Working draft (WD) – Clean version

Title: **OIML R51-2 Automatic catchweighing instruments**

Part 2: Test procedures

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EXPLANATORY NOTE

The 53rd CIML approved as a new project, under the responsibility of TC 9/SC / p10 and under the joint convenorship of the UK (Morayo Awosola), and India (B.N Dixit.) the revision of OIML R51 “Automatic Catchweighing Instruments 2009 E”. This working draft has been restructured from two parts into three separate parts:
Part 1: Metrological and Technical Requirements;
Part 2: Testing procedures;
Part 3: Report Format for Type Evaluation.

To align with other D11, some additional tests for disturbance:
1) Battery voltage variations during starting up a vehicle engine
2) “Load dump” test
3) Ripple on DC mains power

No other changes/comments have been implanted in this first working draft.

<table>
<tr><td colspan="3">TC 9/SC 2/p 10 Revision of R51:2006 Automatic catchweighing instruments
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FOREWORD

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States.

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Part 2 – Test procedures (Mandatory)

1 Examination for type approval

1.1 Documentation (R 51-1, 8.2.1)

Review the documentation that is submitted, including necessary photographs, drawings, diagrams, general software information, relevant technical and functional description of main components, devices etc. to determine if it is adequate and correct. Consider the operational manual.

1.2 Compare construction with documentation

Examine the various devices of the instrument to ensure compliance with the documentation.

1.3 Metrological characteristics

Note the metrological characteristics according to the checklist given in the test report format, OIML R 51-3 [ ].

1.4 Technical requirements (R 51-1, 6)

Examine the instrument for conformity with the technical requirements according to the checklist in the test report format, OIML R 51-3 [ ].

1.5 Functional requirements (R 51-1, 7.2)

Examine the instrument for conformity with the functional requirements according to the checklist given in the test report format, OIML R 51-3 [ ].

2 Examination for initial verification

2.1 Compare construction with documentation

Examine the instrument for conformity with the approved type.

2.2 Descriptive markings (R 51-1, 6.11)

Check the descriptive markings according to the according to the check-list given in the test report format, OIML R 51-3 [ ].

2.3 Sealing and verification marks (R 51-1, 6.12)

Check the arrangements for sealing and verification marks according to the checklist given in the test report format in OIML R 51-3 [ ].

3. General requirements for equipment under test (EUT)

3.1 Power supply stabilizing time

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 the test.

3.2 Zero-setting

Adjust the EUT as closely as practicable to zero prior to each test and do not readjust at any time during the test, except to reset if a significant fault has occurred.

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

3.3 Dynamic setting

Dynamic setting shall be done in accordance with manufacturers' instructions prior to commencing the tests.

Before commencing influence factor tests, dynamic setting may be repeated for each load value and thereafter may not be repeated.

Dynamic setting should not be repeated during disturbance tests except after a significant fault.

If the dynamic setting process is part of a calibration procedure for the whole weighing range then the dynamic setting should not be repeated before testing with different load values.

3.4 Static test loads

Static test loads shall be used for the influence factor testing in 6.2 for machines designed to weigh loose material. For machines that weigh statically, where the conditions in R 51-1, 9.4.5 are met (including a test applied before the testing in 6.2 commences) static test loads may optionally be used.

3.5 Temperature

Except for the temperature test (6.2.1) and the damp heat tests (6.2.3), the tests shall be performed at a steady ambient temperature, usually normal room temperature unless otherwise specified. The temperature is deemed to be steady when the differences between the extreme temperatures noted during the test does not exceed one-fifth of the temperature range of the instrument without being greater than 5 °C, and the rate of change does not exceed 5 °C per hour.

The handling of the instrument shall be such that no condensation of water occurs on the instrument.

3.6 Recovery

After each test, allow the instrument to recover sufficiently before the following test.

3.7 Preloading

Before each weighing test the instrument shall be pre-loaded to Max, except for the tests in 5.2 (warm-up) and 6.2.2 (temperature effect on no-load).

3.8 Multiple range instrument

In principle, each range should be tested as a separate instrument.

3.9 Evaluation of error in automatic operation

3.9.1 Category X

For category X instruments, indications and/or printouts of the weight values (or the difference between the weight value and a nominal set-point) shall be provided for each load for determining the mean error and the standard deviation of the error. With the scale interval d, the error of the MPME (maximum permissible mean (systematic) error for automatic operation) and MPSD (maximum permissible standard deviation of the error for automatic operation) shall be calculated for the number of individual loads defined in R 51-1, 9.1.2.

Alternatively, other practical means for demonstrating compliance with R51-1, Tables 3 and 4 shall be provided by agreement with the metrological authority as described in R 51-1, 9.1.8.

