measurement operation or is not a permanent part of the instrument

A.1.10 remote device

device that (1) is not required for the measurement operation of the instrument or for computing the transaction information in one or more of the available operating modes for commercial measurements, or (2) is not a permanent part of the measuring instrument. In the context of this Annex, a remote device has the ability to adjust a measuring instrument or change its sealable configurable parameters

A.1.11 remotely configurable device

measuring instrument with remote configuration capability that permits sealable configuration or calibration parameter values to be deleted, appended to, modified or substituted in whole or in part by downloading over any type of communications link from another device, such as a geographically local or remote console or computer

A.1.12 seal

as a verb, to seal a device is to make a device secure so that access to adjustments and other sealable parameters will be detectable

A.1.13 sealable parameters

calibration and configuration parameters that are required to be sealed

Additional note: Unrestricted access means that a physical security seal is not present, so that access to the sealable parameters is available from a remote device at any time at the request of an authorized operator subject to the operating status of the receiving device.

A.2 Principles for determining features to be sealed

The need to seal certain features depends upon both the following:

- the ease with which the feature or the selection of the feature can be used to facilitate fraud; and
- the likelihood that the use of the feature will result in fraud being undetected.

Features or functions which the operator routinely uses as part of device operation, such as selecting the grain calibration to be used, are not sealable parameters and shall not be sealed.

If selection of a parameter or set of parameters would result in performance that would be obviously in error, such as the selection of parameters for different countries, then it is not necessary to seal the selection of these features.

If individual device characteristics are selectable from a “menu” or a series of programming steps, then access to the “programming mode” must be sealable.

Note: If an audit trail is the only means of security, then it shall update only after at least one sealable parameter has been changed. Simply accessing the sealable parameters via a menu shall not update the audit trail.

For parameters protected by physical means of security, once a physical security seal is applied to the instrument it should not be possible to make a metrological change to those parameters without breaking that seal. For parameters protected by electronic means of security, it shall not be possible to make a metrological change to those parameters without that change being reflected in an audit trail. Since this philosophy addresses provisions for protecting access to any metrological adjustment, the philosophy should be applied consistently to all electronic device types.

If a device must undergo a physical act, such as cutting a wire and physically repairing the cut to reactivate the parameter, then this physical repair process would be considered an acceptable way to select parameters without requiring a physical seal or an audit trail.

A.3 Typical features and parameters to be sealed

The following provides examples of parameters that are to be sealed. The examples are provided for guidance and are not intended to cover all possible parameters.

A.3.1 Calibration parameters

Calibration parameters are those adjustable parameters that can affect measurement or performance accuracy, and whose values need to be updated on an ongoing basis to maintain device accuracy. Calibration parameters can be classified into three categories:

- (a) those parameters which are adjusted to standardize or normalize instrument response to changes in the physical parameter being measured. Examples include zero-setting and test point adjustments, temperature sensing element zero and span adjustments, amplifier gain settings, optical wavelength standardization adjustments, etc. These parameters are normally set by the manufacturer or a competent service representative;
- (b) those parameters which are common to all instruments of the same type for a given grain type (e.g. grain calibration coefficients). The approval certificate lists the calibration coefficients (or a unique identifier) for each grain type which has been approved for use on a particular type of grain protein measuring instrument; and
- (c) those parameters which are adjusted for each grain type to standardize moisture readings on similar instruments (e.g. slope and bias settings).

A.3.2 Configuration parameters

Configuration parameters are those adjustable or selectable parameters that can affect the accuracy of a transaction or that can significantly increase the potential for fraudulent use of the device, and whose values only need to be updated during instrument installation or upon replacement of a component and which are not expected to change after the initial installation settings have been made:

- (a) system date and time (only if used by an event logger as audit trail information);
- (b) value of minimum indication and recorded moisture;
- (c) sample size and/or number of sub portions measured (if not determined by individual calibrations);
- (d) password for access to sealable parameters (if used);
- (e) enable/disable display of constituent values that are not legally relevant;
- (f) format for the display and recording of results;
- (g) operating range limits (e.g. temperatures); and
- (h) enable/disable display or recording of results for out-of-limits conditions.

A.3.3 Grain moisture meter features and parameters

Typical features or parameters to be sealed	Typical features or parameters not to be sealed
Measuring element adjustments (both mechanical and electronic) Weight sensing adjustments (both mechanical and electronic) Temperature sensing adjustments (both mechanical and electronic) Any tables or parameters residing in software to normalize the response of similar instruments Temperature probes and temperature offsets in software Grain calibration coefficients Slope and bias coefficients System date and time (only if used by an event logger as audit trail information)	Communications protocol

Note: The above examples of adjustments, parameters and features to be sealed are to be considered “typical” or “normal”. This list may not be all-inclusive, and there may be other parameters which affect the metrological performance of the device and which must, therefore, be sealed. If listed parameters or other parameters which may affect the metrological function of the device are not sealed, the manufacturer must demonstrate that all settings comply with the most stringent requirements for the application of the device.

A.4 Methods of sealing and metrological audit trails

A.4.1 Scope

The ability of users to make changes that affect the metrological integrity of the device (e.g. slope, bias, etc.) in normal operation and the remote configuration capability of commercial moisture measuring instruments has led to new, more appropriate means of sealing being implemented. These instruments must either be physically sealed or must incorporate an approved form of audit trail.

