INTERNATIONAL RECOMMENDATION

OIML R 61-2

Edition 2017 (E)

Automatic gravimetric filling instruments.

Part 2: Test procedures

Doseuses pondérales à fonctionnement automatique.

Partie 2: Procédures d'essai

OIML R 61-2 Edition 2017 (E)

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY

Contents

Foreword

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Automatic gravimetric filling instruments

Part 2 – Test procedures

1 Introduction

This OIML Recommendation consists of three separate parts:

Part 1: Metrological and technical requirements - Tests
Part 2: Test procedures
Part 3: Report format for type evaluation

2 Scope

R 61-2 is applicable to the type evaluation and initial verification testing of automatic gravimetric filling instruments (hereafter referred to as "AGFIs"), as defined in 3.2.2 in R 61-1.

R 61-2 sets out details of the test program, principles, equipment and procedures to be used for type evaluation and initial verification testing. Certificates of conformity can be issued for automatic gravimetric filling instruments under the scope of the OIML Certification System (OIML-CS), provided that R 61-1, R 61-2 and R 61-3 are used in accordance with the rules of the System.

R 61-2 also applies to ancillary devices, if required by national regulations.

3 Terms and definitions

For the purposes of R 61-2, the terms and definitions given in R 61-1, 3 apply.

4 Symbols, units and equations

Symbols used in R 61-2 are defined in 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 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 R 61-1, 5 and 8.2.1.

5.3 Metrological requirements

Record the metrological characteristics using the checklist in R 61-3.

5.4 Technical requirements

Examine the AGFI for conformity with the technical requirements in R 61-1, 5, using the checklist in R 61-3.

5.5 Functional requirements

Examine the AGFI for conformity with functional requirements in R 61-1, 6 and 7, using R 61-3.

6 Examination for initial verification

6.1 Compare construction with documentation

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

6.2 Descriptive markings

Check the descriptive markings in accordance with R 61-1, 5.12, using the checklist in R 61-3.

7 General test requirements

7.1 Power supply (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 energized for the duration of each test.

7.2 Zero-setting (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 (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 instrument (R 61-1, 3.2.2.4)

7.6.1 Accuracy of test system (8.4)

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 mass value of the fills are required not to have an error exceeding one third of the mpd and mpse (as appropriate) for the AGFI in accordance with R 61-1, 4.3.2 and 4.3.3.

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 AGFIs 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 AGFI with a scale interval, $d = 5$ 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 in 7.6.2.1.

Evaluate the error at load L, E, by the method in 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 the procedure in the Note to 9.2.3 has to be followed.

7.7 Indication of a digit smaller than d

If an 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 R 61-3.

Note: Such indication is only for test purposes.

7.8 Test program

7.8.1 Type evaluation (R 61-1, 8.2)

The following tests shall normally be applied for type evaluation:

- Examination for type evaluation in 5;
- Static tests in 9;
- Influence factor and disturbance tests in 10;
- Span stability test in 11; and
- Material tests in 12.

7.8.2 Location of testing for type evaluation

AGFIs submitted for type evaluation may be tested either

- on the premises of the metrological authority to which the application has been submitted, or
- in any other suitable location agreed between the metrological authority concerned and the applicant.

7.8.3 Non-automatic weighing instruments (R 61-1, 3.6.1)

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

7.8.4 Initial verification (R 61-1, 8.3)

The following tests shall normally be applied for initial verification:

- examination for initial verification in 6; and
- material tests at initial verification in 12.2.

The 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 10.2.6 shall also be performed.

8 Test methods

8.1 Determination of the mass of individual fills

The value of 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 material tests

8.2.1 Values of the mass of the fills

The tests shall be carried out using fills representing loads at, or near to, 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.

Cumulative weighing instruments 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 selective combination weighing instruments with the average (or optimum) number of loads per fill (R 61.1, 3.4.10).

If the Minfill is less than one third of the Max then tests shall also be carried out at a value near the center 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 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). For initial verification and in-service inspection, the material used for test loads shall consist of products for which the AGFI is intended (R 61-1, 8.3.2).

8.2.3 Conducting 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 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					Minimum number of test fills, *n*
	<	F_P	≤	1 kg	60
1 kg	<	F_P	≤	10 kg	30
10 kg	<	F_P	≤	25 kg	20
25 kg	<	F_P			10

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

a) $4 \times N$, or

b) the values given in Table 1.

where N is the number of AGFIs in the carousel.

Note: This will reduce the number of test fills (for example, for a carousel having 60 AGFIs of Max = 1 kg, 240 test fills are taken from the machine instead of 3600).

In a case such as this, the criteria apply to the whole carousel. The mean value will be calculated on the basis of the 240 results and the deviation of each of these shall be within the maximum permissible deviation from the mean value.

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 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 (7.6 and R 61-1, 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 (R 61-1, 4.3) are for the value of 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 value of the mass of 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 weighing instrument

- 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 value of 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 weighing instrument 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 mass of the fill shall be noted if applicable.

8.7 Average 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 the mass of all the test fills shall be calculated and noted for each preset value.

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 (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 the mass of all the fills in the test for each preset value.

8.9 Preset value error for automatic weighing

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

9 Static tests (type evaluation stage)

9.1 General (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 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 (R 61-1, 4.3) are evaluated after Ref(x) has been determined (R 61-1, 8.2.4).

9.2 Zero-setting and tare devices (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, 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

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 R 61-1, 5.8.3.

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.

9.2.4 Accuracy of zero-setting at tare

The weighing tests should be performed on instruments with subtractive tare: with one tare value at 2/3 of maximum tare.

a) Place the 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.

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 according to the method described in 7.6.2.1.

d) Verify that the zero-setting error is within the limit specified in R 61-1, 5.8.3.

9.3 Static weighing test method for type evaluation (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 8.2.1 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) (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:

a) Perform static weighing tests for influence factors and loads as specified in R 61-1.

b) Determine the mpe for influence factor tests for class X(1), $\text{mpe}_{(1)}$ for each load as follows:

$mpe_{(1)} = 0.25\ mpd_{(1)} \times p_i$ (if applicable) in-service for the mass value of the fill equal to the load.

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

$mpe_{(1)} = p_i \times 0.25 \times 1.5 \times 10^{-2} \times 10\ \text{kg} = p_i \times 37.5\ \text{g}$

where:

p_i (as specified in 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 [| 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 [| Error | / $mpe_{(1)}$] for all the influence factor tests, i.e.:

[| Error | / $mpe_{(1)}]_{Max}$ for all influence factor tests

e) Determine Ref(x) such that:

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

Ref(x) = 1×10^k, 2×10^k, or 5×10^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 (R 61-1, Table 2).

