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EXPLANATORY NOTE

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FOREWORD

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This publication - reference OIML R 61-1 and -2, Edition XXX - was developed by Technical Subcommittee TC 9/SC 2 *Automatic weighing instruments*. It was approved for final publication by the International Committee of Legal Metrology in XXX and will be submitted to the International Conference of Legal Metrology in XXX for formal sanction. It supersedes the previous edition of R 61-1 (2004).

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Automatic gravimetric filling Instruments

Part 2 – Test procedures

1 Introduction

This OIML Recommendation consists of 3 separate parts:

- Part 1: Metrological and Technical Requirements
- Part 2: Test procedures
- Part 3: Report Format for Type Evaluation

2 Scope

This part of OIML R 61 (OIML R 61-2:xxx) is applicable to the type evaluation and initial verification testing of ~~for~~ automatic gravimetric filling instruments (hereafter referred to as “AGFI(s)”), as defined in 3.2.2 in OIML R 61-1:xxx.

OIML R 61 sets out details of the test program, principles, equipment and procedures to be used for type evaluation and initial verification testing. OIML Certificates of Conformity can be issued for automatic gravimetric filling instruments under the scope of the OIML Certificate System, provided that this part of OIML R 61, OIML R 61-1:xxx and OIML R 61-3:xxx are used in accordance with the rules of the System.

The provisions of this part of OIML R 61 also apply to ancillary devices, if required by national regulations.

3 Terms and definitions

For the purposes of OIML R 61, the terms and definitions given in ~~clause 3 of~~ OIML R 61-1, 3 apply.

4 Symbols, units and equations

Symbols used in this part of OIML R 61, are defined in OIML R 61-1, 3.8.

5 Examination for type evaluation

5.1 Documentation

Review the documentation that is submitted to determine if it is adequate and correct. For type evaluation the documentation shall be as specified in OIML R 61-1, 8.2.1.

5.2 Compare construction with documentation

Examine the various devices of the AGFI to ensure compliance with the documentation in accordance with OIML R 61-1, 5 and 8.2.1.

5.3 Metrological requirements

Record the metrological characteristics using the checklist in the report format for type evaluation OIML R 61-3.

5.4 Technical requirements

Examine the AGFI for conformity with the technical requirements according to OIML R 61-1, 5, using the checklist in the report format for type evaluation OIML R 61-3.

5.5 Functional requirements

Examine the AGFI for conformity with functional requirements according to OIML R 61-1, 6 and 7, using the ~~checklist in the~~ report format for type evaluation OIML R 61-3 **and in accordance with the test program in 5.6.**

6 Examination for initial verification

6.1 Compare construction with documentation

Examine the AGFI for conformity with the approved type according to OIML R 61-1, 8.3.1.

6.2 Descriptive markings

Check the descriptive markings in accordance with OIML R 61-1, 5.12, using the checklist in the report format for type evaluation OIML R 61-3.

7 General test requirements

7.1 Power supply (OIML R 61-1, 4.8.3)

Power up the equipment under test (EUT) for a time period equal to or greater than the warm-up time specified by the manufacturer and maintain the EUT energised for the duration of each test.

7.2 Zero-setting (OIML R 61-1, 5.8)

Using the manual or semi-automatic zero-setting facility, adjust the EUT as closely as practicable to zero prior to each test, and do not readjust it at any time during the test, except to reset if a significant fault has been indicated.

Status of automatic zero devices shall be as specified for each test.

7.3 Temperature (OIML R 61-1, 4.8.2)

The tests shall be performed at a steady ambient temperature, usually normal ambient temperature unless otherwise specified. The temperature is deemed to be steady when the difference between the extreme temperatures noted during the test does not exceed one-fifth of the temperature range of the AGFI without being greater than 5 °C, and the rate of change does not exceed 5 °C per hour.

The handling of the AGFI shall not result in condensation of water on the AGFI.

7.4 Recovery

After each test the AGFI shall be allowed to recover sufficiently before the next test.

7.5 Pre-loading

Before each static and influence factor test the AGFI shall be pre-loaded once to Max, except for the tests in 10.2.1 (warm-up time) and 10.2.3 (temperature effect on no-load).

7.6 Control instruments (OIML R 61-1, 3.2.2.4 and 5.13.3)

7.6.1 Accuracy of test system (8.2.4)

Weighing systems for performing the tests with actual products (material tests) which include the control instrument and standard weights used for weighing the test loads and fills are required not to have an error exceeding one third of the mpd and mpse (as appropriate) of for the AGFI in accordance with 8.2.4 and 8.2.5 OIML R 61-1, 4.3.2 and 4.3.3.

~~Note: Accuracy requirements for the test system depend on the error limitation which depends on the accuracy class. However the class is determined from the results of the tests. It is therefore necessary that the metrological authority responsible for testing should be informed of the best accuracy class that may be achieved, prior to commencement of testing.~~

7.6.2 Use of standard weights to assess rounding error of indication

7.6.2.1 General method to assess error of indication prior to rounding

For AFGIAGFIs with digital indication having a scale interval d , changeover points may be used to interpolate between scale intervals i.e. to determine the indication of the instrument, prior to rounding, as follows.

At a certain load, L , the indicated value, I , is noted. Additional weights of say $0.1 d$ are successively added until the indication of the AGFI is increased unambiguously by one scale interval ($I + d$). The additional load ΔL added to the load receptor gives the indication, P , prior to rounding by using the following formula:

$$P = I + 0.5 d - \Delta L$$

The error prior to rounding is: $E = P - L = I + 0.5 d - \Delta L - L$

Example: An AFGIAGFI with a scale interval, d , of 5 g is loaded with 1 kg and thereby indicates 1 000 g. After adding successive weights of 0.5 g, the indication changes from 1 000 g to 1 005 g at an additional load of 1.5 g. Inserted in the above formula these observations give:

$$P = (1\,000 + 2.5 - 1.5) \text{ g} = 1\,001 \text{ g}$$

Thus the true indication prior to rounding is 1 001 g, and the error of indication prior to rounding is:

$$E = (1\,001 - 1\,000) \text{ g} = +1 \text{ g}$$

7.6.2.2 Correction for error at zero

Evaluate the error at zero load, (E_0) by the method of 7.6.2.1.

Evaluate the error at load L , (E) by the method of 7.6.2.1

The corrected error prior to rounding, (E_c) is: $E_c = E - E_0$

For the example in 7.6.2.1, the error calculated at zero load was: $E_0 = +0.5 \text{ g}$,

the corrected error is: $E_c = +1 - (+0.5) = +0.5$

Zero-tracking has to be switched off or procedure as per 9.2.3.2 “note” has to be followed.

7.7 Indication of a digit smaller than d

If an ~~AFI~~AGFI with digital indication has a device for displaying temporarily the indication with a smaller scale interval (not greater than $0.2 d$), this device may be used to determine the error. If a device is used, it should be noted in the Test Report.

Note: Such indication is only for test purposes.

7.8 Test program

7.8.1 Type evaluation (OIML R 61-1, 8.2.2 and 8.2.3)

The following tests shall normally be applied for type evaluation:

- a) Examination for type evaluation in 5,
- b) Static tests in 9,
- c) Influence factor and disturbance tests in 10,
- d) Span stability test in 11, and
- e) Material tests in 12.4

7.8.2 ~~Place~~Location of testing for type evaluation

AGFIs submitted for type evaluation may be tested either:

- a) On the premises of the metrological authority to which the application has been submitted, or
- b) In any other suitable ~~place~~location agreed between the metrological authority concerned and the applicant.

7.8.3 Non-automatic weighing instruments (OIML R 61-1, 23.6.1)

If the weighing function is provided by a non-automatic weighing instrument that has been approved in respect of conformity with OIML R 76 [6], the tests specified in 7.8.1 (except 12.1) may be omitted where equivalent test results specified in OIML R 76 [6] prove conformity with the relevant parts of OIML R 61. Use of OIML R 76 [6] test results shall be recorded in the test report checklist and summary in OIML R 61-3.

7.8.4 Initial verification (OIML R 61-1, 8.3)

The following tests shall normally be applied for initial verification:

- a) Examination for initial verification in 6, and
- b) Material tests at initial verification in 12.2.

Static weighing test method (9.3) may also be used if necessary to verify the indicator for the integral verification method of material tests.

If the AGFI is liable to be tilted or is not fitted with a levelling device and a level indicator, the test in 10.2.9 shall also be performed.

8 Test methods

8.1 Determination of the mass of individual fills

The mass of individual fills is determined using either the separate verification method in 8.5.1 or the integral verification method in 8.5.2.

8.2 Conducting of material tests

8.2.1 Values of the mass of the fills

- a) The tests shall be carried out ~~on using~~ fills ~~with representing~~ loads at, or near to, ~~the~~ Max and also at, or near to, the Minfill of the AGFI, ~~and if Min is different from Minfill fills with loads at, or near to Min.~~
- b) Cumulative weighers shall be tested as in a) with the maximum practical number of loads per fill and also with the minimum number of loads per fill, and ~~associative~~ ~~selective combination~~ weighers with the average (or optimum) number of loads per fill (R 61.1, 3.4.10).
- c) If the Minfill is less than one third of the Max~~fill~~ then tests shall also be carried out at a value near the centre of the load weighing range, at values close to, but not above, 100 g, 300 g, 1 000 g or 15 000 g, as appropriate.

Note: Test fills for some values defined here above may be impossible to obtain or use due to particular conditions on packing lines. Such conditions and the impossibility to perform the test shall be documented and reported on corresponding test or evaluation reports.

8.2.2 Type of materials for the test loads

For type evaluation, the materials used for test loads shall be representative of a product for which the AGFI is designed (R 61-1, 8.2.3.1) and for initial verification and in-service material used for test loads shall be products for which the AGFI is intended (R 61-1, 8.3.2).

8.2.3 ~~Condition~~ Conducting of tests

All tests shall be conducted with any adjustable parameter critical to metrological integrity, e.g. final feed time or rate, set to the most onerous condition allowed by the manufacturer's printed instructions and incorporated in the descriptive markings.

Prior to the start of a new test the AGFI shall be operated for a time period under normal operating conditions to enable stability, i.e. until all the principal parts, devices and parameters such as warm-up, temperature, indications, etc, critical to metrological integrity have stabilized according to the manufacturer's printed instructions. During this stabilization period the fills shall not be included in the test.

Any correction device, e.g. material flow correction, automatic zero-setting fitted to an AGFI, etc shall be operated during the tests according to the manufacturer's printed instructions.

The initial fills after the change between Max and Min shall be included in the test unless the AGFI bears a clear warning to discard the stated number of fills after a change to the AGFI's settings.

8.3 Number of fills

The minimum number of individual test fills depends upon the preset value (F_P) as specified in Table 1.

Table 1- Number of test fills					
Preset value of the fills F_P (kg)					Minimum number of test fills (n)
	<	F_P	\leq	1 kg	60 fills
1 kg	<	F_P	\leq	10 kg	30 fills
10 kg	<	F_P	\leq	25 kg	20 fills
25 kg	<	F_P			10 fills

Where 2 or more AGFIs are integrated in a carousel, the maximum number of test fills shall be the greatest of either:

- a) $4 \times N$, or
- b) the values given in Table 1.

where N is the number of filling stations in the machine.

8.4 Accuracy of standards

The control instrument and standard weights used in testing shall ensure the checking of the test fills to an error not greater than one third of the mpd and mpse (as appropriate) for automatic weighing (see OIML R 61-1, 4.3.2 and 4.3.3).

Note: It is advised to verify the correct and adequate operation of the control instrument or the device used for control purposes prior to executing the material test

8.5 Material test methods

8.5.1 Separate verification method

The separate verification method requires the use of a (separate) control instrument (details as given in 7.6, and OIML R 61-1, 5.13.3.2.2.4) to find the conventional value of the mass of the test fill.

8.5.2 Integral verification method

With this method the AGFI being tested is used to determine the conventional value of the mass of the test fill. The integral verification method shall be conducted using either:

- a) An appropriately designed indicating device, or
- b) An indicating device with standard weights to assess the rounding error.

Note 1: The integral verification method depends on determining the mass of the loads. The error limits (OIML R 61-1, 4.3) are for the mass of the fill. If it is not possible

to ensure that in normal operation all the load is discharged at each cycle of operation, i.e. that the sum of the loads is equal to the fill, then the separate verification method (8.5.1) must be used.

Note 2: When using the integral verification method for a cumulative weighing instrument a sub-division of the test fill is unavoidable. When calculating the conventional value of the mass of the test fill, it is necessary to consider the increased uncertainty due to the division of the test fill.

8.5.2.1 Interruption of automatic filling operation

An automatic filling operation of a test fill shall be initiated as for normal operation. However the automatic operation shall be interrupted twice during each filling cycle in the following conditions:

- a) on the AGFI where the fill is weighed in the load receptor
 - after filling the load receptor (1)
 - after discharge of the load receptor (2)
- b) on the AGFI where the load is weighed in a container on the load receptor
 - after tare balancing the empty container (2)
 - after filling the container (1)
- c) on a subtractive weigher
 - after tare balancing the filled load receptor (1)
 - after discharge of the fill from the load receptor (2)

An automatic filling operation shall not be interrupted during consecutive weighing cycles if the interruption would significantly affect the mass of the fill. In this case, one or two fills shall be discharged in automatic operation without being checked, between the fills that are checked.

(1) Pre-discharge (full) interrupt

The automatic operation shall be interrupted immediately after the feed of material has ceased and the load receptor(s), or the container on the load receptor has been filled, or on a subtractive weigher the filled load receptor has been tare balanced.

When the load receptor(s) has (have) stabilized, the net weight of the fill indicated or determined by balancing with standard weights shall be recorded and the AGFI switched back to automatic operation.

(2) Post-discharge (empty) interrupt

The automatic operation shall be interrupted after the load(s) has (have) been discharged, or a new container has been placed on the load receptor and its weight has been tare balanced, and the load receptor(s) is (are) ready to receive a further load. When the load receptor(s) has (have) stabilized, the empty load receptor weight indicated or determined by balancing with standard weights shall be recorded and the AGFI switched back to automatic operation.

8.6 Preset value

The indicated preset value of the average and deviation fill shall be noted where applicable if applicable.

8.7 Mass and average mass value of the test fills

The test fill shall be weighed on a control instrument and the result shall be considered as being the conventional mass value of the test fill. The average value of all the test fills shall be calculated and noted.

8.8 Deviation for automatic weighing

The deviation for automatic weighing used to determine compliance of each fill with the maximum permissible deviation for automatic weighing (OIML R 61-1, 4.3.1) shall be the difference between the conventional value of the mass of the test fill (8.7) and the average value of all the fills in the test.

8.9 Preset value error for automatic weighing

The preset value error for automatic weighing used to determine compliance with OIML R 61-1, 4.3.3 shall be the difference between the average value of the conventional mass value of the test fills (8.7) and the preset value of the fills.

9 Static tests (type evaluation stage)

9.1 General (OIML R 61-1, 8.2.2 and 8.2.3.2)

AGFIs or instrument simulators are required to have a load indicator, or an interface allowing access to a quantity that can be adjusted to provide an indication of load so that the effect of influence quantities may be tested and the reference accuracy class determined. This facility also enables testing of warm-up time and zero-setting and tare devices ~~where applicable~~ if applicable. The static weighing tests are normally done as part of influence quantity testing.

The limits of error for warm-up time tests and the accuracy of zero- and tare-setting tests (OIML R 61-1, 4.3) are evaluated after Ref(x) has been determined (OIML R 61-1, ~~8.2.5~~ 8.2.4).

9.2 Zero-setting and tare devices (OIML R 61-1, 5.8)

9.2.1 General

Zero and tare functions shall be tested separately unless it is proven that the same hardware and software routines are involved.

Zero-setting and taring may be by more than one mode, for example:

- a) Nonautomatic or semi-automatic,
- b) Automatic at switch-on,
- c) Automatic at start of automatic operation,
- d) Automatic at programmable time intervals,
- e) Automatic as part of weighing cycle.

It is normally only necessary to test the accuracy of zero-setting and taring in one mode if it is clear that the same process is used for each mode. If zero-setting or taring is set as part of the automatic weighing cycle then this mode shall be tested. To test automatic zero-setting or taring it is necessary to allow the AGFI to operate through the appropriate part of the automatic cycle and then to halt the AGFI before testing.

The range and accuracy of zero-setting shall be tested by applying loads as specified below in nonautomatic (static) operation to the load receptor after the AGFI is halted.

9.2.2 Range of zero-setting

9.2.2.1 Initial zero-setting

- (a) Positive range

With the load receptor empty, set the AGFI to zero by switching it off and on. Place a test load on the load receptor and set the AGFI to zero again. Continue this process until it does not reset to zero. The maximum load that can be re-zeroed is the positive portion of the initial zero-setting range.

