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Revision of R 59:

Moisture meters for cereal grain and oilseeds

Part 2: Metrological controls and performance tests (Clean)

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY

Contents

Foreword

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This publication - reference OIML R 59-2, Edition 20xx - was developed by Project Group 1 in Technical Subcommittee TC 17/SC 1. It was approved for final publication by the International Committee of Legal Metrology in 201x and will be submitted to the International Conference of Legal Metrology in 201y for formal sanction. It supersedes the previous edition of R 59 dated 1984.

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Introduction

[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.

[1]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.

[1]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.

This 200X 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 widely vary 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 calibrations 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 2: Metrological controls and performance tests

1 Practical instructions

1.1 Type approval grain samples

The characteristics of the standards (reference materials) shall be representative of the grain being traded in the region. This is particularly important for the assessment of calibrations. Foreign produce, i.e. samples based on grain harvested in another country or region, may not be suitable for the assessment of calibrations due to climatic and crop variability.

The grain samples should be natural; that is, the moisture should not be adjusted by soaking the sample in water or by spraying the sample with water or by extended exposure of the sample to high humidity air, or by any other method of moistening. Sufficient sample size should be available to complete the tests, and satisfy the minimum allowable sample size requirements for the meter and to allow for reference testing.

1.2 Sample records

The sample records should include: the identification number assigned, the date received, source, grain type, moisture, and other pertinent information.

1.3 Sample handling and storage

Upon receipt, the integrity of the moisture-tight sample enclosure should be checked and a new enclosure used if necessary. Most grain samples are to be stored at 2 °C to 8 °C prior to use. Prior to testing, samples shall be removed from cold storage and equilibrated to room temperature. . Except during analysis time, a test sample shall be returned to its enclosure.

1.4 Sample cleaning

The sample must be visibly free from insects, foreign seeds and any other foreign material. The condition of the sample (odour, appearance, damage) is recorded on the sample record. Spatial inhomogeneity in a bulk sample is minimized as much as possible by mixing. The national responsible body may choose to follow specific standards for cleaning grain, such as ISO standards.

1.5 Representative sample size

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

2 Metrological controls

2.1 Units submitted for type test

Manufacturers shall provide the national responsible body with at least two instruments and an operating manual. A manufacturer may also provide data and other information that support a determination of whether the performance of the instrument meets the requirements of this Recommendation.

2.2 Documentation

The documentation submitted with the application for type approval shall include:

(a) description of its general principle of measurement;

(b) lists of the essential sub-assemblies, components (in particular electronics and other essential ones) with their essential characteristics;

(c) mechanical drawings;

(d) electric/electronic diagrams;

(e) installation requirements;

(f) security sealing plan;

(g) panel layout;

(h) software documentation as described in R 59-1, 5.18.3 (as appropriate for severity level 1 validation A procedures);

(i) test outputs, their use, and their relationships to the parameters being measured;

(j) operating instructions provided to the user, documents or other evidence that supports the assumption that the design and characteristics of the measuring instrument comply with the requirements of this Recommendation; and

(k) a list of grains and moisture ranges to be approved using the instrument.

2.3 Type approval

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. The national responsible body shall carry out the tests defined in Annex A to confirm that electronic moisture measuring instruments perform and function as intended in a specified environment and under specified conditions.

2.3.1 Accuracy, repeatability and reproducibility tests

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 shall be tested at 2 % moisture intervals. These tests shall be carried out under reference environmental conditions. The two tests for accuracy are moisture error, i.e. $\overline{y}$, the average of the difference between the meter reading and the reference method, and the standard deviation of this difference, SDD, as defined in A.1.2. The standard deviation, SD, of the sample replicates is used as the measure of the repeatability of the instrument. 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 $\overline{y}$, SDD, SD and SDD_I can be found in Annex A, A.1.

2.3.2 Influence factors tests

During type evaluation, a moisture meter shall be tested for the following influence factors using the applicable reference conditions in R 59-1, 4.1.1. Unless otherwise specified, the national responsible body shall select a single well performing grain type and a 2 % moisture interval for the basic instrument tests. Meter indicated moisture difference determinations shall be made for each influence factor according to the details of the analysis contained in the test procedures in Annex A.