10 Influence factors 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.

Influence factors (R 61-1, 6.5) and disturbance tests (R 61-1, 6.2) are intended to verify that AGFIs 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 process 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 shall 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 R 61-1, 8.2.3.3.

For AGFIs incorporating the typical modules (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.

As far as applicable the same tests shall be performed as for complete instruments. The applicable tests for indicators and analogue data processing devices are given in R 76, Annex C, the applicable tests for digital data processing devices, terminals and digital displays are given in R 76, Annex D, and the applicable tests for weighing modules are given in R 76, Annex E. Test procedures for load cells are provided in R 60.

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

Performance criterion	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 R 60 [5] valid for SH or CH tested load cells (p_{LC} = 0.7).

Note 3: The sign "–" means "not applicable".

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 setup requirements

10.1.2.1 General

The simulated setup 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 shall 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 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

Simulated setups 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
10.2.4.1	Damp heat, steady-state (non-condensing)	Influence factor	mpe
10.2.4.2	Damp heat, cyclic (condensing)	Influence factor	mpe
10.2.5.1	AC mains voltage variation	Influence factor	mpe
10.2.5.2	DC mains voltage variation	Influence factor	mpe
10.2.5.3	Low voltage of internal battery (not connected to the mains power)	Influence factor	mpe
10.2.5.4	Power from external 12 V and 24 V road vehicle batteries	Influence factor	mpe
10.2.6	Tilting	Influence factor	mpe

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

10.2.1 Warm-up time (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.

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 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, every two minutes between 5 and 15 minutes, and 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 the 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 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 R 61-1, 5.8.2.

Other test methods which verify that metrological performance is maintained during the first 30 minutes of operation may be used, such as described in R 76:2006, 5.3.5 and A.5.2.

10.2.2 Temperature test with static load (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 R 61-1, 4.3.2 under conditions of high and low temperature specified in R 61-1, 4.8.2.1
Precondition	The electrical power of the EUT is switched on for at least 16 hours 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. This test may be combined with the test on temperature effect on no-load indication. In such a case the automatic zero-setting or zero-tracking, where available, shall not be enabled. 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.
Test procedure in brief	The test comprises exposure of the EUT 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 mean sufficient air circulation to keep the temperature at a stable level. 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.

	The absolute humidity of the test atmosphere shall not exceed 20 g/m^3. When tests are performed at temperatures below 35 °C, the relative humidity shall not exceed 50 %. Temperature sequence: 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.
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 R 61-1, 4.3.2.

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

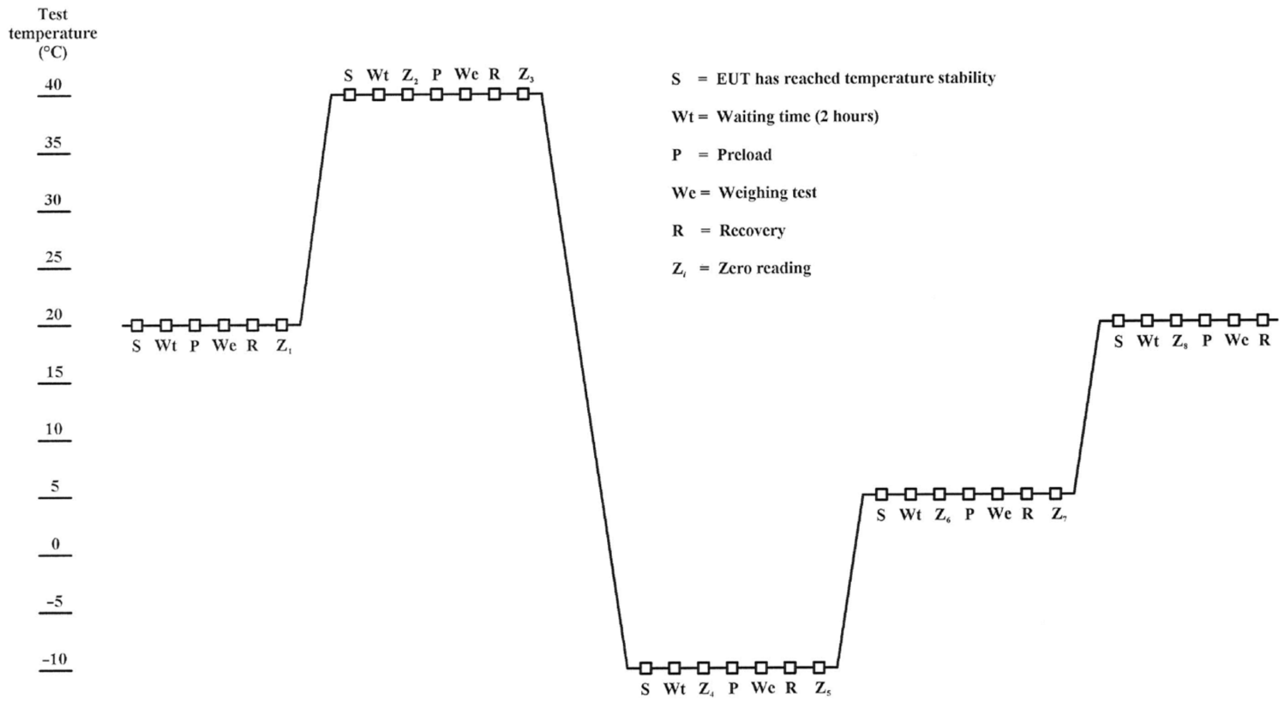
Table 3b - Temperature test at no load condition (dry heat and cold)

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	Generally applicable. This test should not be performed for AGFIs 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 R 61-1, 4.3.2 under conditions of high and low temperature specified in R 61-1, 4.8.2.3.
Precondition	The electrical power of the EUT is switched on for at least 16 hours 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 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: 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
Note	Performing a test for verification of R 61-1, 4.8.2.3 is not required in the case of automatic zero-setting as part of every weighing cycle.
EUT performance	Determine the error at zero, each time just before changing to the next temperature level. After stabilization at each specified temperature conduct the following: - determine the error at zero indication, and - calculate the change in zero indication per 5 °C. These zero error gradients (per 5 °C) shall be calculated for any two consecutive temperatures of this test. At each temperature record the following data: a) date and time, b) temperature, c) relative humidity, d) zero error, e) calculated zero error gradient.
Permitted maximum deviation	All functions shall operate as designed. The change in zero indication shall over a temperature difference of 5 °C not vary by more than the maximum permissible error specified in R 61-1, 4.3.2 for the Minfill of the AGFI.