(b) Negative range

- 1) Remove any load from the load receptor and set the AGFI to zero. Then, if possible, remove any non-essential components of the load receptor. If, at this point, the AGFI can be reset to zero **by switching the AGFI off and on with the zero setting device**, the mass of the non-essential components is used as the negative portion of the initial zero-setting range.
- 2) If the AGFI cannot be reset to zero with the non-essential components removed, add loads to any live part of the scale until the AGFI indicates zero again.
- 3) Then remove the loads and, after each load is removed, reset to zero **by switching the AGFI off and on**. The maximum load that can be removed while the AGFI can still be reset to zero is the negative portion of the initial zero-setting range.
- 4) The initial zero-setting range is the sum of the positive and negative portions.
- 5) Alternatively, if it is not possible to test the negative range of initial zero setting by removing parts of the AGFI, the instrument may be temporarily re-adjusted with a test load applied before step (3) above. (The test load applied for the temporary re-adjustment should be greater than the permissible negative portion of the initial zero setting range which can be calculated from the result of the positive range test).
- 6) If it is not possible to test the negative portion of the initial zero-setting range by these methods then only the positive part of the zero-setting range need be considered.
- 7) Reassemble or re-adjust the AGFI for normal use after the above tests.

9.2.2.2 Automatic zero-setting range

Remove the non-essential parts of the load receptor or re-adjust the AGFI as described in 9.2.2.1 and place weights on the live part of the scale until it indicates zero.

Remove weights in small amounts and after each weight is removed allow the AGFI to operate through the appropriate part of the automatic cycle so as to see if the AGFI is reset to zero automatically.

The maximum load that can be removed so the AGFI can still be reset to zero is the zero-setting range.

9.2.3 Accuracy of zero-setting and taring**9.2.3.1** Accuracy of zero-setting

- a) When the load receptor is empty, zero the AGFI in a mode as determined by 9.2.1.
- b) Add load(s) to the load receptor to determine the additional load at which the indication changes from zero to one scale interval above zero.
- c) Calculate the error at zero according to the method described in 7.6.2.1.
- d) Verify that the zero-setting error is within the limit specified in OIML R 61-1, 5.8.2

Note: The zero tracking device shall be switched off or made inactive. The latter may be achieved e.g. by loading with 10 d. Then the additional load at which the indication changes from one scale interval to the next above is determined and the error is calculated according to the description in 7.6.2.1. It is assumed that the error at zero load would be equal to the error at the load in question.

9.2.3.2 Accuracy of zero-setting at ~~taring~~ tare

The weighing tests should be performed on instruments with subtractive tare: with one tare value at 2/3 of maximum tare. ~~Accuracy of the tare device shall be tested at the maximum tare as specified by the manufacturer.~~

- Place the maximum tare load on the load receptor, operate the tare function key immediately in a mode as determined by 9.2.1 to enable the equilibrium device to release the tare function.
- Add load(s) to the load receptor to determine the additional load at which the indication changes from zero to one scale interval above zero.
- Calculate the error according to the method described in 7.6.2.1.
- Verify that the zero-setting error is within the limit specified in OIML R 61-1, 5.8.2

~~Note: The zero tracking device shall be switched off or made inactive. The latter may be achieved e.g. by loading with 10 d. Then the additional load at which the indication changes from one scale interval to the next above is determined and the error is calculated according to the description in 7.6.2.1. It is assumed that the error at zero load would be equal to the error at the load in question~~

9.3 Static weighing test method for type evaluation (OIML R 61-1, 8.2.3)

Apply test loads from zero up to and including Max, and similarly remove the test loads back to zero. The test loads selected shall include values close to Max and Min and other critical loads as specified in ~~9.2.2.18.2.1~~ c, subject to requirements of this Recommendation.

Determine the error at each test load, using the standard weights assessment procedure of 7.6.2, if necessary, to obtain the accuracy of the test system as specified in 7.6.1.

It should be noted that when loading or unloading, the load shall be progressively increased or progressively decreased.

9.4 Determination of reference accuracy class, Ref(x) (OIML R 61-1, 8.2.4)

The static weighing tests during application of influence factors (as appropriate) shall be used at type evaluation stage to establish the reference value for accuracy class, i.e. Ref(x), as follows:

- Perform static weighing tests for influence factors and loads as specified in ~~this Recommendation~~ OIML R 61.
- Determine the mpe for influence factor tests for class X(1), ~~-mpe₍₁₎~~ for each load as follows:

$mpe_{(1)} = 0.25 \text{ mpd}_{(1)} \times (p_i \text{ if applicable})$ in-service ~~for the fill value equal to the load.~~

For example, with a load of 10 kg, the mpe for influence factor tests as specified in OIML R 61-1, 4.3.2 will be calculated thus:

$$mpe_{(1)} = p_i \times 0.25 \times 1.5 \times 10^2 \times 10 \text{ kg} = p_i \times 37.5 \text{ gmpe}_{(1)} = p_i \times (0.25 \times 1.5 \% \times 10,000 \text{ g})$$

where

p_i (as specified in OIML R 61-1, 8.2.3.3) is a fraction of the mpe applied to a part of the AGFI which is examined separately

c) (Calculate $[| \text{Error} | / mpe_{(1)}]$ for each load

where:

Error is the **error** corrected **for the** error at zero load (see 7.6.2.2).

d) From (c) determine the maximum value of $[| \text{Error} | / mpe_{(1)}]$ for all the influence factor tests,

i.e., $[| \text{Error} | / mpe_{(1)}]_{\text{Max}}$ for all influence factor tests

e) Determine Ref(x) such that:

$$x \geq [| \text{Error} | / mpe_{(1)}]_{\text{Max}} \text{ and}$$

$$\text{Ref}(x) = 1 \times 10^k, 2 \times 10^k, \text{ or } 5 \times 10^k,$$

the index k being a positive or negative whole number or zero. Fault limit values shall then be calculated from the mpd for the reference class (OIML R 61-1, Table 2).

10 Influence factor and disturbance tests

10.1 Test conditions

10.1.1 General requirements

Prior to a test, the error at zero shall be assessed and corrected by the methods given in 7.6.2 and in 7.6.2.2.

Influence factor (OIML R 61-1, 6.5) and disturbance tests (OIML R 61-1, 6.2) are intended to verify that AFGIAGFIs can perform and function as intended under the conditions specified for the environment. Each test indicates, where appropriate, the reference condition under which the intrinsic error is determined.

It is generally not possible to apply the influence factors or disturbances to AGFIs which are processing material automatically. The AGFI shall therefore be subjected to the influence factors or disturbances under static conditions or simulated operation as defined herein. The permissible effects of the influence factors or disturbances, under these conditions, are specified for each case.

When the effect of one influence factor is being evaluated, all other factors are to be held relatively constant, at a value close to normal. After each test the AGFI shall be allowed to recover sufficiently before the following test.

Where parts of the AGFI are examined separately, errors shall be apportioned in accordance with details given in OIML R 61-1, 8.2.3.3.

For AGFIs incorporating the typical modules (OIML R 61-1, 3.3.11) the fractions p_i may have the values given in Table 2, which takes into account the fact that the modules are affected in a different manner depending on the different performance criteria.

Table 2 Fraction of p_i applicable to each performance criteria of the three modules of AGFIs using analogue load cell.

Performance criteria	Load cell	Electronic indicator	Connecting elements, etc.
Combined effect ¹	0.7	0.5	0.5
Temperature effect on no load indication	0.7	0.5	0.5
Voltage supply variation	-	1	-
Effect of creep	1	-	-
Damp heat	0.7 ²	0.5	0.5
Span stability	-	1	-
Note 1: Combined effects: non-linearity, hysteresis, temperature effect on span, repeatability, etc. After the warm-up time specified by the manufacturer, the combined effect error fractions apply to modules.			
Note 2: According to OIML R 60 [5] valid for SH or CH tested load cells ($p_{LC} = 0.7$).			

Note 3: The sign “—” means “not applicable”.
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The operational status of the AGFI or simulator shall be recorded for each test.

When the AGFI is connected in other than a normal configuration, the procedure shall be mutually agreed on by the approving authority and the applicant.

10.1.2 Simulated set-up~~Simulator~~ requirements

10.1.2.1 General

The ~~simulated set-up~~ simulator for influence factor and disturbance tests should include all electronic devices of the weighing system.

10.1.2.2 Load cell

A number of tests can be performed with either a load cell or a simulator but both have to fulfill the requirements in the following paragraph. However the disturbance tests should be performed with a load cell or a weighing platform with load cell being the most realistic case.

If a simulator is used to test a module, the repeatability and stability of the simulator should make it possible to determine the performance of the module with at least the same accuracy as when a complete AGFI is tested with weights, the mpe to be considered being those applicable to the module. If a simulator is used, this shall be noted in the report format for type evaluation OIML R 61-3.

10.1.2.3 Interfaces (details as given in OIML R 61-1, 6.9)

Susceptibility or improvements that would result from the use of electronic interfaces or peripheral equipment shall be simulated in the tests.

10.1.2.4 Documentation

Simulators shall be defined in terms of hardware and functionality by reference to the AGFI under test, and by any other documentation necessary to ensure reproducible test conditions.

This information shall be attached to, or be traceable from the test report.

10.2 Influence factor tests

Summary of influence factor tests

§	Test	Characteristic under test	Conditions applied
10.2.1	Warm-up time	Influence factor	mpe
10.2.2	Temperature with static load	Influence factor	mpe
10.2.3	Temperature effect on no-load indication (dry heat and cold)	Influence factor	mpe
10.2.4	Damp heat test, steady state	Influence factor	mpe
10.2.5	AC mains voltage variation	Influence factor	mpe
10.2.6	DC mains voltage variation	Influence factor	mpe
10.2.7	Low voltage of internal battery (not connected to the mains power)	Influence factor	mpe
10.2.8	Power from external 12 V and 24 V road vehicle batteries	Influence factor	mpe
10.2.9	Tilting	Influence factor	mpe

Note: Although IEC Standards are mentioned, the requirements of OIML R 61 have to be fulfilled. Differences should be taken into account.

10.2.1 Warm-up time (OIML R 61-1, 6.8)

This test is to verify that metrological performance is maintained in the period immediately after switch-on. The method is to check that automatic operation is inhibited until a stable indication is obtained and to verify that the zero variation and the errors at Max comply with the specified requirements during the first 30 minutes of operation. If the zero is set as part of the normal automatic weighing cycle then this function shall be enabled or simulated as part of the test.

Other test methods which verify that metrological performance is maintained during the first 30 minutes of operation may be used.

- a) Disconnect the AGFI from the power supply for a period of at least 8 hours prior to the test.
- b) Reconnect the AGFI and switch on while observing the load indicator.
- c) Check that it is not possible to initiate automatic weighing until the indicator has stabilized.
- d) As soon as the indication has stabilized, set the AGFI to zero if this is not done automatically.
- e) Determine the error at zero by the method of 7.6.2.1, and specify this error as E_{0i} (error of initial zero-setting) at first and as E_0 (zero-setting error) when repeating this step.
- f) From (e) verify that E_{0i} is not greater than the mpe specified in OIML R 61-1, 5.8.2.
- g) Apply a static load close to Max. Determine the error by the method of 7.6.2.1 and 7.6.2.2.
- h) Repeat steps (e), (f) and (g) (every minute within the first 5 minutes, between 5 and 15 minutes every two minutes, after 15 minutes take the readings every five minutes. Observe whether the drift has stopped after 30 minutes. If not, continue taking the readings until warm-up process has completely finished and the indication both at zero and Max remain stable (show no further drift).
- i) From (g) and (h) verify that:
 - 1) The error (corrected for zero error) for a static load close to Max is not greater than the mpe specified in OIML R 61-1, 5.8.2,
 - 2) After each time interval the zero-variation error ($E_0 - E_{0i}$) is not greater than the mpe specified in OIML R 61-1, 5.8.2.

10.2.2 Temperature test with static load (OIML R 61-1, 4.8.2.1)

(See Figure 1 below as a practical approach to performing the temperature tests)

Table 3a Temperature test (dry heat and cold)

Applicable standards	IEC 60068-2-1 [8], IEC 60068-2-2 [9], IEC 60068-3-1 [10]
Test method	Gradual exposure to high and low temperatures not allowing condensation to occur
Applicability	General
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 4.3.2 under conditions of high and low temperature specified in OIML R 61-1, 4.8.2.1
Precondition	The electrical power of the EUT is switched on for at least a 16 hours time period while taking into account the warm-up time specified by the manufacturer.
Condition of the EUT	<p>The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test.</p> <p>This test may be combined with test on temperature effect on no-load indication.</p> <p>In such case the automatic zero-setting or zero-tracking, where available, shall not be enabled.</p> <p>When this test is not combined with the test on temperature effect on no-load indication the automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation</p>
Test procedure in brief	<p>The test comprises exposure to the specified high temperature under “free air” conditions during the period of at least 2 hours (the period specified is the period following the moment at which the EUT has reached temperature stability). “Free air” conditions meaning sufficient air circulation to keep the temperature at a stable level.</p> <p>The change in temperature shall not exceed 1 °C/min during heating up and cooling down. The stabilizing time at each temperature is at least 2 hours.</p> <p>The absolute humidity of the test atmosphere shall not exceed 20 g/m³. When tests are performed at temperatures below 35 °C, the relative humidity shall not exceed 50 %.</p> <p>Temperature sequence:</p> <ol style="list-style-type: none"> 1) Reference temperature of 20 °C 2) Specified high temperature 3) Specified low temperature 4) Temperature of 5 °C if the specified low temperature is ≤ 0 °C, and 5) Reference temperature of 20 °C
Notes	Adjust the EUT as close to zero indication as practicable to ensure that the test result is unaffected by the automatic zero-

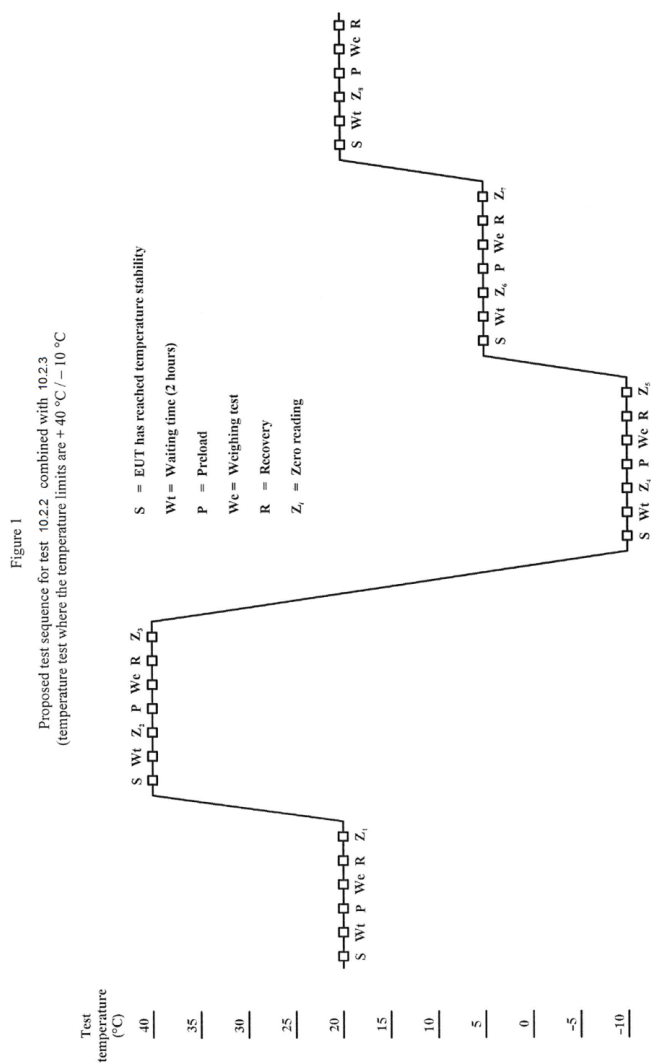
	setting function which should therefore be disabled.
EUT performance	After stabilization at the relevant temperature and again at each specified temperature conduct the following: The EUT shall be tested with at least five different static test loads (or simulated loads) including Max and Min capacities. When loading or unloading weights the load has to be respectively increased or decreased monotonically record the following data: a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance
Permitted maximum deviation	All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in OIML R 61-1, 4.3.2

10.2.3 Temperature effect on no-load indication (dry heat and cold) (OIML R 61-1, 4.8.2.3)

Table 3b Temperature test at no load condition (dry heat and cold)

Applicable standards	IEC 60068-2-1 [8], IEC 60068-2-2 [9], IEC 60068-3-1 [10]
Test method	Gradual exposure to high and low temperatures not allowing condensation to occur
Applicability	General applicable. This test should not be performed for AFGI AGFI that have automatic zero - setting as part of every automatic weighing cycle. This test may be combined with the general temperature test specified above.
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 4.3.2 under conditions of high and low temperature specified in OIML R 61-1, 4.8.2.3
Precondition	The electrical power of the EUT is switched on for at least a 16 hours time period while taking into account the warm-up time specified by the manufacturer.
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall not be enabled.
Test procedure in brief	The AFGI AGFI is set to zero, the temperature is then changed to the prescribed highest and lowest temperatures as well as at 5 °C. After stabilization, the error of the zero indication is determined. The change in zero indication per 5 °C is calculated. The changes of these errors per 5 °C are calculated for any two consecutive temperatures of this test. Temperature sequence:

	<ol style="list-style-type: none"> 1) Reference temperature of 20 °C 2) Specified high temperature 3) Specified low temperature 4) Temperature of 5 °C if the specified low temperature is \leq 0 °C, and 5) Reference temperature of 20 °C <p>After the first time setting at reference temperature and stabilization the EUT is set to zero.</p>
Note	Performing a test for verification of the clause 4.8.2.3 is not required in case of automatic zero-setting as part of every weighing cycle.
EUT performance	<p>Determine the error at zero, each time just before changing to a next temperature level.</p> <p>After stabilization at each specified temperature conduct the following:</p> <ul style="list-style-type: none"> - determine the error at zero indication and - calculate the change in zero indication per 5 °C. <p>These zero error gradients (per 5 °C) shall be calculated for any two consecutive temperatures of this test.</p> <p>At each temperature record the following data:</p> <ol style="list-style-type: none"> a) date and time, b) temperature, c) relative humidity, d) zero error, e) calculated zero error gradient
Permitted maximum deviation	<p>All functions shall operate as designed.</p> <p>The change in zero indication shall over a temperature difference of 5 °C not vary by more than the maximum permissible error specified in OIML R 61-1, 4.3.2 for the Minfill of the AGFI.</p>



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10.2.4 Damp heat test**10.2.4.1 Damp heat, steady state test (non-condensing) (OIML R 61-1, 4.8.1, 6.5)**

The tests in 10.2.4.1 or 10.2.4.2 may be performed alternatively in accordance with R 61-1, 4.8.1, the option chosen being mentioned in the type approval certificate. ~~Damp heat, steady state test in Table 4 is performed in accordance with OIML R 61-1, 4.8.1.~~

Table 4a Damp heat, steady-state (non condensing)

Applicable standards	IEC 60068-2-78 [11], IEC 60068-3-4 [12]	
Test method	Exposure to damp heat in steady-state	
Applicability	This test is considered general applicable where the AFGI AGFI is expected to be used in a non-controlled climatic environment, where adsorption or absorption play the main part.	
Object of the test	Verification of compliance with the provisions in R 61-1, 4.3.2 under conditions of high humidity and constant temperature specified in OIML R 61-1, 4.8.1.	
Precondition	The electrical power of the EUT is switched on for at the warm-up time specified by the manufacturer.	
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.	
Test procedure in brief	<p>A complete weighing test in accordance with 8.2 and 9.3. The EUT shall be tested with at least five different static test loads (or simulated loads) including Max and Min capacities. The test comprises exposure to the specified high level temperature and the specified constant relative humidity for a certain fixed period of time as defined by the test level chosen.</p> <p>The EUT shall be handled such that no condensation of water occurs on it.</p> <p>Climate test sequence:</p> <ol style="list-style-type: none"> 1. Set at reference temperature of 20 °C and at 50 % relative humidity, 2. Maintain for 3 hours at reference temperature of 20 °C and 50 % relative humidity, 3. Set at specified high temperature at 85 % relative humidity, 4. After reaching high temperature at 85 % relative humidity maintain during 48 hours this high temperature and humidity. Maintain during 48 hours this high temperature and 85 % relative humidity, 5. Set at reference temperature of 20 °C and at 50 % relative humidity, 6. Maintain for 3 hours at reference temperature at 50 % relative humidity. 	
	Relative humidity (RH)	Duration
Test level	85	48
unit Unit	%	hours
EUT performance	After stabilization at the relevant temperature and again at each	

	<p>specified temperature. Following the 2 days, and after after step 2, after step 4 and after step 6 and before the next step apply the static test loads (or simulated load) and record the following data:</p> <ul style="list-style-type: none"> a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance
Permitted maximum deviation	<p>The error of the EUT is determined at the specified steps once per day under test conditions and at the end of the test after a recovery period of one hour.</p> <p>All functions shall operate as designed.</p> <p>All errors shall be within the maximum permissible errors specified in OIML R 61-1, 4.3.2</p>

10.2.4.2 Damp heat, cyclic test (condensing)

Damp heat, cyclic tests in Table 4b is performed in accordance with OIML R 61-1, 4.8.1.

Table 4b Damp heat, cyclic (condensing)

Applicable standards	IEC 60068-2-30 [23], IEC 60068-3-4 [12]	
Test method	Exposure to damp heat with cyclic temperature variation	
Applicability	Applicable where condensation is concerned and/or when the penetration of vapour is expected which especially applies to outdoor used AGFIs.	
Object of the test	Verification of compliance with the provisions in R 61-1 4.3.2 under conditions of high humidity combined with cyclic temperature changes specified in R 61-1, 4.8.1.	
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.	
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.	
Test procedure in brief	<p>A complete weighing test in accordance with 8.2 and 9.3. The EUT shall be tested with at least five different static test loads (or simulated loads) including Max and Min capacities. The test comprises exposure to cyclic temperature variation between 25 °C and the appropriate upper temperature while maintaining the relative humidity above 95 % during the temperature change and the low temperature phases and at or above 93 % RH at the upper temperature phases. Condensation is expected to occur on the EUT during the temperature rise.</p> <p>The 24 h cycle comprises:</p> <ol style="list-style-type: none"> 1) temperature rise during 3 hours, 2) temperature maintained at upper value until 12 hours from the start of the cycle, 3) temperature lowered to lower temperature level within a period of 3 to 6 hours, the declination (rate of fall) during the first hour and a half being such that the lower temperature level would be reached in a 3 hour period, 4) temperature maintained at the lower level until the 24 h period is completed. <p>The stabilizing period before and recovery period after the cyclic exposure shall be such that the temperature of all parts of the EUT is within 3 °C of its final value. Special electrical conditions and recovery conditions may need to be specified.</p> <p>The stabilizing period before and recovery after the cyclic exposure shall be such that all parts of the EUT are approximately at their final temperature.</p>	
	Test level	Unit
Upper temperature	40	°C
Duration	2	24-hour cycle(s)

EUT performance	After the exposure to damp heat, at no load and subsequently at test load condition record the following data: a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance
Permitted maximum deviation	The error of the EUT is determined once per day under test conditions and at the end of the test after a recovery period of one hour. All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 4.3.2

10.2.5 AC mains voltage variation (OIML R 61-1, 4.8.3)

Table 5 AC mains voltage variation

Applicable standards	IEC/TR3 61000-2-1 [13], IEC 61000-4-1 [14]	
Test method	Applying low and high level AC mains power voltage (single phase)	
Applicability	Applicable for AFCIAGFI s which are temporarily or permanently connected to an AC mains power network while in operation. This test is not applicable to equipment powered by a road vehicle battery.	
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 4.3.2 under conditions of AC mains network voltage changes between upper and lower limit specified in OIML R 61-1, 4.8.3 ¹⁾	
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.	
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.	
Test procedure in brief	<p>The test comprises exposure of the EUT to the lower and upper limit power supply condition for a period sufficient for achieving temperature stability and subsequently performing the required measurements.</p> <p>Test Sequence:</p> <ol style="list-style-type: none"> 1. Reference voltage level, 2. Upper voltage level, 3. Lower voltage level, 4. Reference voltage level, <p>In the case of three phase power supply, the voltage variation shall apply for each phase successively.</p>	
EUT performance	<p>The EUT shall be applied and tested with a test load approximately equal to the minimum capacity and on load between $\frac{1}{2}$ Max and Max. After stabilization at the relevant voltage record the following:</p> <ol style="list-style-type: none"> a) date and time, b) reference Voltage level ²⁾ c) temperature, d) relative humidity, e) test load value, f) indicated values, g) error values, h) functional performance 	
Test level	Upper limit	$U_{nom1} + 10 \% ^{1)}$
	Lower limit	$U_{nom2} - 15 \% ^{1)}$
Notes	¹⁾ The values of U_{nom} are those as marked on the AFGI. If a range is specified U_{nom1} concerns the highest and U_{nom2} concerns the lowest value. If only one nominal mains voltage value (U_{nom}) is specified then $U_{nom1} = U_{nom2} = U_{nom}$. For three phase mains power supplies, the voltage variation is applicable for each of the phases successively.	

	²⁾ The reference voltage level is equal to $(U_{nom1} + U_{nom2}) / 2$. ⁴⁾ The values of U_{nom} are those as marked on the AFGI. If a range is specified U_{nom1} concerns the highest and U_{nom2} concerns the lowest value. If only one nominal mains voltage value (U_{nom}) is specified then $U_{nom1} = U_{nom2} = U_{nom}$. The reference voltage level is equal to $(U_{nom1} + U_{nom2}) / 2$.
Permitted maximum deviation	<p>The errors shall be determined when the instrument is powered up at the upper limit of the voltage and when it is powered up at the lower limit of the voltage.</p> <p>All functions shall operate as designed.</p> <p>All errors shall be within the maximum permissible errors specified in OIML R 61-1, 4.3.2</p>

10.2.6 DC mains voltage variation (OIML R 61-1, 4.8.3)

Table 6 DC mains voltage variation

Applicable standard	IEC 60654-2 [32]
Test method	Applying low and high level DC mains power voltage
Applicability	Applicable for AFCIAGFI s which are temporarily or permanently connected to a DC mains power network while in operation and generally only applicable in industrial environment. This test is not applicable to equipment powered by a road vehicle battery.
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 4.3.2 under conditions of DC mains power voltage changes between upper and lower limit specified in OIML R 61-1, 4.8.3 ¹⁾
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.
Test procedure in brief	The test comprises exposure to the specified power supply condition for a period sufficient for achieving temperature stability and subsequently performing the required measurements. Test Sequence: a) date and time, b) reference voltage level ²⁾ c) temperature, d) relative humidity, e) test load value, f) indicated values, g) error values, h) functional performance
Test level	The upper voltage limit is the DC level at which the EUT has been designed to automatically detect high-level conditions. The lower limit will be the DC level at which the EUT has been designed to automatically detect low-level conditions.
Notes	¹⁾ The DC operating range is the range as specified by the manufacturer but not less than $U_{nom} - 15\% \leq U_{nom} \leq U_{nom} + 10\%$. ²⁾ The reference voltage level is the nominal DC voltage (U_{nom}) specified by the manufacturer,
EUT performance	The EUT shall be applied and tested with a test load approximately equal to the minimum capacity and on load between $\frac{1}{2}$ Max and Max. After stabilization at the relevant voltage record the following: a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values,

	f) error values, g) functional performance
Permitted maximum deviation	The errors shall be determined when the supplied voltage to the EUT at the upper limit level and when it is at the lower limit level. All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in OIML R 61-1, 4.3.2

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10.2.7 Low voltage of internal battery (not connected to the mains power) (OIML R 61-1, 4.8.3)

Table 7 Low voltage of internal battery (not connected to the mains power)

Applicable standards	No standard is available
Test method	Applying minimum supply voltage
Applicability	Applicable to all AFGIAGFIs supplied by internal battery
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 4.3.2 during low battery voltage specified in OIML R 61-1, 4.8.3
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer. The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.
Test procedure in brief	<p>The test comprises exposure of the EUT to the specific low battery level condition during a period sufficient for achieving temperature stability and for performing the required measurements.</p> <p>The maximum internal impedance of the battery and the minimum battery supply voltage level (U_{bmin}) shall be specified by the manufacturer of the AFGIAGFI.</p> <p>In case of simulating the battery, by using an alternative power supply, the internal impedance of the specified type of battery shall also to be simulated. The alternative power supply shall be capable of delivering sufficient current at the applicable supply voltage.</p> <p>The test sequence is as follows:</p> <ol style="list-style-type: none"> Let the power supply stabilize at a voltage as defined within the rated operating conditions and apply the test load. Let the power supply stabilize at a voltage as defined within the rated operating conditions and apply the measurement and/or loading condition. Record: <ul style="list-style-type: none"> the data defining the actual measurement conditions including date, time and environmental conditions, the actual power supply voltage. Perform measurements and record the error (-s) and other relevant performance parameters. Verify compliance with OIML R 61-1, 4.3.2 Repeat the above procedure with actual supply voltage at U_{bmin} and again at $0,9 U_{bmin}$ <p>Verify compliance with OIML R 61-1, 4.3.2.</p>
Lower limit of the voltage	The lowest voltage at which the EUT functions properly according to the specifications
Number of test cycles	At least one test cycle for each functional mode
EUT performance	<p>The EUT shall be applied and tested with a test load approximately equal to the minimum capacity and on load between $\frac{1}{2}$ Max and Max. After stabilization at the relevant voltage record the following:</p> <ol style="list-style-type: none"> date and time,

	b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance
Permitted maximum deviation	All errors shall be within the maximum permissible errors specified in OIML R 61-1, 4.3.2. For voltages at and above U_{bmin} , all functions shall operate as designed; for voltages below U_{bmin} , the AFGIAGFI may automatically resume normal operation. During all phases of the test the loss of any previous measurement data is not acceptable.

10.2.8 Power from external 12 V and 24 V road vehicle batteries (OIML R 61-1, 4.8.3)

Table 8 Voltage variations

Applicable standard	ISO 16750-2 [24]				
Test method	Variation in supply voltage				
Applicability	Applicable to all AFGIAGFIs supplied by the internal battery of a vehicle and charged by use of a combustion engine driven generator.				
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 4.3.2 under conditions of high while charging) and low battery voltage specified in OIML R 61-1, 4.8.3.				
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.				
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.				
Test procedure in brief	The test comprises exposure to the specified maximum and minimum power supply voltage conditions for a period sufficient for achieving temperature stability and performing the required measurements at these conditions.				
Nominal battery voltage	$U_{nom} = 12$		$U_{nom} = 24$		V
	Lower limit	Upper limit	Lower limit	Upper limit	
Test level	9	16	16	32	V
EUT performance	<p>The EUT shall be applied and tested with a test load approximately equal to the minimum capacity and on load between ½ Max and Max. After stabilization at the relevant voltage record the following:</p> <ul style="list-style-type: none"> a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance 				
Permitted maximum deviation	<p>All functions shall operate as designed.</p> <p>All errors shall be within the maximum permissible errors specified in OIML R 61-1, 4.3.2.</p>				

10.2.9 Tilting (OIML R 61-1, 4.8.4)

No reference to international standards can be given at the present time. This test should therefore be conducted as described below.

Note: This test only applies to ~~AFGI~~AGFIs that will not be permanently installed. This test is not required for transportable ~~AFGI~~AGFIs with a leveling device and a level indicator if it can be established that the tilt can be adjusted to 1 % or less.

If R 61-1, 4.8.4 b) applies, the mentioned requirements ~~must~~shall be tested in addition.

10.2.9.1 Tilting of AGFIs fitted with a levelling device and a level indicator, or a tilt sensor (OIML R 61-1, 4.8.4 a and 4.8.4 b)**10.2.9.1.1** Tilting at no-load

The AGFI shall be set to zero in its reference position (not tilted). The AGFI shall then be tilted longitudinally up to the limiting value of tilting. The zero indication is noted. This test shall be repeated for each direction (longitudinally backwards and forwards, transversally leftside and rightside).

10.2.9.1.2 Tilting when loaded

The AGFI shall be set to zero in its reference position and two weighings shall be carried out at a load close to the lowest load where the maximum permissible error changes, and at a load close to Max. The AGFIs is then unloaded and tilted longitudinally and set to zero. The tilting shall be equal to the limiting value of tilting. Weighing tests as described above shall be performed. This test shall be repeated for each direction (longitudinally backwards and forwards, transversally leftside and rightside).

10.2.9.2 AGFIs not fitted with a levelling device and a level indicator, or an automatic tilt sensor (OIML R 61-1, 4.8.4 c ~~and d~~)

The test in 10.2.9.2 only applies for AGFIs liable to be tilted and not fitted with a level levelling device or indicator which clearly indicates when the maximum permissible tilt has been exceeded nor with an automatic tilt sensor which clearly indicates when the maximum permissible tilt has been exceeded (e.g. by producing an error code or signal) and inhibits any printout and transmission of measurement data.

Table 9 – Tilt test

Object of the test:	To verify compliance with the provisions given in OIML R 61-1, 4.8.4.
Test procedure in brief:	The test consist of tilting the EUT both forwards and backwards, longitudinally and from side to side (transversely), while observing the weight indications for a static test load.
Test severity:	Two test loads at a tilt of 5 % at Min (load close to the lowest load where the maximum permissible

	error changes) and Max. In case of AGFIs intended for installation in vehicles the test shall be conducted at a tilt of 10 % close to the maximum tilt .
Condition of EUT:	<p>The EUT is switched on for at least the warm-up time specified by the manufacturer. During the test the electrical power supplied to the EUT shall not be switched off.</p> <p>Adjust the EUT in its reference position (not tilted) as close to zero indication as practicable. If the AFGI is provided with automatic zero-setting it shall not be in operation.</p>
Test sequence:	<p>Record the zero indication. Apply the test load and record the indication. Remove the test load.</p> <p>Tilt the EUT longitudinally to the appropriate extent and record the zero indication. Apply the test load approximately equal to the Max and record the indication. Remove the test load.</p> <p>Without further adjustment to any control affecting metrological performance tilt the EUT to the appropriate extent in the opposite direction and repeat the weighing tests as above.</p> <p>Tilt the EUT in the transverse direction to the appropriate extent and repeat the above tests.</p> <p>Tilt the EUT in the opposite direction and repeat the above tests.</p>
	<p>Record the following data for each of the test set-ups as prescribed above:</p> <ul style="list-style-type: none"> a) Date and time b) Test load c) Indications at each tilt d) Errors e) Functional performance <p>In order to determine the influence of tilting on the loaded AFGI, the indication obtained at each tilt shall be corrected for the deviation from zero which the AFGI had prior to loading.</p>
Maximum allowable variations:	All indications shall be within maximum permissible errors specified in OIML R 61-1, 4.3.2.