Influence factors	Test procedure section (as appropriate, severity levels are included in the test procedures, Annex A)
Basic instrument tests	
Instrument stability	A.2.2
Instrument warm-up time	A.2.3
Power source variation: voltage* battery voltage* * whichever is appropriate	A.2.4
Instrument storage temperature	A.2.5
Instrument leveling	A.2.6
Instrument humidity sensitivity	A.2.7
Instrument temperature sensitivity	A.2.8
Sample temperature test	
Sample temperature sensitivity	A.3

A description of the performance tests for these influence factors is given in Annex A *Test procedures*.

2.3.3 Disturbance tests

When subjected individually to the disturbances specified in the immunity tests of IEC 61326 (latest revision)[8] and/or recommended disturbances in OIML D 11 the meter shall not exhibit a significant fault as defined in R 59-1, 2.3.14.

Disturbance test	Test procedure section (as appropriate, severity levels are included in the test procedures, Annex A)
AC mains voltage dips, short interruptions and voltage variations	A.4.1 (OIML D 11, 13.4)
Bursts (transients) on AC mains	A.4.2 (OIML D 11, 13.5)
Radiated radiofrequency, electromagnetic susceptibility	A.4.3 (OIML D 11, 12.1.1)
Conducted radiofrequency fields	A.4.4 (OIML D 11, 12.1.2)
Electrostatic discharges	A.4.5 (OIML D 11, 12.2)

2.3.4 Error under rated operating conditions

The type of measuring instrument is presumed to comply with the provisions specified in R 59-1, 4.1 to R 59-1, 4.7 of this Recommendation, if it passes the tests in Annex A, confirming that the error of the measuring instrument does not exceed the maximum permissible error on initial verification specified in R 59-1, 4.4.1 under the reference conditions in R 59-1, 4.1.1.

2.4 Test report

The test 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 Part 3 *Report format for type evaluation*. A specific form may be developed according to national preference. The manufacturer shall be provided specific comments about any test failures.

Annex A

Test procedures

(Mandatory)

General

This Annex defines the program of performance tests intended to ensure that electronic moisture measuring instruments perform and function as intended in a specified environment and under specified conditions. Each test indicates, where appropriate, the reference conditions under which the intrinsic error is determined.

When the effect of one influence quantity or disturbance is being evaluated, all other influence quantities and disturbances are to be held relatively constant, at values close to reference conditions.

The instrument shall be stabilized according to the manufacturer's specifications. If the manufacturer does not recommend a warm-up time, assume that accurate results will be provided immediately after the instrument is turned on.

For testing, the display should allow resolution to 0.01 %.

Specification of grain moisture samples used in type evaluation testing:

- the samples shall be naturally occurring grain. Sample sets should be as homogeneous as possible;
- the test samples of grain shall be clean, sound and fit for purpose;

The tests in A.1 *Accuracy, repeatability, and reproducibility*, A.2 *Basic instrument tests*, and A.3 *Sample temperature sensitivity* are described for two instruments (i.e. two sample units are the equipment under test (EUT). The tests in A.4 are described for one instrument (i.e. one sample unit is the equipment under test).

A.1 Accuracy, repeatability and reproducibility

A.1.1 Sample selection

The testing laboratory shall chose well-performing moisture-stable grain samples comprising three adjacent 2 % moisture intervals within a minimum range of 6 % moisture (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. The national responsible body shall be responsible for determining the variable grains used for conducting testing. Moisture intervals selected should bracket commercially important moisture levels for the grain type. For uniformity of application, each 2 % moisture interval should begin and end with an even number (i.e. the moisture range of 10% to 12% will consist of samples in the moisture range of 10.1 to 12%). The maximum value calculated for a given 2 % moisture interval (i.e. 10 % to 12 %, 12 % to 14 %, 14 % to 16 %) shall be used when calculating the MPEs.

A sample set for accuracy, repeatability and reproducibility shall consist of a minimum of 30 samples with ten samples selected from each 2 % moisture interval. Grain sample sets shall be prescreened for moisture homogeneity by comparing an approved moisture meter result to the result of determinations using the reference moisture method. No sample set shall be used where the standard deviation of the differences (SDD) between the approved moisture meter and the reference method for the samples in any of the 2 % moisture intervals exceed the MPEs defined in column 2 of R 59-1, Table 4.4.1 minus 0.1.