Figure 1

Proposed test sequence for test 10.2.2 combined with 10.2.3
(temperature test where the temperature limits are + 40 °C / – 10 °C



10.2.4 Damp heat test

10.2.4.1 Damp heat, steady state test (non-condensing) (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.

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 generally applicable where the 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 R 61-1, 4.8.1.
Precondition	The electrical power of the EUT is switched on for 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 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 of the EUT 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. The EUT shall be handled such that no condensation of water occurs on it. Climate test sequence: 1) Set at reference temperature of 20 °C (or the mean value of the temperature range whenever 20 °C is outside this range) and at 50 % relative humidity, 2) Maintain for 3 hours at reference temperature 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, 5) Set at reference temperature 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 hours
EUT performance	After stabilization at the relevant temperature and again at each specified temperature, conduct the following: Following the 2 days, and 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: 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 at the specified steps. All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in R 61-1, 4.3.2.	

10.2.4.2 Damp heat, cyclic test (condensing)

The damp heat, cyclic test in Table 4b is performed in accordance with 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 vapor is expected which especially applies to AGFIs used outdoors.
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	Conduct 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 of the EUT 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. The 24 h cycle comprises: 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. 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.	
	Test level	Unit
Upper temperature	Specified high temperature in R 61-1, 4.8.2	°C
Duration	2	24-hour cycle(s)
EUT performance	Before step 1 and after the exposure to damp heat (after step 2) and at the end of step 4 record at no load and subsequently at test loads condition 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 is determined at the specified steps 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 R 61-1, 4.3.2.	

10.2.5 Voltage variation tests

10.2.5.1 AC mains voltage variation (R 61-1, 4.8.4)

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 AGFIs 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 R 61-1, 4.3.2 under conditions of AC mains network voltage changes between upper and lower limit specified in R 61-1, 4.8.31.
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 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. Test sequence: 1) Reference voltage level, 2) Upper voltage level, 3) Lower voltage level, 4) Reference voltage level. In the case of a three-phase power supply, the voltage variation shall apply for each phase successively.
EUT performance	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: 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]
Note 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 $U_{\text{nom1}} = U_{\text{nom2}} = U_{\text{nom}}$. For three-phase mains power supplies, the voltage variation is applicable for each of the phases successively.	
Note 2	The reference voltage level is equal to $(U_{\text{nom1}} + U_{\text{nom2}}) / 2$.	
Permitted maximum deviation	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. All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in R 61-1, 4.3.2.	

10.2.5.2 DC mains voltage variation (R 61-1, 4.8.4)

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 AGFIs 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 R 61-1, 4.3.2 under conditions of DC mains power voltage changes between upper and lower limit specified in 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 of the EUT 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.
Note 1	The DC operating range is the range as specified by the manufacturer but not less than U_{nom} – 15 % ≤ U_{nom} ≤ U_{nom} + 10 %.
Note 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 ½ 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 is 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 R 61-1, 4.3.2.

10.2.5.3 Low voltage of internal battery (not connected to the mains power) (R 61-1, 4.8.4)

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 AGFIs supplied by internal battery
Object of the test	Verification of compliance with the provisions in R 61-1, 4.3.2 during low battery voltage specified in 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	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. The maximum internal impedance of the battery and the minimum battery supply voltage level, U_{bmin}, shall be specified by the manufacturer of the AGFI. In case of simulating the battery, by using an alternative power supply, the internal impedance of the specified type of battery shall also be simulated. The alternative power supply shall be capable of delivering sufficient current at the applicable supply voltage. The test sequence is as follows: a) Let the power supply stabilize at a voltage as defined within the rated operating conditions and apply the test load. b) Record: • data defining the actual measurement conditions including date, time and environmental conditions, • actual power supply voltage. c) Perform measurements and record the error(s) and other relevant performance parameters. d) Verify compliance with R 61-1, 4.3.2. e) Repeat the above procedure with actual supply voltage at U_{bmin} and again at 0.9 U_{bmin} Verify compliance with R 61-1, 4.3.2.
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	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: 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 errors shall be within the maximum permissible errors specified in 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 AGFI may automatically resume normal operation. During all phases of the test the loss of any previous measurement data is not acceptable.

10.2.5.4 Power from external 12 V and 24 V road vehicle batteries (R 61-1, 4.8.4)

Table 8 - Voltage variations

Applicable standard	ISO 16750-2 [24]				
Test method	Variation in supply voltage				
Applicability	Applicable to all AGFIs 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 R 61-1, 4.3.2 under conditions of high voltage while charging and low battery voltage specified in 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 of the EUT 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	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: 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 R 61-1, 4.3.2.

10.2.6 Tilting (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 AGFIs that will not be permanently installed. This test is not required for transportable 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 requirements listed shall be tested in addition.

10.2.6.1 Tilting of AGFIs fitted with a levelling device and a level indicator, or a tilt sensor (R 61-1, 4.8.4 a), and 4.8.4 b))

10.2.6.1.1 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 left side and right side).

10.2.6.1.2 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 AGFI 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 left side and right side).

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

This test only applies to AGFIs which are liable to be tilted and which are neither

- fitted with a levelling device or indicator which clearly indicates when the maximum permissible tilt has been exceeded, nor
- fitted 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 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 the 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	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.
	Adjust the EUT in its reference position (not tilted) as close to zero indication as practicable. If the AGFI is provided with automatic zero-setting it shall not be in operation.
Test sequence	Record the zero indication. Apply the test load and record the indication. Remove the test load.
	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.
	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.
	Tilt the EUT in the transverse direction to the appropriate extent and repeat the above tests.
	Tilt the EUT in the opposite direction and repeat the above tests.
EUT performance	Record the following data for each of the test setups as prescribed above: a) date and time, b) test load, c) indications at each tilt, d) errors, e) functional performance
	In order to determine the influence of tilting on the loaded AGFI, the indication obtained at each tilt shall be corrected for the deviation from zero which the AGFI had prior to loading.

Maximum allowable variations	All indications shall be within maximum permissible errors specified in R 61-1, 4.3.2.

10.3 Disturbance tests (R 61-1, 6.2)

Summary of disturbance tests

§	Test	Condition applied
10.3.1	AC mains voltage dips, short interruptions and reductions	Significant fault
10.3.2	Bursts (fast transient tests) on mains power lines and on signal, data and control lines	Significant fault
10.3.3	Electrostatic discharge	Significant fault
10.3.4	Immunity to electromagnetic fields	Significant fault
10.3.5	Surges on AC and DC mains power lines and on signal, data and control lines	Significant fault
10.3.6	Electrical transient conduction for instruments powered by 12 V and 24 V batteries	Significant fault
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	Load dump test	Significant fault
10.3.10	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 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 D 11 [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 AC mains voltage dips, short interruptions and reductions

AC mains voltage dips and short interruptions tests are carried out according to Table 10.