10.3 Disturbance tests (OIML R 61-1, 6.2)

Summary of disturbance tests

§	Test	Condition applied
10.3.1	Damp heat, cyclic	Significant fault
10.3.2 10.3.1	AC mains voltage dips, short interruptions and reductions	Significant fault
10.3.3 10.3.2	Bursts (fast transient tests) on mains power lines and on signal, data and control lines	Significant fault
10.3.4 10.3.3	Electrostatic discharge	Significant fault
10.3.5 10.3.4	Immunity to electromagnetic fields	Significant fault
10.3.6 10.3.5	Surges on AC and DC mains power lines and on signal, data and control lines	Significant fault
10.3.7 10.3.6	Electrical transient conduction for instruments powered by 12V and 24V batteries	Significant fault
10.3.8 10.3.7	Ripple on DC mains power	Significant fault
10.3.8	Battery voltage variations during starting up a vehicle engine	Significant fault
10.3.9 10.3.8	Load dump test	Significant fault
10.3.10 10.3.9	DC mains voltage dips, short interruptions and (short term) variations	Significant fault
Note 1: Tests shall be conducted to the appropriate classification for electrical tests. The severity level stated in the tests 10.3.1 to 10.3.10 10.3.10 apply to AGFIs installed and used in locations with significant or high levels of electromagnetic disturbances corresponding to those likely to be found in industrial environments, class E2 of OIML D11 [3].		
Note 2: If there are interfaces on the instrument (or simulator), the use of these interfaces to other equipment shall be simulated in the tests. For this purpose, either an appropriate peripheral device or 3 m of interface cable to simulate the interface impedance of the other equipment shall be connected to each different type of interface.		

10.3.1 ~~Damp heat, cyclic test (condensing)~~

~~Damp heat, cyclic tests~~ in Table 10 is performed in accordance with OIML R 61-1, 4.8.1.

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Table 10—~~Damp heat, cyclic (condensing)~~

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Applicable standards	IEC 60068-2-30 [23], IEC 60068-3-4 [12]
Test method	Exposure to damp heat with cyclic temperature variation
Applicability	Applicable where condensation is concerned and/or when the penetration of vapour is expected which especially applies to outdoor used s.
Object of the test	Verification of compliance with the provisions in 4.2 under conditions of

	high humidity combined with cyclic temperature changes specified in.	
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.	
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero setting or zero tracking, where available, shall be enabled as for normal operation.	
Test procedure in brief	<p>The test comprises exposure to cyclic temperature variation between 2 °C and the appropriate upper temperature while maintaining the relative humidity above 95 % during the temperature change and the low temperature phases and at or above 93 % RH at the upper temperature phases. Condensation is expected to occur on the EUT during the temperature rise.</p> <p>The 24 h cycle comprises:</p> <ol style="list-style-type: none"> 1) temperature rise during 3 hours; 2) temperature maintained at upper value until 12 hours from the start of the cycle; 3) temperature lowered to lower temperature level within a period 3 to 6 hours, the declination (rate of fall) during the first hour and a half being such that the lower temperature level would be reached in a 3 hour period; 4) temperature maintained at the lower level until the 24 h period is completed. <p>The stabilizing period before and recovery period after the cyclic exposure shall be such that the temperature of all parts of the EUT is within 3 °C of its final value. Special electrical conditions and recovery conditions may need to be specified. The stabilizing period before and recovery after the cyclic exposure shall be such that all parts of the EUT are approximately at their final temperature.</p>	
	Test level	Unit
Upper temperature	40	°C
Duration	2	24-hour cycle(s)
EUT performance	<p>After the exposure to damp heat, at no load and subsequently at test load condition record the following data:</p> <ol style="list-style-type: none"> a) date and time; b) temperature; c) relative humidity; d) test load value; e) indicated values; f) error values; g) functional performance 	
Permitted maximum deviation	<p>The error of the EUT is determined once per day under test conditions and at the end of the test after a recovery period of one hour. All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 4.2.2</p>	

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AC mains voltage dips, short interruptions and reductions

AC mains voltage dips and short interruptions tests are carried out according to Table 11.

Table 11 AC mains voltage dips, short interruptions and reductions				
Applicable standards	IEC 61000-4-11 [20], IEC 61000-6-1 [27], IEC 61000-6-2 [28]			
Test method	Introducing short-time reductions of mains voltage using the test set-up defined in the applicable standard			
Applicability	Applicable for AFGIAGFI s with rated input current of less than 16 A per phase which are temporarily or permanently connected to an AC mains power network while in operation. This test is only applicable to equipment powered by AC mains supply and is not applicable to equipment powered by a road vehicle battery.			
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 under conditions of short time mains voltage reductions.			
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.			
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.			
Test procedure in brief	<p>A test generator is to be used which is suitable to reduce the amplitude of the AC mains voltage for the required period of time.</p> <p>The performance of the test generator shall be verified before connecting the EUT.</p> <p>The mains voltage reduction tests shall be repeated 10 times with intervals of at least 10 s between the tests.</p> <p>The tests shall be applied continuously during the measurement time.</p> <p>The interruptions and reductions are repeated throughout the time necessary to perform the whole test; for this reason, more than ten interruptions and reductions may be necessary.</p>			
		Reduction of nominal voltage (U_{nom})		unit
Tests and levels	Test a	Reduction to	0	V
		Duration	0.5	cycles
	Test b	Reduction to	0	V
		Duration	1	cycles
	Test c	Reduction to	40	% of U_{nom}
		Duration	10/12	cycles
	Test d	Reduction to	70	% of U_{nom}
		Duration	25/30	cycles
Short interruptions	Reduction to	0		V
		250/300		cycles

EUT performance	<p>The EUT shall be applied and tested with a test load close to zero (10 μ). The fault of the EUT is determined separately for each of the different dips and reductions. Sequentially during and after the exposure to the disturbance record the following parameters:</p> <ul style="list-style-type: none"> a) date and time, b) temperature, c) relative humidity, d) value of the measurand e) percentage of voltage reduction and duration, f) indicated values, g) error values, h) functional performance
Permitted maximum deviation	<p>Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur.</p>

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10.3.3.2 Bursts (fast transient tests) on mains power lines and on signal, data and control lines

Electrical bursts tests (fast transient tests) are carried out according to Tables 12a and Table 12b.

Table 12a Bursts (transients) on AC and DC mains

Applicable standards	IEC 61000-4-4 [17]	
Test method	Introducing transients on the mains power lines	
Applicability	Applicable for AFCI/AGFI s which are temporarily or permanently connected to a mains power network while in operation	
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 during conditions where electrical bursts are superimposed on the mains voltage.	
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.	
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.	
Test procedure in brief	<p>A burst generator as defined in the referred standard shall be used.</p> <p>The characteristics of the generator shall be verified before connecting the EUT.</p> <p>The test comprises exposure to bursts of voltage spikes for which the output voltage on 50 Ω and 1000 Ω load are defined in the referred standard.</p> <p>Both positive and negative polarity of the bursts shall be applied.</p> <p>The duration of the test shall not be less than 1 minute 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.</p> <p>At least 10 positive and negative randomly phased bursts shall be applied.</p> <p>The bursts are applied during all the time necessary to perform the test; therefore, more bursts than indicated above may be necessary.</p>	
	Amplitude (peak value) [kV]	Repetition rate [kHz]
Test level	2	5
EUT performance	<p>Sequentially during and after the exposure to the bursts record the following parameters:</p> <p>a) date and time,</p> <p>b) temperature,</p> <p>c) relative humidity,</p> <p>d) test load value,</p> <p>e) indicated values,</p> <p>f) error values,</p> <p>g) functional performance</p>	
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults	

	to occur. It is acceptable when during the disturbance test the AGFI is not providing a measurement result.
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Table 12b Bursts (transients) on signal, data and control lines

Applicable standards	IEC 61000-4-4 [17]	
Test method	Introducing transients on signal, data and control lines	
Applicability	Applicable for AFGI containing active electronic circuits which during operation are permanently or temporarily connected to external electrical signal, data and/or control lines. Burst tests on signal lines are applicable only for I/O signal, data and control ports, with a cable length exceeding 3 m (as specified by the manufacturer).	
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 during conditions where electrical bursts are superimposed on I/O and communication ports.	
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.	
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.	
Test procedure in brief	A burst generator as defined in the referred standard shall be used. The characteristics of the generator shall be verified before connecting the EUT. The test comprises exposure to bursts of voltage spikes for which the output voltage on 50 Ω and 1000 Ω load are defined in the referred standard. Both positive and negative polarity of the bursts shall be applied. The duration of the test shall not be less than 1 min for each amplitude and polarity. A capacitive coupling clamp as defined in the standard shall be used for the coupling of the bursts into the I/O and communication lines.	
	Test level	unit
Amplitude (peak value)	1	kV
Repetition rate	5	kHz
EUT performance	Sequentially during and after the exposure to the bursts. Record the following parameters: a) date and time, b) temperature, c) relative humidity, d) value of the measurand e) exposed conductors, f) indicated values, g) error values, h) functional performance	
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur.	

	It is acceptable when during the disturbance test the AGFI is not providing a measurement result.
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10.3.410.3.3 Electrostatic discharge

Table 13 Electrostatic discharge

Applicable standard	IEC 61000-4-2 [15]		
Test method	Exposure to electrostatic discharge (ESD)		
Applicability	Applicable to all AFGIAGFIs		
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 in case of direct exposure to electrostatic discharges or such discharges in the neighbourhood of the EUT.		
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.		
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.		
Test procedure in brief	<p>The test comprises exposure of the EUT to electrical discharges. An ESD generator as defined in the referred standard shall be used and the test set-up shall comply with the dimensions, materials used and conditions as specified in the referred standard. Before starting the tests, the performance of the generator shall be verified.</p> <p>At least 10 discharges per preselected discharge location shall be applied.</p> <p>An EUT not equipped with a safety ground connection shall first be fully discharged before being exposed to a next discharge. The time interval between successive discharges shall be at least 1 second.</p> <p>Contact discharge is the preferred test method. Air discharge is far less defined and reproducible and therefore shall be used only where contact discharge cannot be applied.</p> <p>Direct application:</p> <p>In the contact discharge mode to be carried out on conductive surfaces, the electrode shall be in contact with the EUT before activation of the discharge. In such a case the discharge spark occurs in the vacuum relays of the contact discharge tip.</p> <p>On insulated surfaces only the air discharge mode can be applied. The EUT is approached by the charged electrode until a spark discharge occurs.</p> <p>Indirect application:</p> <p>The discharges are applied in the contact mode only on coupling planes mounted in the vicinity of the EUT.</p> <p>Conventionally 3 cycles of tests are performed starting each test at a different moment of the measuring cycle.</p>		
	One of the following test levels may be specified:		
		Charge voltage	unit
Test level	Contact discharge	6	kV
	Air discharge	8	kV
EUT performance	Five measurements shall be performed at each surface exposed to the disturbance. Sequentially during and after the exposure to		

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	<p>the discharges record the following parameters:</p> <ul style="list-style-type: none"> a) date and time, b) temperature, c) relative humidity, d) test load e) value of the measurand, f) discharge type, level and side/surface exposed, g) indicated values, h) error values, i) functional performance
Permitted maximum deviation	<p>Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur.</p> <p>It is acceptable when during the disturbance test the AGFI is not providing a measurement result.</p> <p>Make sure that transient changes of indication of more than the significant fault are detected, e.g. by setting the preset value of the fill to a value corresponding to the indication without disturbance plus the significant fault.</p>

10.3.5 10.3.4 Immunity to electromagnetic fields

10.3.5 10.3.4.1 Immunity to radiated (RF) electromagnetic fields

Radiated, radio frequency electromagnetic immunity tests are carried out according to Table 14 b.

Table 14 b Immunity to radiated electromagnetic fields

Applicable standard	IEC 61000-4-3 [16]; IEC 61000-4-20 [21]			
Test method	Exposure to radiated radio frequency electromagnetic fields			
Applicability	Applicable for AGFIs containing active electronic circuits			
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 while exposed to electromagnetic fields.			
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.			
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.			
Test procedure in brief	<p>The EUT is exposed to electromagnetic fields with the required field strength and the field uniformity as defined in the referred standard.</p> <p>The level of field strength specified refers to the field generated by the unmodulated carrier wave.</p> <p>The EUT shall be exposed to the modulated wave field. The frequency sweep shall be made only pausing to adjust the RF signal level or to switch RF-generators, amplifiers and antennas if necessary. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value.</p> <p>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.</p> <p>Adequate EM fields can be generated in facilities of different type and set-up the use of which is limited by the dimensions of the EUT and the frequency range of the facility.</p>			
Test level	Frequency range	RF amplitude	AM, sine wave modulation	
	(26) 80 - 3000	10	80	1
	MHz	V/m	%	kHz
EUT performance	<p>Sequentially during and after the exposure to the EM field record the following parameters:</p> <p>a) date and time,</p> <p>b) temperature,</p> <p>c) relative humidity,</p> <p>d) value of the measurand,</p> <p>e) field strength level,</p> <p>f) indicated values,</p> <p>g) error values,</p>			

	h) functional performance
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur. It is acceptable when during the disturbance test the AGFI is not providing a measurement result.

10.3.4.2 Immunity to conducted electromagnetic fields

Conducted, radio frequency, electromagnetic field immunity tests are carried out according to Table 14 a.

Table 14 a Conducted (common mode) currents generated by RF EM fields

Applicable standard	IEC 61000-4-6 [19]			
Test method	Injection of RF currents representing exposure to RF electromagnetic fields			
Applicability	Applicable for AFGI AGFIs containing active electronic circuits and equipped with ports for throughput or connection of external electrical wiring (mains power, signal, data and control lines)			
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 while exposed to electromagnetic fields.			
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.			
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.			
Test procedure in brief	An RF EM current, simulating the influence of EM fields shall be 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 characteristics of the test equipment consisting of an RF generator, (de-)coupling devices, attenuators, etc. shall be verified before connecting the EUT. If the EUT comprises several devices the tests shall be performed at each extremity of the cable if both of the elements are part of the EUT.			
	Frequency range	RF amplitude	AM, sine wave modulation	
Test level	0.15 – 80	10	80	1
Unit	MHz	V (e.m.f.)	%	kHz
Note	In the range from 26 MHz to 80 MHz, the type evaluation authority may decide to choose a transition frequency below 80 MHz. Above Below the selected transition frequency tests will be carried out according to Table 14a 14 b. In the event of a			

	dispute, the result of the test according to this Table 14a prevails.
EUT performance	<p>Sequentially during and after the exposure to the RF current record the following parameters:</p> <ul style="list-style-type: none"> a) date and time, b) temperature, c) relative humidity, d) value of the measurand, e) applied RF (e.m.f.) voltage level , f) indicated values, g) error values, h) functional performance
Permitted maximum deviation	<p>Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur.</p> <p>It is acceptable when during the disturbance test the AGFI is not providing a measurement result.</p>

10.3.6 10.3.5 Surges on AC and DC mains power lines and on signal, data and control lines

Electrical surge tests are carried out according to Table 15 a and Table 15 b.

Table 15 a Surges on AC and DC mains power lines

Applicable standard	IEC 61000-4-5 [18]				
Test method	Introducing electrical surges on the mains power lines				
Applicability	Applicable for AFGIAGFIs which are temporarily or permanently connected to a mains power network while in operation This test is not applicable to AFGIAGFIs connected to a local power source through an indoor network				
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 during conditions where electrical surges are superimposed on the mains voltage				
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.				
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.				
Test procedure in brief	<p>A surge generator as defined in the referred standard shall be used. The characteristics of the generator shall be verified before connecting the EUT.</p> <p>The test comprises exposure to electrical surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and the minimum time interval between two successive pulses are defined in the referred standard.</p> <p>At least 3 positive and 3 negative surges shall be applied.</p> <p>On AC mains supply lines the surges shall be synchronised with the AC supply frequency and shall be repeated such that injection of surges on all the 4 phase shifts: 0°, 90°, 180° and 270° compared to the mains phase is covered.</p> <p>The injection network circuit depends on the applicable conductor and is defined in the referred standard.</p> <p>The surges are applied during all the time necessary to perform the test; to that purpose more surges than indicated above may be necessary.</p>				
Mains mode	AC		DC		
	Line to line	Line to ground	Line to line	Line to ground	unit
Test level	1.0	2.0	1.0	2.0	kV
EUT performance	<p>Sequentially during and after the exposure to the surges record the following parameters:</p> <p>a) date and time,</p> <p>b) temperature,</p> <p>c) relative humidity,</p> <p>d) test load value,</p>				

	e) indicated values, f) error values, g) functional performance.
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur. It is acceptable when during the disturbance test the AGFI is not providing a measurement result.