A.4.2 Categories of device and methods of sealing

Categories of device	Method of sealing
<p>Category 1: No remote configuration capability</p>	<p>Seal by physical seal or two event counters: one for calibration parameters (000 to 999) and one for configuration parameters (000 to 999.) If equipped with event counters, the device must be capable of displaying, or printing through the device or through another on-site device, the contents of the counters.</p>
<p>Category 2: Remote configuration capability, but access is controlled by physical hardware.</p> <p>The device shall clearly indicate that it is in the remote configuration mode and shall not be capable of operating in the measuring mode while enabled for remote configuration.</p>	<p>The hardware enabling access for remote communication must be at the device and sealed using a physical seal or two event counters; one for calibration parameters (000 to 999) and one for configuration parameters (000 to 999.) If equipped with event counters, the device must be capable of displaying, or printing through the device or through another on-site device, the contents of the counters.</p>
<p>Category 3: Remote configuration capability, access may be unlimited or controlled through a software switch (e.g. password).</p> <p>When accessed for the purpose of modifying sealable parameters, the device shall clearly indicate that it is in the configuration mode and shall not be capable of operating in the measuring mode.</p>	<p>An event logger is required in the device; it must include an event counter (000 to 999), the parameter ID, the date and time of the change and the new value of the parameter (for calibration changes consisting of multiple constants, the calibration version number may be used rather than the calibration constants). A printed copy of the information must be available through the device or through another on-site device. The event logger shall have a capacity to retain records equal to 25 times the number of sealable parameters in the device, but not more than 1000 records are required.</p> <p><i>Note:</i> This does not require 1000 changes to be stored for each parameter.</p>
<p>Category 3a: No remote capability, but operator is able to make changes that affect the metrological integrity of the device (e.g. slope, bias, etc.) in normal operation.</p> <p>When accessed for the purpose of modifying sealable parameters, the device shall clearly indicate that it is in the configuration mode and shall not be capable of operating in the measuring mode.</p>	<p>Same as Category 3.</p>
<p>Category 3b: No remote capability, but access to metrological parameters is controlled through a software switch (e.g. password).</p> <p>When accessed for the purpose of modifying sealable parameters, the device shall clearly indicate that it is in the configuration mode and shall not be capable of operating in the measuring mode.</p>	<p>Same as Category 3.</p>

Included below are the requirements for the acceptable forms of metrological audit trail, which are recognized as providing acceptable security.

A.4.3 Event logger: an acceptable form of audit trail

An event logger is the minimum form of audit trail for instruments that allow unrestricted access whether by an operator or a remote device, to the configuration or calibration parameters.

- (a) An event logger shall contain the following information: event counter; date and time; parameter ID; new value.

Note: For calibration changes consisting of multiple calibration constants, the calibration version number shall be used as the new value rather than the calibration constants.

- (b) This information shall be automatically entered into the event logger by the measuring instrument. Additional relevant information is permitted (e.g. the identification of the person who made the adjustment or the old value of the parameter that was changed).
- (c) The date and time shall be presented in an understandable format. The date shall include the month, day and year. The time shall include the hour and minutes.
- (d) A hard copy printout of the contents of the event logger shall be available upon demand from the instrument or an associated device on the site of the instrument installation. The printing of the event logger contents shall exclude other information not relevant to the changes logged such as transaction data, number of measurements performed, etc.
- (e) An event logger shall have a capacity of at least 25 times the number of sealable parameters; however, it is not required to retain more than 1000 events for all parameters combined.

A.4.4 General requirements for metrological audit trails

The following general requirements for metrological audit trails shall be satisfied:

- (a) The adjustment mode shall address only sealable parameters in order to avoid entering the adjustment mode to access non-sealable parameters that must be routinely changed as part of the normal use of the device.
- (b) An event counter shall have a capacity of at least 1000 values (e.g. 000 to 999).
- (c) In the case of an event logger, the event counter will increment once for each change to a sealable parameter since each new value must be retained in the event logger. If an adjustment mode is entered but no changes are made, this does not constitute an event and the counter must not increment.
- (d) When the storage memory of the event logger has been filled to capacity, any new event shall cause the oldest event to be deleted. The event counter used in the event logger shall continue to increment to its capacity, although the event logger may retain fewer records than the count capacity of the event counter. The event counter provides the necessary information to indicate the number of records that have been overwritten in the event logger as new information overwrites the old records.
- (e) The audit trail data shall be:
 - 1) Stored in non-volatile memory and shall be retained for at least 30 days if power is removed from the device; and
 - 2) Protected from unauthorized erasure, substitution, or modification.
- (f) Access to the audit trail information for the purpose of printing the contents must be “convenient” for an enforcement official of the national responsible body:
 - 1) Accessing the audit trail information for review shall be separate from the calibration mode so there is no possibility for the official to change or corrupt the device configuration or the contents of the audit trail.

- 2) Accessing the audit trail information shall not affect the normal operation of a device before or after accessing the information.
 - 3) A key (for a panel lock) may be required to gain access to the means to view the contents of the audit trail. Access may be through the supervisor's mode of operation of the device.
 - 4) Accessing the audit trail information shall not require the removal of any additional parts other than normal requirements to inspect the integrity of a physical seal.
- (g) The printed form of the audit trail information shall be readily interpretable by an official.
- (h) The information from an event logger shall be printed in order from the most recent event to the oldest event. If a device is not capable of printing all the information for a single event on one line or at one time, the information shall be displayed in blocks of information, which are readily understandable.