Table 10 - 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 setup defined in the applicable standard			
Applicability	Applicable for AGFIs 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 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	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. The performance of the test generator shall be verified before connecting the EUT. The mains voltage reduction tests shall be repeated 10 times with intervals of at least 10 s between the tests. The tests shall be applied continuously during the measurement time. 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.			
		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
	Test e	Reduction to	80	% of U_{nom}

		Duration	250/300	cycles
Short interruptions	Reduction to		0	V
	Duration		250/300	cycles
EUT performance	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 disturbance, record the following parameters: 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	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults from occurring.			

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

10.3.2.1 Electrical bursts tests (fast transient tests) on AC and DC mains

Table 11a - 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 AGFIs 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 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	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 of the EUT to bursts of voltage spikes for which the output voltage on 50 Ω and 1000 Ω loads 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 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. At least 10 positive and negative randomly phased bursts shall be applied. The bursts are applied during all the time necessary to perform the test; therefore, more bursts than indicated above may be necessary.	
	Amplitude (peak value) (kV)	Repetition rate (kHz)
Test level	2	5
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) 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 from occurring.	

10.3.2.2 Electrical bursts tests (fast transient tests) on signal, data and control lines

Table 11b - 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 AGFIs 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 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 of the EUT to bursts of voltage spikes for which the output voltage on 50 Ω and 1000 Ω loads 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 from occurring.	

10.3.3 Electrostatic discharge

Table 12 - Electrostatic discharge

Applicable standard	IEC 61000-4-2 [15]
Test method	Exposure to electrostatic discharge (ESD)
Applicability	Applicable to all AGFIs
Object of the test	Verification of compliance with the provisions in R 61-1, 6.2 in case of direct exposure to electrostatic discharges or such discharges in the neighborhood 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	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 setup 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. At least 10 discharges per preselected discharge location shall be applied. 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. 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. **Direct application:** 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. On insulated surfaces only the air discharge mode can be applied. The EUT is approached by the charged electrode until a spark discharge occurs. **Indirect application:** The discharges are applied in the contact mode only on coupling planes mounted in the vicinity of the EUT.

	One of the following test levels may be specified:		
		Charge voltage	Unit
Test level	Contact discharge	6	kV
	Air discharge	8	kV
EUT performance	Sequentially during and after the exposure to the discharges, record the following parameters: 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	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults from occurring. 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.		

10.3.4 Immunity to electromagnetic fields

10.3.4.1 Immunity to radiated (RF) electromagnetic fields

Radiated, radio frequency electromagnetic immunity tests are carried out according to Table 13a.

Table 13a - 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 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

<table>
<tr><td></td><td colspan="4">automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.</td></tr>
<tr><td>Test procedure in brief</td><td colspan="4">The EUT is exposed to electromagnetic fields with the required field strength and the field uniformity as defined in the referred standard.

The level of field strength specified refers to the field generated by the unmodulated carrier wave.

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.

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.

Adequate EM fields can be generated in facilities of different type and setup, the use of which is limited by the dimensions of the EUT and the frequency range of the facility.</td></tr>
<tr><td rowspan="4">Test level</td><td>Frequency range (MHz)</td><td>RF amplitude (V/m)</td><td colspan="2">AM, sine wave modulation (kHz)</td></tr>
<tr><td>(26) 80(1) – 2000</td><td>10</td><td>80 %</td><td>1</td></tr>
<tr><td>2000(2) – 3000*</td><td>10</td><td>80 %</td><td>1</td></tr>
<tr><td colspan="4">Notes:
1 For EUTs having no mains or other I/O ports available, so that the test according to 10.3.4.2 cannot be applied, the lower limit of the radiation test is 26 MHz.
In this case, for the frequencies from 26 MHz up to 80 MHz, the test method described in IEC 61000-4-3 shall be applied.
2 Appropriate for conditions where influences from wireless networks, mobile phones and the like cannot be excluded.</td></tr>
<tr><td>EUT performance</td><td colspan="4">Sequentially during and after the exposure to the EM field, record the following parameters:
a) date and time,
b) temperature,
c) relative humidity,
d) value of the measurand,
e) field strength level,
f) indicated values,
g) error values,
h) functional performance</td></tr>
<tr><td>Permitted maximum deviation</td><td colspan="4">Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults from occurring.</td></tr>
</table>

10.3.4.2 Immunity to conducted electromagnetic fields

Conducted, radio frequency, electromagnetic field immunity tests are carried out according to Table 13b.

Table 13b - Conducted (common mode) currents generated by RF EM fields

<table>
<tr><td>Applicable standard</td><td colspan="4">IEC 61000-4-6 [19]</td></tr>
<tr><td>Test method</td><td colspan="4">Injection of RF currents representing exposure to RF electromagnetic fields</td></tr>
<tr><td>Applicability</td><td colspan="4">Applicable for AGFIs containing active electronic circuits and equipped with ports for throughput or connection of external electrical wiring (mains power, signal, data and control lines)</td></tr>
<tr><td>Object of the test</td><td colspan="4">Verification of compliance with the provisions in R 61-1, 6.2 while exposed to electromagnetic fields.</td></tr>
<tr><td>Precondition</td><td colspan="4">The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.</td></tr>
<tr><td>Condition of the EUT</td><td colspan="4">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.</td></tr>
<tr><td>Test procedure in brief</td><td colspan="4">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.</td></tr>
<tr><td></td><td>Frequency range</td><td>RF amplitude</td><td colspan="2">AM, sine wave modulation</td></tr>
<tr><td>Test level</td><td>0.15 – 80</td><td>10</td><td>80</td><td>1</td></tr>
<tr><td>Unit</td><td>MHz</td><td>V (e.m.f.)</td><td>%</td><td>kHz</td></tr>
<tr><td>Note</td><td colspan="4">In the range from 26 MHz to 80 MHz, the type evaluation authority may decide to choose a transition frequency below 80 MHz. Above the selected transition frequency, tests will be carried out according to Table 13a. In the event of a dispute, the result of the test according to this prevails.</td></tr>
<tr><td>EUT performance</td><td colspan="4">Sequentially during and after the exposure to the RF current, record the following parameters:
a) date and time,
b) temperature,
c) relative humidity,
d) value of the measurand,
e) applied RF (e.m.f.) voltage level,</td></tr>
</table>

	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 from occurring.