Three replicates will be run on each instrument for each sample, resulting in a total of 180 observations per grain type (2 instruments x 3 moisture intervals x 10 samples x 3 replicates)

A.1.2 Accuracy test

The accuracy test consists of two tests: error determination and SDD. Accuracy acceptance requirements for both are defined in column 2 of R 59-1, Table 4.4.1 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. The two tests for accuracy are moisture error, $\overline{y}$, (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. Each instrument shall be individually tested. The equations for $\overline{y}$ and SDD are given below:

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

where

$\overline{y}$ = average overall 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)

The manufacturer may adjust the calibration bias to compensate for differences from the type evaluation laboratory in reference methods or sample sets.

A.1.3 Repeatability

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 shall be tested individually. The equation used to calculate SD is given below:

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

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 defined in column 4 of R 59-1, Table 4.4.1 for the appropriate 2 % moisture interval.

A.1.4 Reproducibility

Reproducibility between submitted instruments is estimated by calculating the standard deviation of differences, SDD_I over the 6 % moisture range. The equation used to calculate instrument reproducibility is given below:

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

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 defined in column 5 of R 59-1, Table 4.4.1 for the 6 % moisture range.

A.2 Basic instrument tests – influence factors

A.2.1 Sample selection

Unless otherwise specified the following tests shall be performed using a single, stable moisture sample. Throughout the influence factor testing, portions of the grain samples shall be tested to determine that the moisture content is appropriate for the test and that the sample was stable throughout the test. As an example a reference moisture method or master instrument can be used. In any case, the method used to assess the sample stability shall be indicated in the test report.

A.2.2 Instrument stability

Three samples shall be tested, one from each of the three 2 % moisture interval samples of a single grain type (e.g. 10 % to 12 %, 12 % to 14 %, 14 % to 16 %).

Number of repetitions: 5.

The minimum time period for assessing instrument stability shall be four weeks. Each of the 3 samples shall 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 × 5 replicates) shall be recorded. The 3 samples shall be stored and retested once all other type evaluation testing has been completed. The maximum permitted difference between the means of the two tests is defined in column 3 of R 59-1, Table 4.4.1.

A.2.3 Instrument warm-up time

Number of repetitions: 5.

The following test procedures shall 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, test after waiting for the specified warm-up time.

(3) Test after waiting one hour or twice the manufacturer's recommended warm-up time, whichever is greater.

For an instrument where no warm-up time is specified, the sample shall be tested immediately upon the instrument being powered on and then again after 1 hour. The maximum permitted difference between the means of the two tests is defined in column 3 of R 59-1, Table 4.4.1.

A.2.4 Instrument power supply

A.2.4.1 Main voltage variation

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 %

Voltage shall be varied to the above stated levels. Voltage settings shall be determined and recorded to ± 0.1 V. The difference between the mean moisture indication at the nominal voltage and the mean moisture indication at the tested extremes of voltage shall be evaluated.

The maximum permitted difference between the mean moisture meter value at nominal voltage and the mean value determined at the high and low voltage test points is defined in column 3 of R 59-1, Table 4.4.1. The maximum allowable standard deviation of 10 repeat measurements at any of the voltage levels is 0.10 %. For battery-powered devices the SD for 10 repeat measurements for a nominal battery charge is 0.10 %.

Stabilizing period after voltage change: 30 min

A.2.4.2 Low voltage of internal battery (not connected to the mains power)

The test method consists of a variation in the supply voltage. The objective of this test is to verify compliance with the provisions in R 59-1, 4.4.1 under conditions of low battery voltage.

The test procedure consists of exposure to the specified condition of the battery(s) for a period sufficient for achieving temperature stability and for performing the required measurements. If an alternative power source (standard power supply with sufficient current capacity) is used in bench testing to simulate the battery, it is important that the internal impedance of the specified type of battery also be simulated. The maximum internal impedance of the battery shall be specified by the manufacturer of the instrument.

Test sequence:

Stabilize the power supply at a voltage within the defined limits and apply the measurement and/or loading condition. Record the following data:

a) Date and time

b) Temperature

c) Power supply voltage

d) Functional mode

e) Measurements and/or loading condition

f) Indications (as applicable)

g) Errors

h) Functional performance

Reduce the power voltage to the EUT until the equipment clearly ceases to function properly according to the specifications and metrological requirements, and note the following data:

i) Power supply voltage

j) Indications

k) Errors

l) Other relevant responses of the instrument

The severity for this test is level 1. At level 1 the lower limit of the voltage is the lowest voltage at which the EUT functions properly according to the specifications and the number of cycles is at least one test cycle for each functional mode.

A.2.5 Instrument storage temperature

Number of repetitions: 10.