Table 15 b Surges on signal, data and ~~control~~ control lines

Applicable standard	IEC 61000-4-5 [18]				
Test method	Introducing electrical surges on signal, data and control control lines				
Applicability	Applicable for AFGI AGFIs containing active electronic circuits which during operation are temporarily or permanently connected to electrical signal, data and/or control lines that may exceed a length of 10 m. This test is not applicable to AFGI AGFIs connected to a local power source through an indoor network.				
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 during conditions where electrical surges are superimposed on I/O and communication ports.				
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.				
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.				
Test procedure in brief	A surge generator as defined in the referred standard shall be used. The characteristics of the generator shall be verified before connecting the EUT. The test comprises exposure to electrical surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and the minimum time interval between two successive pulses are defined in the referred standard. At least 3 positive and 3 negative surges shall be applied. The applicable injection network depends on the kind of wiring the surge is coupled into and is defined in the referred standard.				
	Unsymmetrical lines		Symmetrical lines	Shielded I/O and communication lines	
Test Level	Line to line	Line(s) to ground	Line(s) to ground	Line(s) to ground	Unit
	1.0	2.0	2.0	2.0	kV
EUT performance	Sequentially during and after the exposure to the surges record the following parameters: a) date and time, b) temperature, c) relative humidity,				

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	d) value of the measurand e) exposed conductors, f) indicated values, g) error values, h) functional performance
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur. It is acceptable when during the disturbance test the AGFI is not providing a measurement result.

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10.3.7 10.3.6 Electrical transient conduction for AFGI AGFIs powered by 12V and 24V batteries

10.3.7 10.3.6.1 Electrical transient conduction along supply lines

Table 16 a Electrical transient conduction along supply lines

Applicable standard	ISO 7637-2 [25]				
Test method	Electrical transient conduction along supply lines.				
Applicability	Applicable to all AFGI AGFIs while in operation are supplied by the internal battery of a vehicle which may at the same time be charged by use of a combustion engine driven generator				
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 under the following conditions: <ul style="list-style-type: none"> transients due to a sudden interruption of currents in a device connected in parallel with the device under test due to the inductance of the wiring harness (pulse 2a); transients from DC motors acting as generators after the ignition is switched off (pulse 2b); transients on the supply lines which occur as a result of the switching processes (pulses 3a and 3b). 				
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.				
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.				
Test procedure in brief	The test comprises exposure to disturbances on the power voltage by direct coupling into the supply lines.				
Test level	Test pulse	$U_{nom}^{1)}$	12	24	V
	2a	$U_s^{2)}$	+ 50	+ 50	V
	2b	$U_s^{2)}$	10	20	V
	3a	$U_s^{2)}$	- 150	- 200	V
	3b	$U_s^{2)}$	+ 100	+ 200	V
Notes	¹⁾ U_{nom} = nominal battery voltage ²⁾ As specified in ISO 7637-2 [25]				
EUT performance	Sequentially during and after the exposure to the transient record the following parameters: a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance				
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur. It is acceptable when during the disturbance test the AGFI is				

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	not providing a measurement result.
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10.3.7 10.3.6.2 Electrical transient conduction via lines other than supply lines

Table 16 b Electrical transient conduction via lines other than supply lines

Applicable standard	ISO 7637-3 [26], § 3.5.1: fast transient test pulses a and b				
Test method	Electrical transient conduction along lines other than supply lines				
Applicability	Applicable to analogue I/O cabling of modular AFGI AGFIs installed in vehicles ⁽¹⁾				
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 under conditions of transients which occur on other lines as a result of the switching processes (pulses a and b)				
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.				
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.				
Test procedure in brief	The test consists of exposure to bursts of voltage spikes by capacitive and inductive coupling via lines other than supply lines. Only the Capacitive coupling clamp method shall be applied.				
Test level	Test pulse	$U_{nom}^{(1)}$	12	24	V
	pulse a	$U_s^{(2)}$	$\Delta -60$	$\Delta -80$	V
	pulse b	$U_s^{(2)}$	$\Delta 40$	$\Delta 80$	V
Notes	⁽¹⁾ U_{nom} = nominal battery voltage ⁽²⁾ As specified in ISO 7637-3				
EUT performance	Sequentially during and after the exposure to the transient record the following parameters: a) date and time, b) temperature, c) relative humidity, d) value of the measurand e) exposed conductors, f) indicated values, g) error values, h) functional performance				
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur. It is acceptable when during the disturbance test the AGFI is not providing a measurement result.				

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10.3.8 10.3.7 Ripple on DC mains power

Table 17 Ripple on DC mains power

Applicable standard	IEC 61000-4-17 [31]	
Test method	Introducing a ripple voltage on the DC input power port.	
Applicability	Applicable for AFGIAGFIs which are temporarily or permanently connected to a DC mains power network (distribution system) supplied by external rectifier systems while in operation and generally only applicable in industrial environment. This test is only applicable to equipment powered by DC mains supply and is not applicable to equipment powered by a road vehicle battery.	
Object of the test	Verification of compliance with the provisions in R 61-1, 6.2 under conditions of the introduction of a ripple on the DC mains voltage to simulate the ripple introduced by rectifiers applied in a DC mains power network. This test is not applicable for AFGIAGFIs connected to battery charger systems with incorporated switch mode converters.	
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.	
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.	
Test procedure in brief	A test generator as defined in the referred standard shall be used. Before starting the tests, the performance of the generator shall be verified. The test comprises subjecting the EUT to ripple voltages such as those generated by traditional rectifier systems and/or auxiliary service battery chargers overlaying on DC power supply sources. The frequency of the ripple voltage is the applicable power frequency or a multiple (2, 3 or 6) dependant on the rectifier system used for the mains. The waveform of the ripple, at the output of the test generator, has a sinusoid-linear character. The test level is a peak-to-peak voltage expressed as a percentage of the nominal DC voltage, UDC.	
Test level	Percentage of the nominal DC voltage	2 %
EUT performance	After stabilization at the relevant a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance	
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur.	

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10.3.9 10.3.8 Battery voltage variations during starting up a vehicle engine

Table 18 Battery voltage variations during starting up a vehicle engine

Applicable standard	ISO 16750-2 [24]				
Test method	Supply voltage variation due to energizing the starter motor of a vehicle				
Applicability	AFCI/AGFI is powered by on board DC battery and may be in operation while the vehicle engine is started				
Object of the test	Verification of compliance with the provisions in R 61-1, 6.2 under conditions of starting the vehicle engine (during and after cranking)				
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.				
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.				
Test procedure in brief	The test comprises exposure to a typical supply voltage characteristic simulating the voltage variation while cranking the engine using a DC electrical starter motor.				
	$U_{nom}^{1)}$	12		24	
Test levels	Test profile ²⁾	I	III	I	III
	U_S	8	3	10	6
	U_A	9,5	5	20	10
	t_g	1	1	1	1
	t_f	40	100	40	40
					V
					V
					s
					ms
Notes	¹⁾ U_{nom} = nominal battery voltage ²⁾ As specified in ISO 16750-2[24]				
EUT performance	Sequentially during and after the exposure to the disturbance record the following parameters: a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance				
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur. It is acceptable when during the disturbance test the AGFI is not providing a measurement result.				

10.3.10.3.9

Load dump test

Table 19 Load dump test

Applicable standard	ISO 16750-2 [24]					
Test method	Supply voltage variation due to disconnecting a discharged battery					
Applicability	AFGI is powered by on board DC battery and may be in operation while the vehicle engine is running					
Object of the test	Verification of compliance with the provisions in OIML R 61-1, 6.2 under conditions of disconnecting a discharged vehicle battery while the charging alternator is running.					
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.					
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.					
Test procedure in brief	The test comprises exposure to a typical pulse on the supply voltage, simulating the voltage peak due to the impedance of connected loads when disconnecting the battery.					
	$U_{nom}^{1)}$	12		24		V
	Test pulse shape ²⁾	↓ Htest B		↓ Htest B		
	U_s	8079	400101	450151	200202	V
	R_i	0,5	4	1	8	Ω
	t_r	10	10	10	10	ms
	t_d	40-400	40-400	100-350	100-350	ms
Notes	¹⁾ U_{nom} = nominal battery voltage ²⁾ As specified in ISO 16750-2 [24]					
EUT performance	Sequentially during and after the exposure to the disturbance record the following parameters: a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance					
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur. It is acceptable when during the disturbance test the AGFI is not providing a measurement result.					

10.3.11 DC mains voltage dips, short interruptions and (short term) variations

Table 20 DC mains voltage dips, short interruptions and (short term) variations

Applicable standard	IEC 61000-4-29 [34]		
Test method	Introducing voltage dips, short interruptions and voltage variations on DC mains power lines using the test set-up defined in the applicable standard		
Applicability	Applicable for AFCIAGFI s which are temporarily or permanently connected to a DC mains power network while in operation. This test is only applicable to equipment powered by DC mains supply and is not applicable to equipment powered by a road vehicle battery.		
Object of the test	Verification of compliance with the provisions in R 61-1, 6.2 under conditions of voltage dips, voltage variations and short interruptions on DC.		
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.		
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.		
Test procedure in brief	<p>A test generator as defined in the referred standard shall be used. Before starting the tests, the performance of the generator shall be verified.</p> <p>The EUT shall be exposed to voltage dips, short interruptions, for each of the selected combinations of amplitude and duration, using a sequence of three dips/interruptions and intervals of at least 10 s between each test event.</p> <p>The most representative operating modes of the EUT shall be tested three times at 10 s intervals for each of the specified voltage variations.</p> <p>The disturbances are applied during all the time necessary to perform the test; to that purpose more disturbances than indicated may be necessary.</p>		
Voltage dips		Test Levels	unit
	Amplitude	40 and 70	% of the rated voltage
	Duration	0.01; 0.03; 0.1; 0.3; 1	s
Short interruptions	Test condition	High impedance and/or low impedance	
	Amplitude	0	% of the rated voltage
	Duration	0.001; 0.003; 0.01; 0.03; 0.1; 0.3; 1	s
Voltage variations	Amplitude	85 and 120	% of the rated voltage
	Duration	0.1; 0.3; 1; 3; 10	s
EUT performance	<p>The EUT shall be applied and tested with a test load close to zero (10 d). The fault of the EUT is determined separately for each of the different dips and reductions. Sequentially during and after the exposure to the dips and interruptions the following parameters shall</p>		

	be recorded: a) date and time, b) temperature, c) relative humidity, d) measurand value, e) percentage of voltage reduction and duration, f) indicated values and error values, g) functional performance
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur.

Table 21 – Span stability test

Test method:	Span stability.
Object of the test:	To verify compliance with the provisions given in OIML R 61-1, 7.3 after the EUT has have been subjected to the performance tests.
Reference to standard:	No reference to international standards is given.
Test procedure in brief:	<p>The test consists of observing the variations of error of the EUT under sufficiently constant ambient conditions (reasonably constant conditions in a normal laboratory environment) at various intervals, before, during and after the EUT has been subjected to performance tests.</p> <p>The performance tests shall include the temperature test and, if applicable, the damp heat test. Other performance tests listed in this Annex may be performed.</p> <p>The EUT shall be disconnected from the power supply two times for at least 8 hours during the period of the test. The number of disconnections may be increased if the manufacturer of the AGFI specifies so or at the discretion of the approved authority in the absence of any such specification.</p>
	<p>In the conduct of this test, the operating instructions for the measuring instrumentAGFI as supplied by the manufacturer shall be considered.</p> <p>The EUT shall be stabilized at sufficiently constant ambient conditions after switch-on for at least 5 hours, and at least 16 hours after the temperature and damp heat tests have been performed.</p>
Test severities:	Test duration: 28 days or over the period necessary for the conduct of the performance tests, whichever is less.
Time t (days) between tests:	$0.5 \leq t \leq 10$
Test load:	A static test load near Max; the same test weights shall be used throughout the test.
Maximum allowable variations:	The variation in the indication of the test load shall not exceed half of the absolute value of the mpe for influence factor tests (OIML R 61-1, 4.3.2) for the test load applied on any of the (n) tests conducted.
Number of tests (n):	$n \geq 8$. If the test results indicate a trend more than half the permissible variation specified above, conduct additional tests until the trend comes to rest or reverses itself, or until the error exceeds the maximum permissible variation.
Precondition:	None required.
Test equipment:	Verified mass standards.
Condition of the EUT:	Adjust the EUT as close to zero indication as practicable

	before each test.
Test sequence:	<p>Stabilize all factors at nominal reference conditions. Automatic zero-setting shall not be in operation.</p> <p>Apply the test load (or simulated load) and record the following data:</p> <ul style="list-style-type: none"> a) Date and time b) Temperature c) Barometric pressure d) Relative humidity e) Test load f) Indication g) Errors h) Changes in test location <p>And apply all necessary corrections resulting from variations of temperature, pressure, etc. between the various measurements.</p> <p>At the first measurement immediately repeat zeroing and loading four times to determine the average value of error. For the next measurements perform only one, unless either the result is outside the specified tolerance or the range of the five readings of the initial measurement was more than 1/10 of the maximum permissible variation.</p> <p>Repeat this test at periodic intervals during and after the conduct of the various performance tests.</p> <p>Allow full recovery of the EUT before any other tests are performed.</p>

12 Procedure for material tests

12.1 Material tests at type evaluation (OIML R 61-1, 8.2.3.1)

Operational tests with material shall be done on a complete AGFI to assess compliance with the requirements of OIML R 61-1, **clauses** 5, 6 and 7 with material for the test load as specified in OIML R 61-1, 8.2.3.1.

12.1.1 Feeding device (details as given in **R6R** 61-1, 5.6)

Check that the feeding device provides sufficient and regular flow rate.

Check that any adjustable feed device has an indication of the direction of movement corresponding to the sense of the adjustment of the feed (~~where applicable~~ **if applicable**).

For AGFIs using the subtractive weighing principle check that residual material retained at the feeding device after each load is delivered, is negligible relative to error limitation.

12.1.2 Load receptor (details as given in **R6R** 61-1, 5.7)

For AGFIs that weigh material in a separate load receptor prior to discharge to a container,

Check that the residual material retained at the load receptor after each discharge is negligible relative to error limitation.

Check that manual discharge of the load receptor is not possible during automatic operation.

12.2 Material tests at initial verification (**R6R** 61-1, 8.3.2)

Metrological tests with material shall be done on a complete AGFI, fully assembled and fixed in the position in which it is intended to be used and as specified in R 61-1, 8.3.2.

The accuracy class X(x) (or classes) shall be determined from the results.

12.2.1 Requirements for metrological material tests:

- (a) Types of loads shall be as specified in 8.2.2.2
- (b) Mass of test loads and fills shall be as specified in 8.2.2.1 a, b and c).
- (c) Condition of material tests shall be as specified in 8.2.2.3
- (d) Number of fills shall be as specified in 8.2.3.

12.2.2 Methods for metrological material tests (as given in 8.2. 5)

One of the following verifications methods shall be used:

- a) Separate verification method in 8.5.1.
- b) Integral verification method in 8.5.2.

12.2.3 Procedure for metrological material tests

- a) Set up the AGFI in accordance with the conditions of test given in 8.2.28.2.3.
- b) Select a preset value for the fill and set the load value if different from the fill, in accordance with values of the mass of the fills as specified in 8.2.28.2.1. Record the indicated preset value.
- c) Run the AGFI to produce a number of fills as specified in 8.3 using types of test loads specified in 8.2.2.
- d) Weigh all the fills by either:
 - 1) Separate verification method specified in 8.5.1 or
 - 2) The integral verification method specified in 8.5.2
- e) In accordance with 8.2.7 calculate the average value of all the fills in the test as follows:

$$\sum_{i=1}^n F_i / n$$

where:

F is the mass of the fill (conventional true value), in units of mass

n is the number of fills in the test

- (f) In accordance with 8.2.8 calculate the deviation of each fill from the average of all the fills in the test as follows:

$$F_i - \left(\sum_{i=1}^n F_i / n \right) = |md|$$

where:

md is the deviation from average, in units of mass

- (g) Repeat stages (b) to (f) for other loads as specified for values of the mass of the fills in 8.2.28.2.1.

12.2.4 Determination of accuracy class, X(x) (OIML R 61-1, 8.2.4)

- (a) For each preset value of the test fill (F_p):

- (1) Calculate the preset value error specified in R6R 61-1, 4.3.3 in accordance with 8.2.9 as follows:

$$se = \left(\sum_{i=1}^n F_i / n \right) - F_p$$

where:

se is the preset value error.

- (2) Determine the maximum permissible preset value error for class X(1), mpse₍₁₎ as follows:

mpse₍₁₎ = 0.25 mpd₍₁₎ ~~in-service~~, corresponding to the value of a fill equal to F_p

- (3) Then calculate: [|se| / mpse₍₁₎].

- (b) For each preset value of the test fill (F_p):

- (1) Determine the maximum (largest) of the absolute values of the actual deviation from the average i.e. md_{max}
- (2) Determine the maximum permissible deviation from the average for class X(1), mpd₍₁₎.
- (3) Then calculate: [md_{max} / mpd₍₁₎].

- (c) From (a) determine the maximum (largest) value of [|se| / mpse₍₁₎],

i.e. [|se| / mpse₍₁₎]_{max} from all the preset test fills

- (d) From (b) determine the maximum (largest) value of [md_{max} / mpd₍₁₎],

i.e. [md_{max} / mpd₍₁₎]_{max} from all the preset test fills

- (e) Determine the accuracy class X(x) such that:

$$x \geq [|se| / mpse_{(1)}]_{max}$$

$$\text{and } x \geq [md_{max} / mpd_{(1)}]_{max}$$

$$\text{and } x = 1 \times 10^k, 2 \times 10^k, \text{ or } 5 \times 10^k,$$

the index k being a positive or negative whole number or zero.