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

10.3.5.1 Electrical surge tests on AC and DC mains power lines

Table 14a - 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 AGFIs which are temporarily or permanently connected to a mains power network while in operation This test is not applicable to AGFIs connected to a local power source through an indoor network
Object of the test	Verification of compliance with the provisions in 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	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 of the EUT 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. On AC mains supply lines the surges shall be synchronized 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. The injection network circuit depends on the applicable conductor and is defined in the referred standard. The surges are applied during all the time necessary to perform the test; to that purpose more surges than indicated above may be necessary.

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	Sequentially during and after the exposure to the surges, 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 from occurring.				

10.3.5.2 Electrical surge tests on signal, data and control lines

Table 14b - Surges on signal, data and control lines

Applicable standard	IEC 61000-4-5 [18]
Test method	Introducing electrical surges on signal, data and control lines
Applicability	Applicable for 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 AGFIs connected to a local power source through an indoor network.
Object of the test	Verification of compliance with the provisions in 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 of the EUT 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, 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 from occurring.				

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

10.3.6.1 Electrical transient conduction along supply lines

Table 15a - Electrical transient conduction along supply lines

Applicable standard	ISO 7637–2 [25]
Test method	Electrical transient conduction along supply lines.
Applicability	Applicable to all 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 R 61-1, 6.2 under the following conditions: • 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 of the EUT to disturbances on the power voltage by direct coupling into the supply lines.				
	Test pulse	U_{nom} [1]	12	24	V
Test level	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
Note 1:	U_{nom} = nominal battery voltage				
Note 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 from occurring.				

10.3.6.2 Electrical transient conduction via lines other than supply lines

Table 15b - Electrical transient conduction via lines other than supply lines

<table>
<tr><td>Applicable standard</td><td colspan="5">ISO 7637–3 [26], § 3.5.1: fast transient test pulses a and b</td></tr>
<tr><td>Test method</td><td colspan="5">Electrical transient conduction along lines other than supply lines</td></tr>
<tr><td>Applicability</td><td colspan="5">Applicable to analogue I/O cabling of modular AGFIs installed in vehicles</td></tr>
<tr><td>Object of the test</td><td colspan="5">Verification of compliance with the provisions in 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)</td></tr>
<tr><td>Precondition</td><td colspan="5">The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.</td></tr>
<tr><td>Condition of the EUT</td><td colspan="5">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.</td></tr>
<tr><td>Test procedure in brief</td><td colspan="5">The test comprises exposure of the EUT 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.</td></tr>
<tr><td rowspan="3">Test level</td><td>Test pulse</td><td>U_{nom} [1]</td><td>12</td><td>24</td><td>V</td></tr>
<tr><td>pulse a</td><td>U_s [2]</td><td>–60</td><td>–80</td><td>V</td></tr>
<tr><td>pulse b</td><td>U_s [2]</td><td>40</td><td>80</td><td>V</td></tr>
<tr><td>Note 1:</td><td colspan="5">U_{nom} = nominal battery voltage</td></tr>
<tr><td>Note 2:</td><td colspan="5">As specified in ISO 7637-3</td></tr>
<tr><td>EUT performance</td><td colspan="5">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</td></tr>
<tr><td>Permitted maximum deviation</td><td colspan="5">Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults from occurring.</td></tr>
</table>

10.3.7 Ripple on DC mains power

Table 16 - 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 AGFIs 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 an 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 AGFIs 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) dependent 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 voltage, 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 from occurring.

10.3.8 Battery voltage variations during starting up a vehicle engine

Table 17 - 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	AGFIs powered by on-board DC battery and which 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 of the EUT 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		V
Test levels	Test profile [2]	I	III	I	III	
	U_S	8	3	10	6	V
	U_A	9.5	5	20	10	V
	t_8	1	1	1	1	s
	t_f	40	100	40	40	ms
Note 1:	U_{nom} = nominal battery voltage					
Note 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 from occurring.

10.3.9 Load dump test

Table 18 - Load dump test

Applicable standard	ISO 16750-2 [24]					
Test method	Supply voltage variation due to disconnecting a discharged battery					
Applicability	AGFIs powered by on-board DC battery and which may be in operation while the vehicle engine is running					
Object of the test	Verification of compliance with the provisions in 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 of the EUT 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]	test B		test B		
	U_S	79	101	151	202	V
	R_i	0.5	4	1	8	Ω
	t_r	10	10	10	10	ms
	t_d	40	400	100	350	ms
Note 1:	U_{nom} = nominal battery voltage					
Note 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 from occurring.

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

Table 19 - DC mains voltage dips, short interruptions and (short term) variations

<table>
<tr><td>Applicable standard</td><td colspan="3">IEC 61000-4-29 [34]</td></tr>
<tr><td>Test method</td><td colspan="3">Introducing voltage dips, short interruptions and voltage variations on DC mains power lines using the test setup defined in the applicable standard</td></tr>
<tr><td>Applicability</td><td colspan="3">Applicable for AGFIs 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.</td></tr>
<tr><td>Object of the test</td><td colspan="3">Verification of compliance with the provisions in R 61-1, 6.2 under conditions of voltage dips, voltage variations and short interruptions on DC.</td></tr>
<tr><td>Precondition</td><td colspan="3">The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.</td></tr>
<tr><td>Condition of the EUT</td><td colspan="3">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.</td></tr>
<tr><td>Test procedure in brief</td><td colspan="3">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 EUT shall be exposed to voltage dips and 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.
The most representative operating modes of the EUT shall be tested three times at 10 s intervals for each of the specified voltage variations.
The disturbances are applied during all the time necessary to perform the test; therefore, more disturbances than indicated may be necessary.</td></tr>
<tr><td rowspan="3">Voltage dips</td><td></td><td>Test levels</td><td>Unit</td></tr>
<tr><td>Amplitude</td><td>40 and 70</td><td>% of the rated voltage</td></tr>
<tr><td>Duration</td><td>0.01; 0.03; 0.1; 0.3; 1</td><td>s</td></tr>
<tr><td rowspan="3">Short interruptions</td><td>Test condition</td><td>High impedance and/or
low impedance</td><td></td></tr>
<tr><td>Amplitude</td><td>0</td><td>% of the rated voltage</td></tr>
<tr><td>Duration</td><td>0.001; 0.003; 0.01; 0.03; 0.1; 0.3; 1</td><td>s</td></tr>
</table>

Voltage variations	Amplitude	85 and 120	% of the rated voltage
	Duration	0.1; 0.3; 1; 3; 10	s
EUT performance	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 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 from occurring.		