The purpose of this test is to simulate extreme shipping conditions. The national responsible body may specify different temperature limits. A single sample is analyzed ($n = 10$) at reference conditions (5.1.1) prior to temperature cycling. The instrument is then powered down and placed in the environmental chamber. The chamber temperature is then increased to 50 °C or greater as specified by the national responsible body over a 1-hour period and maintained at that temperature for 3 hours. The 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. The instrument is equilibrated at reference conditions (R 59-1, 4.1) 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 shall be determined before and after temperature cycling. The maximum allowable difference in the mean values due to temperature cycling is defined in column 3 of R 59-1, Table 4.4.1.

A.2.6 Instrument leveling

A.2.6.1 Instruments without level indicators

Number of repetitions: 5.

Reference tilt condition: instrument level within 0.1°

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

The test procedure consists of measuring the single sample with the instrument mounted on a level surface (reference alignment); then in each of the two orientations of tilt front-to-back and left to right, at a tilt of 5 %, 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 or master meter before and after the instrument level tests, and the results recorded.

The mean of each replicate measurement shall 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 defined in column 3 of R 59-1, Table 4.4.1.

A.2.6.2 Instruments with level indicators

Meters equipped with leveling indicators shall be tested at the indicated limits of the level indicator (front to back and left to right) rather than the specified tilt in A.2.6.1. Orientations similar to those in A.2.6.1 shall be applied with the same performance requirements.

A.2.7 Humidity

Number of repetitions: 10.

Instruments (power on) shall be placed in an environmental chamber at 22 °C and a relative humidity of 20 % for 16 hours. Samples shall be stored sealed at reference conditions. After equilibration the sample shall then be analyzed in the chamber. The relative humidity shall be raised to 90 % (22 °C) and, after the instrument has equilibrated at this humidity for at least 16 hours, the sample shall again be analyzed.

The mean of each replicate measurement shall be determined for each humidity level. The maximum allowable difference in the mean values between the two humidity levels is defined in column 3 of R 59-1, Table 4.4.1.

A.2.8 Instrument temperature sensitivity (converting to heat test and cold test)

One grain type

Three samples, one from each of the three 2 % moisture intervals of a single grain type (e.g. 10 % to 12 %, 12 % to 14 %, 14 % to 16 %)

Instruments shall 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 0.005 kg of water per kg of dry air. The manufacturer shall 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 shall apply.

Instrument temperature sensitivity tests shall be run using three moisture level samples. Each sample shall be cut into 3 portions for testing at t_R, at t_1, and at t_2 . Instruments shall remain in the chamber throughout cycling to the appropriate temperatures; the sample shall be placed in the test chamber at 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 4 hours prior to sample testing. The mean of each replicate measurement shall 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 0.8 × the value in column 2 of R 59-1, Table 4.4.1.

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. The national responsible body may address these requirements procedurally.

A.3 Sample temperature sensitivity - influence factor test

Three grain 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

Instrument temperature: at reference conditions (5.1.1), reference temperature (t_{ref})

Grain or seed temperatures: reference temperature (t_{ref}), manufacturer declared $t_{ref} \pm \Delta t$ or minimum Δt of ± 10 °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 there is a difference in temperature between the sample and the instrument. The sample temperature sensitivity test shall be conducted using the three grain or seed types comprising three 2 % moisture intervals. For

practical reasons due to the ability to accurately determine the reference value of elevated temperature grain samples, the maximum sample temperature for type approval testing shall be 45 °C.

The grain and seed test temperature shall be according to the manufacturer's specification. If there is no separate specification, the minimum temperature difference requirement shall be ± 10 °C from the reference temperature. Tests shall be conducted with the instrument at reference temperature (t_{ref} , see 5.1.1) and the sample temperature varying from $t_{ref} - \Delta t_C$ to $t_{ref} + \Delta t_H$, where t_{ref} is the reference temperature. The manufacturer's 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 shall $t_{ref} + \Delta t_H$ be allowed to exceed 45 °C for the test.

Three moisture level analyses shall be made for each grain sample at each of the three test temperatures. The means for the 18 observations (2 samples × 3 moisture intervals × 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 2.25 × column 3 of R 59-1, Table 4.4.1. for grain types in row I, otherwise it is 2 × column 3 of R 59-1, Table 4.4.1. for grain types in row II.

A.4 Additional test for electronic instruments - disturbance tests

The tests, which are specific to electronic instruments, as described in this section, are tests from the International Electrotechnical Commission (IEC) and OIML D 11.