Annex A - Error calculation for multi-load filling **AFGI**AGFIs (Mandatory)

A.1 Fault limit for multi-load AGFIs

a) Fault limit for selective combination weighers:

A fault greater than 0.25 mpd in-service of each fill (OIML R 61-1, Table 2) divided by the square root of the average (or optimum) number of loads in a fill, for a fill equal to the Min multiplied by the average (or optimum) number of loads in a fill.

Example: For a class X(1) AGFI with Min = 200 g designed for an average of 8 loads per fill, fill = 1 600 g, the mpd in-service of each fill from the average fill (OIML R 61-1, Table 2) is 1.5 % = 24 g. Hence the fault limit is:

$$0.25 \times (24 / \sqrt{8}) = 2.12 \text{ g}$$

b) Fault limit for cumulative weighers:

A fault greater than 0.25 mpd in-service of each fill (OIML R 61-1, Table 2), for a fill equal to the Minfill, divided by the square root of the minimum number of loads per fill.

Example: For a class X(1) AGFI with Max = 1 200 g and Minfill of 8 kg: 8 kg/1.2 kg = 6.67; therefore the minimum number of loads per fill is 7. The mpd (in OIML R 61-1, Table 2) for the Minfill of 8 kg is 1.5 % or 120 g. Hence the fault limit is:

$$0.25 \times (120 / \sqrt{7}) = 11.34 \text{ g}$$

Note: This calculation of the fault limit value for cumulative weighers does not include Min. A cumulative weigher would normally be used at or near to Max.

A.2 Influence factor tests mpes for multi-load AGFIs

This method determines the maximum permissible error for influence factor testing for a fill consisting of more than one static test load.

a) For selective combination weighers the mpe for any static test load during influence factor tests shall be 0.25 mpd in-service for the appropriate mass of the fill divided by the square root of the average (or optimum) number of loads per fill.

Example: Class X(1) selective combination weigher, where the average number of loads per fill is equal to 4. For a static test load = 100 g the appropriate mass of the fill will be 400 g for which the mpd in-service is 3 %, i.e. 12 g. Hence the mpe for influence factor tests is:

$$0.25 \times (12 \text{ g} / \sqrt{4}) = 1.5 \text{ g}$$

b) For cumulative weighers the mpe for any static test load during influence factor tests shall be 0.25 mpd in-service for the Minfill divided by the square root of the minimum number of loads per fill.

Example: For a class X(1) AGFI with Max = 1 200 g and Minfill of 8 kg: $8 \text{ kg}/1.2 \text{ kg} = 6.67$; therefore the minimum number of loads per fill = 7. The mpd (as specified in OIML R 61-1, Table 2) for the Minfill of 8 kg is 1.5 %, i.e. 120 g. Hence the mpe for influence factor tests is:

$$0.25 \times (120 / \sqrt{7}) = 11.34 \text{ g}$$

Note: For cumulative weighers the average number of loads per fill is not known. Therefore it is not possible to define the maximum permissible error for influence factors in terms of average loads per fill and appropriate mass of the fill. The above definition is based on Max load and Minfill.

Annex B (Informative)

Equipment Under Test

B.1 Selection of EUTs

AGFIs shall be categorized primarily by the fundamental engineering design they are constructed upon. The categories of design may include but are not limited to the following basic operating principles:

1. Mechanical – no electronics;
2. Analogue, strain gauge type load cells;
3. Digital load cells

Those AGFIs using load cell technology may further be categorized by using the method that the load cells are mounted / connected to the weight receiving element and supporting structures. Examples may include but are not limited to:

1. Direct mounting of load cells without check rods;
2. Connection of the weighing elements to load cell via lever system;
3. Isolated from load cell and with check rods or flexures

The selection of EUTs to be tested shall be such that at least the EUT that represents the “worst case” sample from that family is selected along with a EUT representing a best (or better) case from the family. It is recommended that the worst case EUT be selected based on the following:

For testing performed in a laboratory setting:

- 1) Lowest input signal from the force transducer(s);
- 2) Unit with all the interfaces (i.e. peripheral equipment, hardware components);
- 3) Unit with all the necessary load cells

B.2 Other metrological features to be considered

Variations in metrologically relevant features and functions such as different:

- housings;
- load receptors;
- temperature and humidity ranges;
- AGFI functions;
- displacement transducer;
- indicators

may require additional partial testing of those factors which are influenced by that feature. These additional tests should preferably be carried out on the same EUT, but if this is not possible, tests on one or more additional EUTs may be performed under the responsibility of the testing authority.

The ability of the AGFI to withstand all required performance tests during the evaluation may be a good indication of the durability.

Annex C (Informative)

Metrological control

~~A durability assessment performed under type evaluation should take into account that (lack of) durability may be a characteristic of a particular installation. Hence a decision not to perform durability assessment under type evaluation for an AGFI may only be justified where the unacceptable level of durability is clearly a characteristic of the type.~~

Where measures to ensure durability are taken **in accordance with 8.1, R 61-1**, this shall be recorded in the report format for type evaluation OIML R 61-3.

~~Should an AGFI (installed in a particular location) be found to be of unacceptable durability, that AGFI shall be withdrawn from use. If unacceptable durability was found to be a characteristic of the type (unacceptable durability regardless of the installation), withdrawal of the type approval shall be considered.~~

Annex D (Informative)

Considerations on rated minimum fill (MinFill)

The value of Minfill relates to a number of requirements.

These requirements are:

- Temperature effect on no load indication (R6R 61-1, 4.8.2.3)
- Zero-setting accuracy (OIML R 61-1, 5.8.2)
- Disturbances (OIML R 61-1, 6.2 if applicable)
- Warm-up time (OIML R 61-1, 6.8 if applicable)

The value as defined by the manufacturer shall be confirmed, using the results of the corresponding test procedures.

If all required criteria are met and the zero-setting accuracy is 0.25 mpd this leads to:

$$0.25 \text{ mpd} \leq 0.25 \text{ mpd}_{\text{in-service}} \times \text{Minfill}, \text{ or } \text{Minfill} \geq d / \text{mpd}_{\text{in-service}}$$

For class X(x) AGFIs the minimum permissible values of Minfill for d values are given in R6R 61-1, Table 3.

For calculating the Minfill value for class X(x) AGFIs the mpd and F values (masses of the fills in OIML R 61-1, Table 2) are applied.

Example 1:

Estimated mass of the fills with 400 g

Class X(0.2) AGFI

d = 20 g and estimated mpd (3 % x 0.2) = 0.6 %

Combining the estimated mpd percentage and the value of d results in an absolute value of Minfill of: 20 g / 0.006 = 3330 g;

This value is in the F range having an mpd_{in-service} of 1.5 % times the class; resulting in 0.3 % relative to the fill, which is less than the 0.6 %.

Therefore further calculation is necessary as follows:

Applying the 0,3 % the resulting Minfill value will be: 20 g / 0.003 = 6660 g, which value is correct while F range and mpd are coherent.

Not for each absolute values of the mpd a Minfill can be obtained. Only the relative mpd values can be used for the calculation of the Minfill and the calculated Minfill shall be in the same (F) range as the mpd used in the calculation.

Example 2:

Class X(1) AGFI

d = 10 g

Estimated Minfill 250 g

From OIML R 61-1, Table 2 a F of 250 g results in the constant value for mpd = 9 g; which implies 9 g = 3.6 % for the estimated Minfill of 250 g.

Based on the d value (10 g) and using this mpd percentage the Minfill would be: 10 g / 0.036 = 280 g;

but for 280 g the mpd = 3.2 % therefore further calculation(iteration) is necessary;

using the last percentage the resulting Minfill value will be: $10 \text{ g} / 0.032 = 310 \text{ g}$;
but for 310 g the mpd = 3.0 % ;therefore further calculation is necessary;
using the last percentage the resulting Minfill value will be: $10 \text{ g} / 0.03 = 330 \text{ g}$;
which value is correct because the F range and mpd are coherent.

Example 3

The calculation for selective combination weighers will be similar to Example 2 since the fill is composed of many partial fills which are combined into a fill.

Annex E (Informative)

Conversion of NAWI (Indicator) Test results for AWI purposes

Further information on using results of tests performed on NAWIs based on OIML R76 [6] to issue type evaluation certificates according to R 61 is given in this Annex ~~and~~ (available in the WELMEC Guide 2.8 [33]).

A main prerequisite is that the ~~AFCI~~AGFI that is to be approved on these test results is not working dynamically (load in relative motion to the load receptor when being weighed).

Another condition is that the load cells intended to be used have been tested on basis of OIML R 60 [5] or of OIML R 76 [6] as far as applicable.

The principle and examples to make necessary calculation more transparent is detailed below.

E.1 Tests of importance for conversion

Basic conditions:

- A module including the A/D converter (indicator analogue data processing unit) has been tested, to which neither a verification scale interval “e” nor a scale interval “d” in units of mass has been assigned but only a minimum signal voltage in microvolt per “e” or “d” and a maximum number of scale intervals.
- The manufacturer wants to build a wide range of types of instruments with different maximum loads (Max), minimum load (Min) and scale intervals (d), as well as different Minfills.
- Minfill is unknown.

Influence factors and disturbances having an effect on the result of the fill:

1. The change of span

Tests to be considered: temperature and damp heat

2. The change of zero

Tests to be considered: accuracy of zero / tare setting, temperature (drift of zero), warm up (drift of zero)

3. Faults due to disturbances

Tests to be considered: short time power reductions, bursts, surge, electrostatic discharges, radiated electromagnetic fields, conducted radio-frequency fields

Note:

Transitory faults can be very critical to filling machines, but these are not considered while testing according to R 76 [6] since they are regarded as being obvious to the user. Yet, with filling machines this is different, since the instrument could consider the set value to be reached due to a temporary disturbance increasing the weight indication, and thus might open the flaps of the weighing hopper. This would lead to incorrect fillings. Therefore, the results of R 76 [6] disturbance tests cannot be

generally accepted for conversion to R 61, unless the transitory faults have been taken into account in the R 76 [6] report.

E.2 Conversion of relevant test results

The error limits according R 76 [6] are based on the maximum number of scale intervals only, irrespective of the mass value of the scale interval, since they are given as fractions of the scale interval. This is not the case with R 61 which introduces a completely different error regime based on the concrete mass values of the fill. Therefore the minimum microvolt per e/d or a corresponding number of digits have to be assigned to a concrete value of d in gram. The d has to be listed in the type approval certificate since the attainable minimum fill (Minfill) depends on this value. The smaller d is, the smaller the permissible Minfill will be. The value of d is independent of the minimum microvolt per d (e) the indicator is specified for, since it is the load cell of which the Max is crucial, provided that its output signal is sufficiently high to fulfill the requirement not to fall below the minimum voltage per d .

Generally the fill is affected by influences on the span and on zero of the instrument. The latter is especially critical for gravimetric filling machines because zero setting is normally not part of every weighing cycle. Thus any drift of zero directly affects the fill. This effect may be more significant than any effect on the span. This can be well seen from a comparison of R 76 [6] error limits to R 61 error limits. Since the latter ones are (in principle) percentage error limits, the absolute maximum permissible error (mpe) for fills higher than $200d$ according to R 61 (setting error $0.25 \text{ mpd}_{\text{in service}}$) is much higher than the mpe according to R 76 [6], depending on the fill. The higher the fill related to d , the more uncritical is the R 61 error limit compared to R 76 [6] (see Figure 2).

Remarks:

For all following example calculations the percentage values instead of absolute values given in R 61-1, Table 2 has been used. The reason can most easily be explained by giving the following example: The fill shall be e.g. 75 g. The maximum permissible deviation for this fill is 4.5 g. This is the maximum error also for the highest fill in this range (100 g) and would be the smallest relative (or percentage) permissible deviation of all fills between $>50 \text{ g}$ and $\leq 100 \text{ g}$. Thus taking this relative value of $\text{mpd}_{\text{in service}}$ is the worst case and will guarantee that for all fills smaller than 100 g within this range the $\text{mpd}_{\text{in service}}$ is not exceeded at any time.

E.2.1 Change of span

The error limits of R 76 [6] (weighing performance) compared to error limits of R 61-1, 4.3.2 for influence factor test:

R 61-1, 4.3.2 says: $\text{mpd}_{\text{influence factors}} = 0.25 \text{ mpd}_{\text{in service}}$

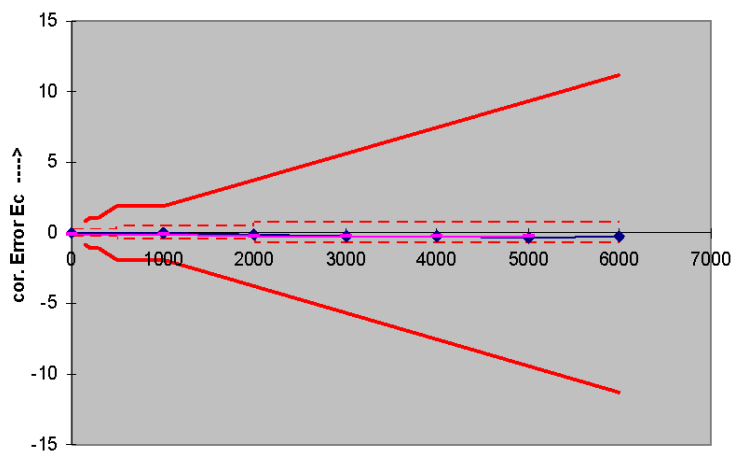
Testing an indicator (module) p_i has to be considered: e.g. $p_i = 0.5$

Furthermore the reference accuracy class Ref(x) has to be considered.

The diagram (all values in gram) below shows the following example:

Based on $d = 1 \text{ g}$ and $p_i = 0.5$ and Ref(1) error limits according to R 61 (continuous line) and according to R 76 [6] (dashed line):

Figure 2: R 61 error limits (continuous line) in comparison to R 76 [6] error limits (dashed line)



Example fill: 2000 g

Error limit according to R 61-1, 4.3.2:

$$\text{mpd} = \text{Fill} \times \text{mpd}_{\text{in-service}} \times 0.25 \text{ (R 61-1, 4.3.2)} \times \text{Ref}(x) \times p_i$$

$$\text{mpd} = 2000 \text{ g} \times 1.5 \% \times 0.25 \times 1 \times 0.5$$

$$\text{mpd} = 3.75 \text{ g}$$

Error limit according to R 76 [6] at a load corresponding to 2000 e:

$$\text{mpe} = 1 \text{ e} \times p_i = 1 \text{ e} \times 0.5 = 0.5 \text{ g}$$

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From the graph one can perceive that the higher the fill, the higher is the difference between the R 76 [6] error limits and the R 61, 4.3 error limits. Therefore, it is sufficient to consider only small loads or, to be more precise, the minimum fill (Minfill). For automatic gravimetric filling machines the error at zero is more critical with regard to Minfill and thus first Minfill should be calculated on basis of the following ideas before checking whether e.g. span drift due to temperature has an effect.

E.2.2. The change of zero.

The change of zero is important to consider for every instrument that is not automatically set to zero before each weighing as the zero error is directly added to the weighing result.

Effects preventing the zero from being accurate:

A) *Insufficient accuracy of zero / tare setting*

$$\text{from R 61-1, 5.8: } \text{mpd}(\text{zero}) \leq 0.25 \times \text{mpd}(X)_{\text{in service}} \times \text{Min}(\text{fill}) \quad (\text{R 61-1, 5.8.2})$$

$$\Leftrightarrow \text{Min}(\text{fill}) \geq \text{mpd}(\text{zero}) / 0.25 \times \text{mpd}(X)_{\text{in service}}$$

The required accuracy for electronic weighing instruments according to R 76 [6] is limited to 0.25 e (or d). This fact leads to the absolutely smallest Minfills possible since the zero / tare setting error adds to the fill error under all conditions.

Example:

Non-automatic weighing instrument with $e = 1$ g, zero setting error being 0.25 g. The reference accuracy class is $\text{Ref}(x) = 1$. Thus absolutely smallest Minfill is:

$$\text{Minfill} \geq 0.25 \text{ g} / (0.25 \times \text{mpd}(X)_{\text{in service}})$$

The problem is that $\text{mpd}(X)_{\text{in service}}$ is unknown since it depends on the (Min)fill. Thus as a first step the fill is estimated and a subsequent iteration is necessary. The iteration starts assuming that Minfill is smaller than 50 g, then

$$\text{mpd}(X)_{\text{in service}} = 9 \% \text{ (R 61-1, 4.3.1, Table 2)}$$

The first step of iteration:

$$\text{Minfill} \geq 0.25 \text{ g} / (0.25 \times 9 \%)$$

$$\text{Minfill} \geq 11.1 \text{ g and rounded to } d$$

$$\text{Minfill} \geq 11 \text{ g}$$

The Minfill of this instrument (having $d = 1$ g) can never be smaller than 11 g at a reference class $\text{Ref}(X) = 1$.

The same procedure must be followed for calculating all other possible Minfills depending on other values of scale interval d and other reference classes $\text{Ref}(X)$.