11 Span stability test (R 61-1, 7.2)

Table 20 - Span stability test

Test method	Span stability
Object of the test	To verify compliance with the provisions given in R 61-1, 7.2 after the EUT has been subjected to the performance tests.
Reference to standard	No reference to international standards is given.
Test procedure in brief	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. 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. 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.
	In the conduct of this test, the operating instructions for the AGFI as supplied by the manufacturer shall be considered. 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.
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 (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:	Stabilize all factors at nominal reference conditions. Automatic zero-setting shall not be in operation. Apply the test load (or simulated load) and record the following data: a) date and time b) temperature c) barometric pressure d) relative humidity e) test load f) indication g) errors h) changes in test location Apply all necessary corrections resulting from variations of temperature, pressure, etc. between the various measurements. At the first measurement immediately repeat zeroing and loading four times to determine the average value of the 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. Repeat this test at periodic intervals during and after conducting the various performance tests. Allow full recovery of the EUT before any other tests are performed.

12 Procedure for material tests

12.1 Material tests at type evaluation (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 R 61-1, clauses 5, 6 and 7 with material for the test load as specified in R 61-1, 8.2.3.1.

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

Check that the feeding device provides sufficient and regular flowrate.

Check that any adjustable feed device has an indication of the direction of movement corresponding to the sense of the adjustment of the feed (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 R 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 (R 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) The types of loads shall be as specified in 8.2.2.

b) The mass of the test loads and the mass of the fills shall be as specified in 8.2.1 a, b and c).

c) The condition of the material tests shall be as specified in 8.2.3

d) The number of test fills shall be as specified in 8.3.

12.2.2 Methods for metrological material tests (as given in 8.5)

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 8.2.3.

b) Select a preset value for the fill and set the load value if different from the mass value of the fill, in accordance with values of the mass value of the fills as specified in 8.2.1. Record the indicated preset value.

c) Run the AGFI to produce a number of test fills as specified in 8.3 using types of test loads specified in 8.2.2.

d) Weigh all the test fills by either:

   1) the separate verification method specified in 8.5.1, or

   2) the integral verification method specified in 8.5.2

   to determine the value of the mass of the fill in accordance with 8.7 so that the result of weighing the test fill on the control instrument shall be considered as the conventional true value of the test fill.

e) In accordance with 8.7 calculate the average value of all the mass of the fills in the test as follows:

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

   where:

   F is the value of 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 8.8 calculate the deviation of each mass value of the fill from the average mass value of all the fills in the test as follows:

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

   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 8.2.1.

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

a) For each preset value of the mass of the test fill, F_P:

   1) Calculate the preset value error specified in R 61-1, 4.3.3 in accordance with 8.9 as follows:

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

      where:

      se is the preset value error.

   2) Determine the maximum permissible preset value error for class X(1), $\mathrm{mpse}_{(1)}$ as follows:

      $\mathrm{mpse}_{(1)} = 0.25\ \mathrm{mpd}_{(1)}$, corresponding to the value of the mass 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), $\mathrm{mpd}_{(1)}$.

   3) Then calculate [md_{max} / $\mathrm{mpd}_{(1)}$].

c) From (a) determine the maximum (largest) value of [|se| / $\mathrm{mpse}_{(1)}$], i.e. [|se| / $\mathrm{mpse}_{(1)}$]max from all the preset test fills.

d) From (b) determine the maximum (largest) value of [mdmax / mpd(1)], i.e. $[md_{max} / mpd_{(1)}]_{max}$ from all the preset test fills.

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

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

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

and $x = 1 \times 10^k$, 2×10^k, or 5×10^k,

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

Annex A
(Mandatory)

Error calculation for multi-load filling AGFIs

A.1 Fault limit for multi-load AGFIs

a) Fault limit for selective combination weighing instruments:

A fault greater than 0.25 mpd in-service of each fill (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 = 1600 g, the mpd in-service of each fill from the average fill (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 weighing instruments:

A fault greater than 0.25 mpd in-service of each fill (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 = 1200 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 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 weighing instruments does not include Min. A cumulative weighing instrument 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 weighing instruments 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 weighing instrument, 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 weighing instruments 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 = 1200 g and Minfill of 8 kg: 8 kg/1.2 kg = 6.67; therefore the minimum number of loads per fill = 7. The mpd (as specified in 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 weighing instruments 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 the load cells without check rods;
2) Connection of the weighing elements to the load cell via a lever system;
3) Isolated from the 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, or
- 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

C.1 Type approval

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 type approve an instrument may only be warranted where the unacceptable durability is clearly a characteristic of the type. Where measures to ensure durability are taken, this shall be recorded in the test report format in R 61-3.

C.2 Subsequent metrological control

To reduce the risks of non-durable instruments, the arrangements for subsequent metrological control shall incorporate means for reviewing intervals for subsequent verification and in-service inspection, based on performance of an instrument over time. ILAC-G24/OIML D 10 [25] indicates methods (see D 10, 3) which are useful for this purpose.

If an instrument (installed in a particular location) is found to be of unacceptable durability, that instrument 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 (R 61-1, 4.8.2.3)
- Zero-setting accuracy (R 61-1, 5.8.2)
- Disturbances (R 61-1, 6.2 if applicable)
- Warm-up time (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:

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

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

For calculating the Minfill value for class X(x) AGFIs, the mpd and F values (masses of the fills in 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 % × 0.2) = 0.6 %

Combining the estimated mpd percentage and the value of d results in an absolute value of Minfill of:

$$20 \text{ g} / 0.006 = 3330 \text{ g.}$$

This value is in the F range having an $\text{mpd}_{\text{in-service}}$ 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 the F range and mpd are coherent.

A Minfill cannot be obtained for each absolute value of the mpd. 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 R 61-1, Table 2, an 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 of 10 g, and using this mpd percentage, the Minfill would be:

$$10 \text{ g} / 0.036 = 280 \text{ g}$$

But for 280 g, the mpd = 3.2 % and 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 is a correct value because the *F* range and mpd are coherent.

Example 3

The calculation for selective combination weighing instruments 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 the results of tests performed on NAWIs based on R 76 [6] to issue type evaluation certificates according to R 61 is given in this Annex.

A main prerequisite is that the 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 R 60 [5] or R 76 [6] as far as applicable.

The principle and examples to make the necessary calculations more transparent are 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 microvolts per *e* or per *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 loads, 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) Change of span

   Tests to be considered: temperature and damp heat

2) 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, surges, electrostatic discharges, radiated electromagnetic fields, conducted radio-frequency fields

Note: Transitory faults can be 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 transitory faults have been taken into account in the R 76 [6] report.