The disturbance tests in this section are described for a single instrument, i.e. one sample unit is the equipment under test (EUT). Testing with appropriate measures where the use of grain samples would not be possible or constructive due to the test conditions of the disturbance test is permitted.

References to the IEC publications have been made in each section as appropriate and publication dates for these documents are included in the Bibliography of this Recommendation. When conducting these tests for electronic instruments, the test should be conducted on the basis of the most recent versions valid at the time of testing. The standard and the version date used for the test shall be noted in the test report.

A.4.1 AC mains voltage dips, short interruptions and voltage variations

Standards	IEC 61000-4-11 [21], IEC 61000-6-1 [19], IEC 61000-6-2 [20]
Test method	Short-time reductions in mains voltage
Sample	One sample with mid-range moisture and stable moisture content. Allowable grains are specified by the national responsible body. Wheat is the preferred grain type. Consecutive measurements per sample at each condition: 10
Test procedure in brief	Over four tests, the EUT shall be subjected to voltage reductions and interruptions of varying intensity and duration. A test generator suitable to reduce the amplitude of the AC mains voltage for a defined period of time is used. The performance of the test generator shall be verified before connecting to the EUT. The mains voltage interruptions and reductions shall be repeated with a time interval less than the time required for a single measurement so that at least one voltage interruption occurs per measurement. At least 10 cycles are necessary for each test to enable the required number of measurements. Record the following prior to and during each test: a) moisture measurements; b) indications and errors; and c) functional performance.
Test severity	Test a) U_{nom} to zero for a duration equal to half a cycle of frequency Test b) U_{nom} to zero for a duration equal to one cycle of frequency Test c) U_{nom} to 70 % reduction for a duration equal to 25/30* cycles of frequency Test d) U_{nom} to zero for a duration equal to 250/300* cycles of frequency
Notes	*Values are for 50 Hz and 60 Hz respectively
Requirements	All operational functions shall operate as designed (e.g. indicators). The effect of the disturbance on moisture measurements shall not exceed a significant fault or the instrument shall detect and react to the fault (see R 59-1, 2.3.14 and 2.3.3)

A.4.2 Bursts (Transients) on AC mains

Standards	IEC 61000-4-1 [8], IEC 61000-4-4 [21]
Test method	Electrical bursts
Sample	One sample with mid-range moisture and stable moisture content. Allowable grains are specified by the national responsible body. Wheat is the preferred grain type. Consecutive measurements per sample at each condition: 10
Test procedure in brief	The test consists of subjecting the EUT to bursts of double exponential wave form transient voltages. All bursts shall be applied during the same measurement in symmetrical mode and asymmetrical mode. The characteristics of the burst generator shall be verified before connecting the EUT. The duration of the test shall not be less than 1 min for each amplitude and polarity. The injection network on the mains shall contain blocking filters to prevent the burst energy being dissipated in the mains. Record the following prior to test and during the application of bursts: a) moisture measurements; b) indications and errors; and c) functional performance.
Test severity	Amplitude (peak value): 1 kV Repetition rate: 5 kHz
Number of test cycles	At least 10 positive and 10 negative randomly phased bursts shall be applied at 1000 V. The bursts are applied during all the time necessary to perform a measurement. At least 10 measurements shall be made with the bursts applied.
Requirements	All operational functions shall operate as designed (e.g. indicators). The effect of the disturbance on moisture measurements shall not exceed a significant fault or the instrument shall detect and react to the fault (see R 59-1, 2.3.14 and 2.3.3).