B) Temperature effect on no-load indication

$$\text{from 10.2.3: } \Delta z_{\max} \leq 0.25 \times \text{mpd}_{\text{in service}} \times \text{Minfill} \times p_i \times \text{Ref}(X)$$

$$\Leftrightarrow \text{Minfill} \geq \Delta z_{\max} / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(X))$$

$$\text{mpd}_{\text{in service}} \rightarrow \text{from Table 2 (R 61-1, 4.3.1)}$$

$$0.25 \rightarrow \text{from R 61-1, 4.3.2}$$

The maximum zero drift depending on variation of temperature according to R 76 [6] is 1 e per 5 K (°C). The assumption made is that the maximum temperature drift is not more than 5 K / h. (This figure is taken from 7.3, see also R 76 [6], A.4.1.2). The maximum time interval assumed to be chosen by the manufacturer between two zero settings is 2 hours. Thus the maximum zero drift to be considered is the theoretical drift within two hours, that is, twice the maximum value taken from the R 76-2 [6] protocol.

From the R 76-2 protocol form the maximum zero drift has to be taken, and then Minfill can be calculated by iteration.

Example: $e = d = 1$ g, $\text{Ref}(X) = 1$, $p_i = 0.5$, zero drift 1 e / 5 K, $\text{mpd}_{\text{in service}} = 9 \%$ (assumption that $\text{Minfill} \leq 50$ g)

from R 61-2, 10.2.3: $\Delta z_{\max} \leq 0.25 \times \text{mpd}_{\text{in service}} \times \text{Minfill} \times p_i \times \text{Ref}(X)$

$$\Leftrightarrow \text{Minfill} \geq \Delta z_{\max} / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(X))$$

Assuming that the instrument is not set to zero before 2 h have elapsed:

$$\text{Minfill} \geq (2 \text{ h} \times 1 \text{ e} / \text{h}) / (0.25 \times 9 \% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq (2 \text{ h} \times 1 \text{ g} / \text{h}) / (0.25 \times 9 \% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 2 \text{ g} / (0.25 \times 9 \% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 177.78 \text{ g} > 50 \text{ g (assumption with regard to Minfill has been wrong)}$$

Next iteration step: $\text{Minfill} \leq 200 \text{ g}$ and $\text{mpd}_{\text{in service}} = 4.5 \%$ (obviously leading to double the value calculated before)

$$\text{Minfill} \geq 2 \text{ g} / (0.25 \times 4.5\% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 355.56 \text{ g} > 200 \text{ g (assumption with regard to Minfill has been wrong)}$$

Next iteration step: $\text{Minfill} \leq 500 \text{ g}$ and $\text{mpd}_{\text{in service}} = 3 \%$

$$\text{Minfill} \geq 2 \text{ g} / (0.25 \times 3\% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 533.33 \text{ g} > 500 \text{ g (assumption with regard to Minfill has been wrong)}$$

Next iteration step: $\text{Minfill} \leq 1000 \text{ g}$ and $\text{mpd}_{\text{in service}} = 1.5 \%$, corresponding to 1.5 % (obviously leading to double the value calculated before)

$$\text{Minfill} \geq 2 \text{ g} / (0.25 \times 1.5\% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 1066.67 \text{ g (more than 1000 g, however for fills between 1000 g (or 1 kg) and 10,000 g (or 10 kg) a deviation of 1.5% is acceptable, thus 1067 g is the final permissible Minfill)}$$

Shorter zero setting intervals:

In a lot of cases a zero setting interval of 2 h may not be adequate especially when caking and adhesive material is filled. Some notified bodies require even an interval of not more than 15 minutes. The following example shows what happens to Minfill when the maximum time interval between two zero settings is reduced to for example 15 minutes or 0.25 h respectively.

The maximum zero drift per 5 K and therefore per 1 h has been assumed to be 1 e (e = 1 g). Thus in a quarter of an hour it cannot be more than 0.25 e. Minfill would then be:

$$\text{Minfill} \geq \Delta z_{\max} / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(X))$$

$$\text{Minfill} \geq 1 \text{ g} \times 0.25 / (0.25 \times 9\% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 0.25 \text{ g} / (0.25 \times 9\% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 22.2 \text{ g}$$

C) Warm up time

$$\text{from R 61-2, 10.2.1: } E_0 - E_{0 \text{ init}} \leq 0.25 \times \text{mpd}_{\text{in service}} \times \text{Minfill} \times p_i \times \text{Ref}(X)$$

$$\Leftrightarrow \text{Minfill} \geq (E_0 - E_{0 \text{ init}}) / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(X))$$

$$\text{mpd}_{\text{in service}} \rightarrow \text{from Table 2 (R 61-1, 4.3.1)}$$

$$0.25 \rightarrow \text{from R 61-1, 4.3.2}$$

$$\text{Ref}(X) \rightarrow \text{has to be chosen (may be given by manufacturer)}$$

Remark: If $(E_0 - E_{0 \text{ init}}) < 0$ then the absolute value of $(E_0 - E_{0 \text{ init}})$ has to be used.

From the R 76-2 protocol form the maximum zero drift due to warm up has to be taken, and then Minfill can be calculated by iteration.

Example: $e = d = 1 \text{ g}$, $\text{Ref}(X) = 1$, $p_i = 0.5$, zero drift due to warm up 3 e,
 $\text{mpd}_{\text{in service}} = 9\%$ (assumption that $\text{Minfill} \leq 50 \text{ g}$)

$$\text{Minfill} \geq (E_0 - E_{0 \text{ init}}) / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(X))$$

$$\Leftrightarrow \text{Minfill} \geq 3 \text{ g} / (0.25 \times 9\% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 266.6 \text{ g} > 200 \text{ g},$$

Assumption being Minfill between $>200 \text{ g}$ and $\leq 300 \text{ g}$.

$\text{mpd}_{\text{in service}} = 9 \text{ g}$. For a new calculation that has to be put in relation to the highest fill of this range, i.e. 300 g . The maximum percentage deviation would then be: $9 \text{ g} / 300 \text{ g} = 0.03 = 3\%$. (See remarks under E.2)

$$\text{Minfill} \geq 3 \text{ g} / (0.25 \times 3\% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 800 \text{ g} > 500 \text{ g}, \text{ next iteration step.}$$

Assumption being Minfill between $>500 \text{ g}$ and $\leq 1000 \text{ g}$.

$\text{mpd}_{\text{in service}} = 15 \text{ g}$. For a new calculation that has to be put in relation to the highest fill of this range, i.e. 1000 g . The maximum percentage deviation would then be: $15 \text{ g} / 1000 \text{ g} = 0.015 = 1.5\%$. (see initial remarks)

$$\text{Minfill} \geq 3 \text{ g} / (0.25 \times 1.5\% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 1600 \text{ g} \leq 10000 \text{ g}, \text{ iteration stops here.}$$

E.2.3. Faults due to disturbances

The significant fault for all disturbance tests is 0.25 of the maximum permissible deviation (mpd) of each fill for in-service verification, for a fill equal to the rated minimum fill (see R 61-1, 3.5.2.7). Thus the maximum deviation must be

$$md_{\text{disturbance}} \leq 0.25 \times mpd_{\text{in service}} \times \text{Ref}(X) \times \text{Minfill}$$

$$(p_i = 1 \text{ for disturbance tests; see WELMEC Guide 2.1})$$

$$\Leftrightarrow \text{Minfill} \geq md_{\text{disturbance}} / (0.25 \times mpd_{\text{in service}} \times \text{Ref}(X))$$

The significant fault for nonautomatic weighing instruments is 1 e. However, when testing without high resolution this could amount even to 1.5 e.

The following example is based on the assumption that the significant fault amounts to 1.5 e, while $e = 1$ g. The reference class of the instrument shall again be $\text{Ref}(x) = 1$. The error fraction p_i , however, now is not 0.5 but 1 because the susceptibility to disturbances is a feature of the indicator alone as well as the influence of variation of the supply voltage (see R 76-1, C.2, Table 12). The expected Minfill is between >50 g and ≤ 100 g, so $mpd_{\text{in service}} = 4.5 \%$

Then:

$$\text{Minfill} \geq md_{\text{disturbance}} / (0.25 \times mpd_{\text{in service}} \times \text{Ref}(X))$$

$$\Leftrightarrow \text{Minfill} \geq 1.5 \text{ g} / (0.25 \times 4.5 \% \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 133.3 \text{ g}$$

Since $mpd_{\text{in service}}$ for a fill of 133.3 g is 4.5% as well, no further calculations are necessary. A Minfill smaller than or equal to 50 g is not possible since maximum deviation due to disturbance would be:

$$md_{\text{disturbance}} \leq 0.25 \times mpd_{\text{in service}} \times \text{Ref}(X) \times \text{Minfill}$$

$$\Leftrightarrow md_{\text{disturbance}} \leq 0.25 \times 9 \% \times 1 \times 50 \text{ g}$$

$$\Leftrightarrow md_{\text{disturbance}} \leq 1.125 \text{ g}$$

Summary of example test results and conclusions

The Minfills based on the calculations above are:

Based on accuracy of zero / tare setting:	11 g (rounded down)
Based on temperature effect on no-load indication	1067 g (rounded up)
Based on warm up time	400 -1600 g
Based on faults due to disturbances	133 g (rounded down)

The highest Minfill (1067 g) has to be selected as being the worst case. The R 61 error limit at this fill is $1067 \text{ g} \times 1.5 \% \times 0.5 = 8 \text{ g}$. Comparing the figure to the error limit according to R 76 [6] (considering p_i) being 0.5 g ($1 \text{ g} \times 0.5$) it is evident that normally the incorrect zero and the deviation due to disturbances are the crucial points. Thus the corresponding Minfills have to be calculated first and then the highest Minfill has to be

compared to the R 61 error limits (see Figure 2 above) valid for temperature and damp heat tests.

E.3 Calculating of Minfills with Selective Combination Weighers

Selective combination weighers have to be handled slightly differently as the fill is composed of many partial fills. Each weighing unit producing a partial fill produces its own partial errors due to influence factors and disturbances. However, corresponding to the addition of error fractions p_i within the frame of the modular approach, the single errors of the weighing units are added geometrically (Annex A.1). The examples are based on the same data as for the single load filling instruments with the exception that the $e = d$ of the single load instrument now is considered being the d_{WU} of the single weighing unit.

$$d \geq d_{WU} \times \sqrt{i} \quad (\text{R 61-2, Annex A.2})$$

E.3.1 The change of zero

from R 61-1, 5.8.2 and R 61-2, Annex A.2:

$$\text{mpd}(\text{zero}) \leq 0.25 \times (\text{mpd}(X)_{\text{in service}} \times \text{Min}(\text{fill}) / \sqrt{\text{lpf}})$$

[$\sqrt{\text{lpf}}$ is the square root of the number of loads per fill]

A) Insufficient accuracy of zero / tare setting

The required accuracy for electronic weighing instruments according to R 76 [6] is limited to $0.25 e$ (or d_{WU}). This fact leads to the absolutely smallest Minfills possible since the zero / tare setting error adds to the fill error under all conditions.

$$0.25 d_{WU} \leq 0.25 \times (\text{mpd}(X)_{\text{in service}} \times \text{Min}(\text{fill}) / \sqrt{\text{lpf}})$$

$$\Leftrightarrow d_{WU} \geq \text{mpd}(X)_{\text{in service}} \times \text{Min}(\text{fill}) / \sqrt{\text{lpf}}$$

$$\Leftrightarrow \text{Min}(\text{fill}) \geq d_{WU} \times \sqrt{\text{lpf}} / \text{mpd}(X)_{\text{in service}}$$

Example:

Nonautomatic weighing instrument with $d_{WU} = 1 \text{ g}$, zero setting error being 0.25 g . The reference accuracy class is $\text{Ref}(x) = 1$. The average number of partial fills (loads per fill, "lpf") is 4. Thus absolutely smallest Minfill is:

$$\text{Minfill} \geq d_{WU} \times \sqrt{\text{lpf}} / \text{mpd}(X)_{\text{in service}}$$

The problem is that $\text{mpd}(X)_{\text{in service}}$ is unknown since it depends on the Minfill. Thus as a first step the fill is estimated and a subsequent iteration is necessary. The iteration starts assuming that Minfill is smaller than 50 g , then

$$\text{mpd}(X)_{\text{in service}} = 9 \% \quad (\text{R 61-1, 4.3.1, Table 2})$$

The first step of iteration:

$$\text{Minfill} \geq 1 \text{ g} \times \sqrt{4} / 9 \%$$

$$\text{Minfill} \geq 22.2 \text{ g and rounded to } d$$

Minfill ≥ 22 g

The Minfill of this instrument (having $d_{WU} = 1$ g, average number of 4 loads per fill) can never be smaller than 22 g at a reference class $\text{Ref}(X) = 1$.

The same procedure must be followed for calculating all other possible Minfills depending on other values of scale interval d_{WU} and other reference classes $\text{Ref}(X)$.

The following table ~~is~~ shows the absolute minimum Minfills of a selective combination weigher with 4 loads per fill, related to d_{WU} , depending on normal accuracy of zero setting of NAWIs:

d_{WU} (g)	Minimum permissible value of Minfill (g) / lpf = 4			
	X(0.2)	X(0.5)	X(1)	X(2)
1	333	44	22	11
2	1 334	88 178	44	22
5	3 335	1 335	335	110
10	6-660 6 670	2-660 2 670	1 330	330
20	13-340 20 000	5-330 5 340	2 660	1340
50	50 000	13-350 20 000	6 650	1-650 3 350
100	100 000	40 000	20 000	6-600 6 700
200	200 000	80 000	40 000	20 000
≥ 500	1 000 d	500-400 d	200 d	100 d

As an alternative to the method above all calculations could be based on the d of whole filling instrument instead of d_{WU} of the weighing unit.

$d/\text{sqr}(\text{lpf})$ lpf = 4	calculated $d_{WU}d_{WU+}$	permissible $d_{WU}d_{WU+}$	class X(1) d rounded up	
			Minfill	Minfill
2 g/2	1 g	1 g	22 g	22 g
5 g/2	2,5 g	2 g	44 g	45 g
10 g/2	5 g	5 g	110 g	110 g
20 g/2	10 g	10 g	1 330 g	1 340 g
50 g/2	25 g	20 g	2 660 g	2 700 g
100 g/2	50 g	50 g	6 650 g	6 700 g
200 g/2	100 g	100 g	20 000 g	20 000 g
500 g/2	250 g	200 g	40 000 g	40 000 g

B) Temperature effect on no-load indication

from 10.2.3 and R 61-1, Annex A.2:

$$\Delta z_{\max} \leq 0.25 \times \text{mpd}_{\text{in service}} \times \text{Minfill} \times p_i \times \text{Ref}(X) / \text{sqr}(\text{lpf})$$

$$\Leftrightarrow \text{Minfill} \geq \Delta z_{\max} \times \text{sqr}(\text{lpf}) / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(X))$$

$$\text{mpd}_{\text{in service}} \rightarrow \text{from Table 2 (R 61-1, 4.3.1)}$$

$$0.25 \rightarrow \text{from R 61-1, 4.3.2}$$

The maximum zero drift depending on variation of temperature according to R 76 [6] is 1 e per 5 K (°C). The assumption made is that the maximum temperature drift is not more than 5 K / h. (This figure is taken from 7.3, see also R 76 [6], A.4.1.2). The maximum time interval assumed to be chosen by the manufacturer between two zero settings is 2 hours. Thus the maximum zero drift to be considered is the theoretical drift within two hours, that is twice the maximum value taken from the R 76-2 protocol.

From the R 76-2 protocol form the maximum zero drift has to be taken, and then Minfill can be calculated by iteration.

Example: $e = d_{WU} = 1 \text{ g}$, $\text{Ref}(X) = 1$, $p_i = 0.5$, zero drift 1 e / 5 K,
 $\text{mpd}_{\text{in service}} = 9 \%$ (assumption that $\text{Minfill} \leq 50 \text{ g}$)

from 10.2.3 and R 61-2, Annex A.2:

$$\Delta z_{\max} \leq 0.25 \times \text{mpd}_{\text{in service}} \times \text{Minfill} \times p_i \times \text{Ref}(X) / \text{sqr}(\text{lpf})$$

$$\Leftrightarrow \text{Minfill} \geq \Delta z_{\max} \times \text{sqr}(\text{lpf}) / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(X))$$

Assuming that the instrument is not set to zero before 2 h have elapsed:

$$\Leftrightarrow \text{Minfill} \geq (2 \text{ h} \times 1 \text{ e} / \text{h}) \times \text{sqr}(4) / (0.25 \times 9 \% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq (2 \text{ h} \times 1 \text{ g} / \text{h}) \times 2 / (0.25 \times 9 \% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 4 \text{ g} / (0.25 \times 9 \% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 355.56 \text{ g} > 50 \text{ g} \text{ (assumption with regard to Minfill has been wrong)}$$

Next iteration step: $\text{Minfill} \leq 500 \text{ g}$ and $\text{mpd}_{\text{in service}} = 3 \%$ (obviously leading to three times the value calculated before)

$$\Leftrightarrow \text{Minfill} \geq 4 \text{ g} / (0.25 \times 3\% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 1066.67 \text{ g} > 500 \text{ g} \text{ (assumption with regard to Minfill has been wrong)}$$

Next iteration step: $\text{Minfill} \leq 10000 \text{ g}$ and $\text{mpd}_{\text{in service}} = 1.5 \%$

$$\Leftrightarrow \text{Minfill} \geq 4 \text{ g} / (0.25 \times 1.5\% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 2133.33 \text{ g} < 10000 \text{ g} \text{ (for fill between 1000 g and 10,000 g a deviation of 1.5\% is acceptable, thus 2133 g is the final permissible Minfill)}$$

C) Warm up time

from 10.2.1: $E_0 - E_{0i} \leq 0.25 \times \text{mpd}_{\text{in service}} \times \text{Minfill} \times p_i \times \text{Ref}(X) / \text{sqr}(\text{lpf})$

$$\Leftrightarrow \text{Minfill} \geq (E_0 - E_{0i}) \times \text{sqr}(\text{lpf}) / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(X))$$

$\text{mpd}_{\text{in service}} \rightarrow$ from Table 2 (R 61-1, 4.3.1)

0.25 \rightarrow from R 61-1, 4.3.2

$\text{Ref}(X) \rightarrow$ has to be chosen (may be given by manufacturer)

Remark: If $(E_0 - E_{0i}) < 0$ then the absolute value of $(E_0 - E_{0i})$ has to be used.