E.2 Conversion of relevant test results

The error limits according to 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 microvolts per e or per d, or a corresponding number of digits has to be assigned to a concrete value of d in grams. 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 microvolts per d or per 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 the R 76 [6] error limits to the R 61 error limits. Since the latter are (in principle) percentage error limits, the absolute maximum permissible error (mpe) for fills higher than 200 d 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 the following example calculations, the percentage values instead of the absolute values given in R 61-1, Table 2 have 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 g and ≤ 100 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 the error limits of R 61-1, 4.3.2 for the influence factor test:

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

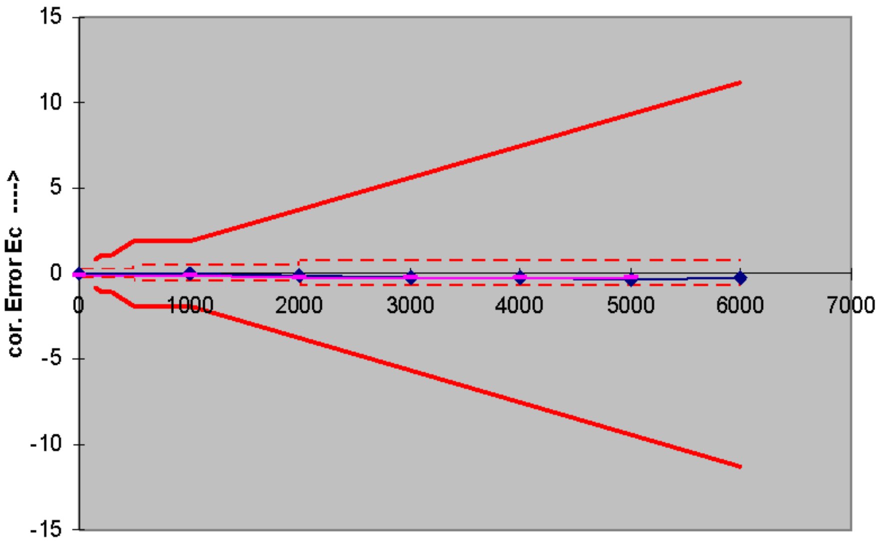
Testing an indicator (module), p_i has to be considered: e.g. $p_i = 0.5$

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

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

Based on $d = 1$ g and $p_i = 0.5$, with 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: 2 000 g

Error limit according to R 61-1, 4.3.2:

mpd = Fill × mpd in-service × 0.25 (R 61-1, 4.3.2) × Ref(x) × p_i

mpd = 2 000 g × 1.5 % × 0.25 × 1 × 0.5

mpd = 3.75 g

Error limit according to R 76 [6] at a load corresponding to 2 000 e:

mpe = 1 $e \times p_i$ = 1 e × 0.5 = 0.5 g

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 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

From R 61-1, 5.8: mpd(zero) ≤ 0.25 × mpd(x)$_{\text{in service}}$ × Min(fill) (R 61-1, 5.8.2)

⇔ Min(fill) ≥ mpd(zero) / 0.25 × 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 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

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

The first step of iteration:

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

Minfill ≥ 11.1 g and rounded to d

Minfill ≥ 11 g

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

B) Temperature effect on no-load indication

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

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

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

0.25 → 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 two 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, Ref(x) = 1, $p_i = 0.5$, zero drift = 1 e/5 K, $\text{mpd}_{\text{in service}} = 9\ \%$ (assumption that Minfill ≤ 50 g)

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

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

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

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

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

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

⇔ Minfill ≥ 177.78 g > 50 g (assumption with regard to Minfill has been wrong)

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

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

⇔ Minfill ≥ 355.56 g > 200 g (assumption with regard to Minfill has been wrong)

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

Minfill ≥ 2 g / (0.25 × 3 % × 0.5 × 1)

⇔ Minfill ≥ 533.33 g > 500 g (assumption with regard to Minfill has been wrong)

Next iteration step: Minfill ≤ 1 000 g, and $mpd_{in\ service}$ = 15 g, corresponding to 1.5 % (obviously leading to double the value calculated before)

Minfill ≥ 2 g / (0.25 × 1.5 % × 0.5 × 1)

⇔ Minfill ≥ 1 066.67 g (more than 1 000 g, however for fills between 1 000 g (or 1 kg) and 10 000 g (or 10 kg) a deviation of 1.5 % is acceptable, thus 1 067 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.

The maximum zero drift per 5 K[1] 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:

Minfill ≥ Δz_{max} / (0.25 × $mpd_{in\ service}$ × p_i × Ref(x))

Minfill ≥ 1 g × 0.25 / (0.25 × 9 % × 0.5 × 1)

⇔ Minfill ≥ 0.25 g / (0.25 × 9 % × 0.5 × 1)

⇔ Minfill ≥ 22.2 g

C) Warm-up time

From R 61-2, 10.2.1: $E_0 - E_{0\ init} \leq 0.25 \times mpd_{in\ service} \times Minfill \times p_i \times Ref(x)$

Minfill ≥ ($E_0 - E_{0\ init}$) / (0.25 × $mpd_{in\ service}$ × p_i × Ref(x))

$mpd_{in\ service}$ → from R 61-1, 4.3.1 Table 2

0.25 → from R 61-1, 4.3.2

Ref(x) → has to be chosen (may be given by manufacturer)

Remark: If ($E_0 - E_{0\ init}$) < 0 then the absolute value of ($E_0 - E_{0\ init}$) 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: $e = d = 1$ g, Ref(x) = 1, p_i = 0.5, zero drift due to warm-up 3 *e*, $mpd_{in\ service}$ = 9 % (assumption that Minfill ≤ 50 g)

Minfill ≥ (E_0 - $E_{0\ init}$) / (0.25 × $mpd_{in\ service}$ × p_i x Ref(X))

⇔ Minfill ≥ 3 g / (0.25 × 9% x 0.5 × 1)

⇔ Minfill ≥ 266.6 g > 200 g,

Assumption being Minfill between > 200 g and ≤ 300 g.

[1] The unit K is used here to illustrate the influence of temperature variation on zero expressed in changes of the input signal in µV, calculated with the help of a straight line through the indications at two adjacent temperatures. The zero drift should be less than $p_i \times e$ / 5 K. (Taken from R 76:2006, C.3.1).

$mpd_{in\ service}$ = 9 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:

$$9\ g / 300\ g = 0.03 = 3\ \%. \text{ (See remarks under E.2)}$$

⇔ Minfill ≥ 3 g / (0.25 × 3 % × 0.5 × 1)

⇔ Minfill ≥ 800 g > 500 g, next iteration step.

Assumption being Minfill between > 500 g and ≤ 1 000 g.