A.4.3 Radiated, radio-frequency, electromagnetic susceptibility

Standards	IEC 61000-4-3 [22]
Test method	Radiated electromagnetic fields
Sample	One sample with mid-range moisture and stable moisture content. Allowable grains are specified by the national responsible body. Wheat is the preferred grain type. One sample with mid-range moisture.
Test procedure in brief	The test procedure involves the exposure of the EUT to electromagnetic field strength as specified by the severity level and field uniformity as defined by the referred standard. The specified field strength shall be established prior to the actual testing (without the EUT in the field). The field shall be generated in two orthogonal polarizations and the frequency range shall be scanned slowly. If antennas with circular polarization (i.e. log-spiral or helical antennas) are used to generate the electromagnetic field, a change in the position of the antennas is not required. When the test is carried out in a shielded enclosure to comply with international laws prohibiting interference on radio communications, care shall be taken to handle reflections from the walls. The frequency ranges to be considered are swept with the modulated signal, pausing to adjust the RF signal level or to switch oscillators and antennas as necessary. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value. The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the EUT to be exercised and to respond, but shall in no case be less than 0.5 s. The sensitive frequencies (e.g. clock frequencies) shall be analyzed separately. Record the following prior to the test and then with radiated EM fields: a) moisture measurements; b) indications and errors; and c) functional performance.
Test severity	EM frequency range: 26 MHz–2 GHz For the frequency range 26–80 MHz, the testing laboratory may carry out the test according to A.4.4 “Conducted RF fields”. Field strength: Radiated 10 V/m Modulation: 80 % AM, 1 kHz sine wave
Requirements	All operational functions shall operate as designed (e.g. indicators). The effect of the disturbance on moisture measurements shall not exceed a significant fault or the instrument shall detect and react to the fault (see R 59-1, 2.3.14 and 2.3.3).
Notes	The EM field can be generated in different facilities, however the use of which is limited by the dimensions of the EUT and the frequency range of the facility: a) the strip line is used at low frequencies (below 30 MHz or in some cases 150 MHz) for small EUT; b) the long wire is used at low frequencies (below 30 MHz) for larger EUT; c) dipole antennas or antennas with circular polarization placed at least 1 m from the EUT are used at high frequencies.

A.4.4 Conducted radio-frequency fields

Standards	IEC 61000-4-6 [16]
Test method	Conducted electromagnetic fields
Sample	One sample with mid-range moisture and stable moisture content. Allowable grains are specified by the national responsible body. Wheat is the preferred grain type. Consecutive measurements per sample at each setting: as many as possible over the sweep across the frequency range.
Test procedure in brief	The test procedure involves the use of radio frequency EM current, simulating the influence of EM fields coupled or injected into the power ports and I/O ports of the EUT using coupling/decoupling devices as defined in the referred standard. The performance of the test equipment consisting of an RF generator, coupling devices, attenuators, etc. shall be verified. Record the following prior to the test and then with conducted EM fields: a) moisture measurements; b) indications and errors; and c) functional performance.
Test severity	EM frequency range: 0.15–80* MHz *For the frequency range 26–80 MHz, the testing laboratory may carry out the test according to A.4.3. However, in case of dispute, the result from the test according to A.4.4 shall prevail. RF amplitude (50 Ω): 10 V (e.m.f) Modulation: 80 % AM, 1 kHz sine wave
Requirements	All operational functions shall operate as designed (e.g. indicators). The effect of the disturbance on the moisture measurement shall not exceed a significant fault or the instrument shall detect and react to the fault (see R 59-1, 2.3.14 and 2.3.3).

A.4.5 Electrostatic discharge

Standards	IEC 61000-4-2 [17]
Test method	Electrostatic discharge (ESD)
Sample	One sample with mid-range moisture and stable moisture content. Allowable grains are specified by the national responsible body. Wheat is the preferred grain type. Consecutive measurements per sample at each condition: 10
Test procedure in brief	A capacitor of 150 PF is charged by a suitable DC voltage source. The capacitor is then discharged through the EUT by connecting one terminal to ground (chassis) and the other via 330 Ω to surfaces which are normally accessible to the operator. The test includes the paint penetration method, if appropriate. For direct discharges, the air discharge shall be used where the contact discharge method cannot be applied. Before starting the tests, the performance of the ESD generator shall be verified. For EUT not equipped with a ground terminal, the EUT shall be fully discharged between discharges. Direct application: In the contact discharge mode to be carried out on conductive surfaces, the electrode shall be in contact with the EUT. In the air discharge mode on insulated surfaces, the electrode is approached to the EUT and the discharge occurs by spark. Indirect application: The discharges are applied in the contact mode to coupling planes mounted in the vicinity of the EUT. Record the following prior to test and then during application of ESDs: a) moisture measurements; b) indications and errors; and c) functional performance.
Test severity	Air discharge voltage: 2, 4, 6, 8 kV Contact discharge voltage: 2, 4, and 6 kV
Number of test cycles	At least one direct discharge and one indirect discharge shall be applied during the one measurement. At least 10 deliveries shall be made with the discharges applied. The time interval between successive discharges shall be at least 10 seconds.
Requirements	All operational functions shall operate as designed (e.g. indicators). The effect of the disturbance on the moisture measurement shall not exceed a significant fault or the instrument shall detect and react to the fault (see R 59-1, 2.3.14 and 2.3.3).