From the R 76-2 protocol form the maximum zero drift due to warm up has to be taken, and then Minfill can be calculated by iteration.

Example: $e = d = 1 \text{ g}$, $\text{Ref}(X) = 1$, $p_i = 0.5$, zero drift due to warm up $3 e$, $\text{mpd}_{\text{in service}} = 9 \%$ (assumption that $\text{Minfill} \leq 50 \text{ g}$)

$$\Leftrightarrow \text{Minfill} \geq (E_0 - E_{0 \text{ init}}) \times \text{sqr}(\text{lpf}) / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(X))$$

$$\Leftrightarrow \text{Minfill} \geq 3 \text{ g} \times \text{sqr}(4) / (0.25 \times 9 \% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 533.3 \text{ g} > 500 \text{ g},$$

Assumption being Minfill between $>500 \text{ g}$ and $\leq 1000 \text{ g}$.

$\text{mpd}_{\text{in service}} = 15 \text{ g}$. For a new calculation that has to be put in relation to the highest fill of this range, i.e. 1000 g . The maximum percentage deviation would then be: $15 \text{ g} / 1000 \text{ g} = 0.015 = 1.5 \%$. (see remarks under E.2)

$$\Leftrightarrow \text{Minfill} \geq 3 \text{ g} \times \text{sqr}(4) / (0.25 \times 1.5 \% \times 0.5 \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 3200 \text{ g} \geq 1000 \text{ g}, \text{ next iteration step.}$$

Minfill between $>1000 \text{ g}$ and $\leq 10000 \text{ g}$, $\text{mpd}_{\text{in service}} = 1.5\%$, thus Minfill is 3200 g , iteration stops here.

E.3.3. Faults due to disturbances

For selective combination weighers the significant fault for all disturbance tests is 0.25 of the maximum permissible deviation (mpd) of each fill for in-service verification, for a fill equal to the rated minimum fill (see T.4.2.5), however divided by the square root of loads per fill. Thus the maximum deviation must be

$$\text{md}_{\text{disturbance}} \leq 0.25 \times \text{mpd}_{\text{in service}} \times \text{Ref}(X) \times \text{Minfill} / \text{sqr}(\text{lpf})$$

$$\Leftrightarrow \text{Minfill} \geq \text{md}_{\text{disturbance}} \times \text{sqr}(\text{lpf}) / (0.25 \times \text{mpd}_{\text{in service}} \times \text{Ref}(X))$$

Assuming again that the real fault for nonautomatic weighing instruments could amount to $1.5 e$ the following example is given.

While $e = 1$ g, the reference class of the instrument shall again be $\text{Ref}(x) = 1$, and the number of loads per fill shall be $\text{lpf} = 4$. The error fraction p_i , is again 1. (see R 76-1, C.2.2, Table 12). The expected Minfill is between >100 g and ≤ 200 g, so $\text{mpd}_{\text{in service}} = 4.5 \%$

Then:

$$\Leftrightarrow \text{Minfill} \geq \text{md}_{\text{disturbance}} \times \text{sqr}(\text{lpf}) / (0.25 \times \text{mpd}_{\text{in service}} \times \text{Ref}(X))$$

$$\Leftrightarrow \text{Minfill} \geq 1.5 \text{ g} \times \text{sqr}(4) / (0.25 \times 4.5 \% \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 266.6 \text{ g}$$

Expectation has been wrong, thus next iteration:

Assumption Minfill between >300 g and ≤ 500 g, $\text{mpd}_{\text{in service}} = 3\%$

$$\Leftrightarrow \text{Minfill} \geq 1.5 \text{ g} \times \text{sqr}(4) / (0.25 \times 3 \% \times 1)$$

$$\Leftrightarrow \text{Minfill} \geq 400 \text{ g}$$

A Minfill smaller than or equal to 300 g is not possible since maximum deviation due to disturbance would be:

$$\Leftrightarrow \text{md}_{\text{disturbance}} \leq 0.25 \times \text{mpd}_{\text{in service}} \times \text{Ref}(X) \times \text{Minfill}$$

$$\Leftrightarrow \text{md}_{\text{disturbance}} \leq 0.25 \times 3 \% \times 1 \times 300 \text{ g}$$

BIBLIOGRAPHY

Ref.	Standards and reference documents	Description
[1]	International Vocabulary of Metrology -Basic and General Concepts and Associated Terms (VIM) (2012)	Vocabulary, prepared by a joint working group consisting of experts appointed by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP and OIML
[2]	International Vocabulary of Terms in Legal Metrology, VIML, Paris (2000)	Vocabulary including only the concepts used in the field of legal metrology. These concepts concern the activities of the legal metrology service, the relevant documents as well as other problems linked with this activity. Also included in this Vocabulary are certain concepts of a general character which have been drawn from the VIM
[3]	OIML D 11:2013 <i>General requirements for electronic measuring instruments - Environmental Conditions</i>	Contains general requirements for electronic measuring instruments
[4]	OIML R 111:2004 <i>Weights of classes E_1, E_2, F_1, F_2, M_1, M_{1-2}, M_2, M_{2-3} and M_3</i>	Provides the principal physical characteristics and metrological requirements for weights used with and for the verification of weighing instruments and weights of a lower class
[5]	OIML R 60:2000 <i>Metrological regulation for load cells</i>	Provides the principal static characteristics and static evaluation procedures for load cells used in the evaluation of mass
[6]	OIML R 76:2006 <i>Non-automatic weighing instruments</i>	Provides the principal physical characteristics and metrological requirements for the verification of non-automatic weighing instruments
[7]	OIML D 19:1988 <i>Type evaluation and type approval</i>	Provides advice, procedures and influencing factors on type evaluation and type approval
[8]	IEC 60068-2-1 Ed. 6.0 (2007-03) Environmental testing – Part 2: Test methods – Section 1: Test A: Cold Stability date: 2017	Concerns cold tests on both non heat dissipating and heat dissipating equipment under test (EUT)

Ref.	Standards and reference documents	Description
[9]	IEC 60068-2-2 (2007-07) Ed. 5.0 Environmental testing Part 2: Tests, Test B: Dry heat Stability date: 2017	Contains test Ba: dry heat for non heat dissipating specimen with sudden change of temperature; test Bb dry heat for non heat dissipating specimen with gradual change of temperature; tests Bc: dry heat for heat dissipating specimen with sudden change of temperature; test Bd dry heat for heat dissipating specimen with gradual change of temperature
[10]	IEC 60068-3-1 Ed. 2.0 (2011-08) Environmental testing – Part 3: Supporting documentation and guidance –Section 1: Cold and dry heat tests Stability date: 2016	Gives background information for Tests A: Cold (IEC 68-2-1), and Tests B: Dry heat (IEC 68-2-2). Includes appendices on the effect of: chamber size on the surface temperature of a specimen when no forced air circulation is used; airflow on chamber conditions and on surface temperatures of test specimens; wire termination dimensions and material on surface temperature of a component; measurements of temperature, air velocity and emission coefficient. Supplement A - gives additional information for cases where temperature stability is not achieved during the test
[11]	IEC 60068-2-78 Ed. 2.0 (2012-10) Environmental testing – Part 2: Tests methods – Section 78:Test Cab: Damp heat, steady state Stability date: 2017	Provides a test method for determining the suitability of electro-technical products, components or equipment for transportation, storage and use under conditions of high humidity. The test is primarily intended to permit the observation of the effect of high humidity at constant temperature without condensation on the specimen over a prescribed period This test provides a number of preferred severities of high temperature, high humidity and test duration. The test can be applied to both heat-dissipating and non-heat dissipating specimens. The test is applicable to small equipment or components as well as large equipment having complex interconnections with test equipment external to the chamber, requiring a set-up time which prevents the use of preheating and the maintenance of specified conditions during the installation period

Ref.	Standards and reference documents	Description
[12]	IEC 60068-3-4 (2001-08) Environmental testing - Part 3-4: Supporting documentation and guidance - Damp heat tests Stability date :2015	Provides the necessary information to assist in preparing relevant specifications, such as standards for components or equipment, in order to select appropriate tests and test severities for specific products and, in some cases, specific types of application. The object of damp heat tests is to determine the ability of products to withstand the stresses occurring in a high relative humidity environment, with or without condensation, and with special regard to variations of electrical and mechanical characteristics. Damp heat tests may also be utilized to check the resistance of a specimen to some forms of corrosion attack
[13]	IEC TR 61000-2-1 Ed. 1.0 (1990-05) Electromagnetic compatibility (EMC) – Part 2: Environment – Section 1: Description of the environment – Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems Stability date: 2015	Has the status of a technical report, and gives information on the various types of disturbances that can be expected on public power supply systems. The following disturbance phenomena are considered: harmonics, inter-harmonics, voltage fluctuations, voltage dips and short supply interruptions, voltage unbalance, mains signalling, power frequency variation, and DC components.
[14]	IEC 61000-4-1 Ed. 3.0 (2006-10) Ed. 3.0 Basic EMC Publication Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques. Section 1: Overview of IEC 61000-4 series Stability date: 2012	Gives applicability assistance to the users and manufacturers of electrical and electronic equipment on EMC standards within the IEC 61000-4 series on testing and measurement techniques Provides general recommendations concerning the choice of relevant tests
[15]	IEC 61000-4-2 Ed. 2.0 (2008-12) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test Stability date: 2014	Provides the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges, from operators directly, and from any person to adjacent objects. It additionally defines ranges of test levels which relate to different environmental and installation conditions and establishes test procedures.

Ref.	Standards and reference documents	Description
[16]	IEC 61000-4-3 consolidated Ed. 3.2 (2010-04) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic field immunity test Stability date: 2013	Provides the immunity requirements of electrical and electronic equipment to radiated electromagnetic energy. It 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 from any source.
[17]	IEC 61000-4-4 Ed. 3.0 (2012-04) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test Stability date: 2015	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. The test method documented in this part of IEC 61000-4 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon. The standard defines: <ul style="list-style-type: none"> ▪ test voltage waveform; ▪ range of test levels; ▪ test equipment; ▪ verification procedures of test equipment; ▪ test set-up; and ▪ test procedure. The standard gives specifications for laboratory and post-installation tests
[18]	IEC 61000-4-5 Ed. 2.0 (2005-11), Correction 1 on Ed. 2.0 (2009-10) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test Stability date: 2012	Relates to the immunity requirements, test methods, and range of recommended test levels for equipment to unidirectional surges caused by over-voltages from switching and lightning transients. Several test levels are defined which relate to different environment and installation conditions. These requirements are developed for and are applicable to electrical and electronic equipment. Establishes a common reference for evaluating the performance of equipment when subjected to high-energy disturbances on the power and inter-connection lines.

Ref.	Standards and reference documents	Description
[19]	IEC 61000-4-6 Ed 4.0 (2013-10) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radio-frequency fields Stability date: 2018	Relates to the conducted immunity requirements of electrical and electronic equipment to electromagnetic disturbances coming 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.
[20]	IEC 61000-4-11 Ed 2.0 (2004-03) Ed 2.0 Electromagnetic compatibility (EMC) Part 4-11: Testing and measuring techniques - Voltage dips, short interruptions and voltage variations immunity tests Stability date: 2015	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 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
[21]	IEC 61000-4-20 Ed 2.0 (2010-08) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 20: Emission and immunity testing in transverse electromagnetic (TEM) waveguides Stability date: 2014	Provides radiated immunity test methods for electrical and electronic equipment using various types of transverse electromagnetic (TEM) waveguides. These types include open structures (for example, striplines and electromagnetic pulse simulators) and closed structures (for example, TEM cells).

Ref.	Standards and reference documents	Description
[22]	OIML D 28 Edition 2004 (E)	Conventional value of the result of weighing in air
[23]	IEC 60068-2-30 Ed 3.0 (2005-08) Environmental testing – Part 2: Test methods – Section 30: Test Db: Damp heat, cyclic (12 + 12 hour cycle) Stability date: 2017	Determines the suitability of components, equipment and other articles for use and/or storage under conditions of high humidity when combined with cyclic temperature changes. Amendment No. 1 replaces the third paragraph of Clause 8, Recovery.
[24]	ISO 16750-2 Ed. 4.0 (2012) Road vehicles – Environmental conditions and testing for electrical and electronic equipment – Part 2: Electrical loads	Specifies electrical loads and provides corresponding tests and requirements for the mounting of electric and electronic systems and components on road vehicles. It is applicable to environmental conditions and tests affecting electrical and electronic equipment mounted directly on or in the vehicle. It does not cover electromagnetic compatibility (EMC).
[25]	ISO 7637-2 (2011) Road vehicles - electrical disturbance from conducting and coupling – Part 2: Electrical transient conduction along supply lines only	Specifies bench tests for testing the compatibility to conducted electrical transients of equipment installed on passenger cars and light commercial vehicles fitted with a 12 V electrical system or commercial vehicles fitted with a 24 V electrical system. Failure mode severity classification for immunity to transients is also given. It is applicable to these types of road vehicle, independent of the propulsion system (e.g. spark ignition or diesel engine, or electric motor).
[26]	ISO 7637-3 (2007) Road vehicles - Electrical disturbance by conducting and coupling - Part 3: Passenger cars and light commercial vehicles with nominal 12 V supply voltage and commercial vehicles with 24 V supply voltage - Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines	Establishes a common basis for the evaluation of the EMC of electronic instruments, devices and equipment in vehicles against transient transmission by coupling via lines other than supply lines. The test intention is the demonstration of the immunity of the instrument, device or equipment when subjected to coupled fast transient disturbances, such as those caused by switching (switching of inductive loads, relay contact bounce, etc)

Ref.	Standards and reference documents	Description
[27]	IEC 61000-6-1 Ed. 2.0 (2005-3) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 6: Generic standards – Section 1: Immunity for residential, commercial and light-industrial environments Stability date: 2013	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.
[28]	IEC 61000-6-2 Ed. 2.0 (2005-01) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 6: Generic standards – Section 2: Immunity for industrial environments Stability date :2013	Defines the immunity performance requirements for electrical and electronic apparatus intended for use in industrial environments, both indoor and outdoor and 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, and are specified for each port considered. This standard applies to apparatus intended to be connected to a power network supplied from a high or medium voltage transformer dedicated to the supply of an installation feeding manufacturing or similar plant, and intended to operate in or in proximity to industrial locations, as described below. This standard also applies to apparatus which are battery operated and intended to be used in industrial locations. Industrial locations are in addition characterised by the existence of one or more of the following: - industrial, scientific and medical (ISM) apparatus (as defined in CISPR 11); - heavy inductive or capacitive loads are frequently switched; - currents and associated magnetic fields are high.

Ref.	Standards and reference documents	Description
[29]	OIML D 31: 2008 E General requirements for software controlled measuring instruments	Provides guidance for establishing appropriate requirements for software related functionalities in measuring instruments covered by OIML Recommendations.
[30]	ILAC-G24/OIML D 10: 2007 Guidelines for the determination of recalibration intervals of measuring equipment used in testing laboratories	The purpose of this Document is to give laboratories, particularly while setting up their calibration system, guidance on how to determine calibration intervals. This Document identifies and describes the methods that are available and known for the evaluation of calibration intervals.
[31]	IEC 61000-4-17 Consolidated Ed. 1.2 (2009-01) (incl. Amendment 1 and Amendment 2) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 17: Ripple on DC input power port immunity test Stability date: 2015	Provides test methods for immunity to ripple at the DC input power port of electrical or electronic equipment. This standard is applicable to low-voltage DC power ports of equipment supplied by external rectifier systems, or batteries which are being charged. This standard defines: - test voltage waveform, - range of test levels, - test generator, - test setup, - test procedure. This test does not apply to equipment connected to battery charger systems incorporating switch mode converters.
[32]	IEC 60654-2 Ed. 1.0 (1979-01), with amendment 1 (1992-09) on Ed. 1.0 Operating conditions for industrial-process measurement and control equipment – Part 2: Power Stability date: 2015	Gives the limiting values for power received by land-based and offshore industrial-process measurement and control systems or parts of systems during operation. Maintenance and repair conditions are not considered.
[33]	WELMEC Guide 2.8	Guide for conversion of NAWI (Indicator) Test results for AWI purposes
[34]	IEC 61000-4-29 Ed. 1.0 (2000-08) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 29: Voltage dips, short interruptions and voltage variations on DC input power port immunity tests Stability date: 2015	Provides test methods for immunity to voltage dips, short interruptions and voltage variations at the DC input power ports of electrical or electronic equipment. This standard is applicable to low voltage DC power ports of equipment supplied by external DC networks. This standard defines: - the range of test levels, - the test generator, - the test setup, - the test procedure.