$mpd_{in\ service}$ = 15 g. For a new calculation that has to be put in relation to the highest fill of this range, i.e. 1 000 g. The maximum percentage deviation would then be:

$$15\ g / 1\ 000\ g = 0.015 = 1.5\ \%. \text{ (see initial remarks)}$$

⇔ Minfill ≥ 3 g / (0.25 × 1.5% × 0.5 × 1)

⇔ Minfill ≥ 1 600 g ≤ 10 000 g, 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:

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

(p_i = 1 for disturbance tests; see WELMEC Guide 2.1)

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

The significant fault for non-automatic 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 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 $mpd_{in\ service}$ = 4.5 %

Then:

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

⇔ Minfill ≥ 1.5 g / (0.25 × 4.5 % × 1)

⇔ Minfill ≥ 133.3 g

Since $mpd_{in\ service}$ 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:

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

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

⇔ $md_{disturbance} \leq 1.125\ g$

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	1 600 g (rounded up)

Based on warm-up time	1 600 g
Based on faults due to disturbances	133 g (rounded down)

The highest Minfill (1 600 g) has to be selected as being the worst case.

E.3 Calculating Minfill with selective combination weighing instruments

Selective combination weighing instruments 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.

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

E.3.1 Change of zero

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

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

[√(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.

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

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

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

Example: Non-automatic weighing instrument with d_{WU} = 1 g, zero setting error being 0.25 g. The reference accuracy class is 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

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

The first step of iteration:

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

Minfill ≥ 22.2 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 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 Ref(x).

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

Table A

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	178	44	22
5	3 335	1 335	335	110
10	6 670	2 670	1 330	330
20	20 000	5 340	2 660	1 340
50	50 000	20 000	6 650	3 350
100	100 000	40 000	20 000	6 700
200	200 000	80 000	40 000	20 000
≥ 500	1 000 *d*	400 *d*	200 *d*	100 *d*

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

d/√lpf lpf = 4	calculated d_{WU}	permissible 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, 4.8.3.3:

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

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

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

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

From 10.2.3 and R 61-1, 4.8.3.3:

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

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

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

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

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

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

⇔ Minfill ≥ 355.56 g > 50 g (assumption with regard to Minfill has been wrong)

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

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

⇔ Minfill ≥ 1 066.67 g > 500 g (assumption with regard to Minfill has been wrong)

Next iteration step: Minfill ≤ 10 000 g and $\text{mpd}_{\text{in service}} = 1.5$ %

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

⇔ Minfill ≥ 2 133.33 g < 10 000 g (for fill between 1 000 g and 10 000 g, a deviation of 1.5 % is acceptable, thus 2 133 g is the final permissible Minfill)

C) Warm-up time

From 10.2.1: $E_0 - E_{0\text{I}} \leq 0.25 \times \text{mpd}_{\text{in service}} \times \text{Minfill} \times p_i \times \text{Ref}(x) / \sqrt{\text{lpf}}$

$\text{Minfill} \geq (E_0 - E_{0\text{I}}) \times \sqrt{\text{lpf}} / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(x))$

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

0.25 → from R 61-1, 4.3.2

Ref(X) → has to be chosen (may be given by manufacturer)

Remark: If $(E_0 \times E_{0\text{I}}) < 0$ then the absolute value of $(E_0 - E_{0\text{I}})$ 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: $e = d = 1$ g, Ref(X) = 1, $p_i = 0.5$, zero drift due to warm up = 3 e, $\text{mpd}_{\text{in service}} = 9$ % (assumption that Minfill ≤ 50 g)

Minfill ≥ $(E_0 - E_{0\ \text{init}}) \times \sqrt{\text{lpf}} / (0.25 \times \text{mpd}_{\text{in service}} \times p_i \times \text{Ref}(x))$

Minfill ≥ 3 g × √4 / (0.25 × 9 % × 0.5 × 1)

Minfill ≥ 533.3 g > 500 g,

Assumption being Minfill between 500 g and 1 000 g.

$\text{mpd}_{\text{in service}}$ = 15 g. For a new calculation that has to be put in relation to the highest fill of this range, i.e. 1 000 g. The maximum percentage deviation would then be:

15 g / 1 000 g = 0.015 = 1.5 %. (see remarks under E.2)

Minfill ≥ 3 g × √4 / (0.25 × 1.5 % × 0.5 × 1)

Minfill ≥ 3 200 g ≥ 1 000 g, next iteration step.

Minfill between 1 000 g and 10 000 g, $\text{mpd}_{\text{in service}}$ = 1.5 %, thus Minfill is 3 200 g, iteration stops here.

E.3.2 Faults due to disturbances

For selective combination weighing instruments 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

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

⇔ Minfill ≥ $\text{md}_{\text{disturbance}} \times \sqrt{\text{lpf}} / (0.25 \times \text{mpd}_{\text{in service}} \times \text{Ref}(x))$

Assuming again that the real fault for non-automatic 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 Ref(x) = 1, and the number of loads per fill shall be 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:

Minfill ≥ $\text{md}_{\text{disturbance}} \times \sqrt{\text{lpf}} / (0.25 \times \text{mpd}_{\text{in service}} \times \text{Ref}(x))$

⇔ Minfill ≥ 1.5 g × √4 / (0.25 × 4.5 % × 1)

⇔ Minfill ≥ 266.6 g

Expectation has been wrong, thus next iteration:

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

⇔ Minfill ≥ 1.5 g × √4 / (0.25 × 3 % × 1)

⇔ Minfill ≥ 400 g

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

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

⇔ $\text{md}_{\text{disturbance}} \leq 0.25 \times 3\ \% \times 1 \times 300$ 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 (2013)	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]	D 11:2013 General requirements for electronic measuring instruments - Environmental Conditions	Contains general requirements for electronic measuring instruments
[4]	R 111:2004 Weights of classes E1, E2, F1, F2, M1, M1–2, M2, M2–3 and M3	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]	R 60:2017 Metrological regulation for load cells	Provides the principal static characteristics and static evaluation procedures for load cells used in the evaluation of mass
[6]	R 76:2006 Non-automatic weighing instruments	Provides the principal physical characteristics and metrological requirements for the verification of non-automatic weighing instruments
[7]	D 19:1988 Type evaluation and type approval	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 (2016-04) 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.
[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 form any source.

Ref.	Standards and reference documents	Description
[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: • 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. 3.0 (2014-05), 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 61000-4-6:2013/COR1:2015 Edition 4.0 (2015-06-12) 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 61000-4-11:2004 + AMD1:2017 CSV Edition 2.1 (2017-05-18) Electromagnetic compatibility (EMC) Part 4-11: Testing and measuring techniques - Voltage dips, short interruptions and voltage variations immunity tests	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).
[22]	D 28 Edition 2004 (E)	Conventional value of the result of weighing in air

Ref.	Standards and reference documents	Description
[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 (2016) 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 (2016) 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 characterized 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.
[29]	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 Recommendations.

Ref.	Standards and reference documents	Description
[30]	ILAC-G24/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.