3.9.2 Category Y

3.9.2.1 Indication with a scale interval not greater than 0.2 e

If an instrument with digital indication has a device for displaying the indication with an actual scale interval $d \leq 0.2$ e, this device shall be used to determine the error. When the device is used it should be noted in the test report.

3.9.2.2 Indication with a scale interval greater than 0.2 e

The rounding error included in any digital indication shall be eliminated if the actual scale interval d is greater than 0.2 e. This shall be accomplished by one of the following methods:

a) If possible, the mass of the test load shall be selected to eliminate the rounding error:
   - if the maximum permissible error = 1.5 e (or 0.5 e, 2.5 e, ...) the value of the mass of the test load shall be selected as close as possible to a whole scale interval.
   - if the maximum permissible error = 1.0 e (or 2.0 e, 3.0 e, ...) the mass of the test load shall be selected as close as possible to a whole scale interval plus (or minus) 0.5 e.

or

b) If a) is not applicable the rounding error shall be taken into consideration by adding an additional 0.5 e to the maximum permissible errors specified in R 51-1, Table 5.

3.10 Evaluation of error in nonautomatic (static) operation

3.10.1 Indication with a scale interval not greater than 0.2 e

If an instrument with digital indication has a device for displaying the indication with $d \leq 0.2$ e, this device may be used to determine the error. If a device is used it should be noted in the test report.

3.10.2 Use of standard weights to assess rounding error

3.10.2.1 General method to assess error prior to rounding

For instruments with digital indication having scale interval e, 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 e are successively added until the indication of the instrument is increased unambiguously by one

scale interval (I + e). The additional load ∆L added to the load receptor gives the indication, P, prior to rounding by using the following formula:

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

The error prior to rounding is:

$$E = P - L = I + 0.5\ e - \Delta L - L$$

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

$$P = (1\ 000 + 2.5 - 1.5)\ g = 1\ 001\ g$$

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

$$E = (1\ 001 - 1\ 000)\ g = +\ 1\ g$$

3.10.2.2 Correction for error at zero

Evaluate the error at zero load, (E_0) and the error at load L, (E), by the method of 3.10.2.1.

The corrected error prior to rounding, (E_c) is:

$$E_c = E - E_0$$

Example: if, for the example in 3.10.2.1, the error calculated at zero load was:

$$E_0 = +\ 0.5\ g,$$

the corrected error is:

$$E_c = +\ 1 - (+\ 0.5) = +\ 0.5\ g$$

4 Test program

4.1 Type evaluation (R 51-1, 8.2.3)

Clauses 1.1 and 5 to 6.2 shall normally be applied for type evaluation, using the test methods detailed in R 51-1, 9.

4.2 Initial verification (R 51-1, 8.3)

Clauses 2 and 5, except for 5.2 (warm-up) and 5.4.2 (range of zero-setting), and for instruments mounted on vehicles 6.2.8, shall be applied for initial verification.

The types of test loads used shall comply with R 51-1, 9.1.3.2.

5 Metrological performance tests

5.1 General conditions

5.1.1 Standard operational test for automatic operation (R 51-1, 8.2.3.1)

The test procedure shall be as follows.

1) Start the automatic weighing system, including (if the EUT is installed in the place of use) the surrounding equipment which is normally operational when the instrument is in use.
2) Set the load transport system to its maximum speed of operation (R 51-1, 9.1.4).
3) Except where stated, select four test loads which must include values close to Min and Max and at values close to, but not above, two critical points (R 51-1, 4.3.2.6) in between Min and Max (R 51-1, 9.1.1). More than one test load may be required for each of the above load values to achieve the maximum rate of operation. Weigh the test loads on the control instrument specified in R 51-1, 9.1.5 to determine the conventional true value of each test load as specified in R 51-1, 9.1.6.
4) The number of test weighings for each load depends on the mass of the test load as specified in R 51-1, 9.1.2.
5) Enable the test loads to be automatically weighed for the specified number of times and record each indication. Determine the individual errors of weighing in accordance with:
    a) R 51-1, 9.1.7.1 for category X instruments
    b) R 51-1, 9.1.7.2 for category Y instruments
6) Determine the mean error (R 51-1, 4.4.3.5) and the standard deviation of the error (R 51-1, 4.4.3.6) for category X instruments in accordance with R 51-1, 9.1.8, or the individual errors for category Y instruments (R 51-1, 9.1.7.2).

The standard operational test is used for a number of different tests:

1) dynamic setting,
2) eccentricity for dynamic weighing instruments,
3) static temperatures,
4) temperature effect on no load indication,
5) voltage variation,
6) operational tests.

5.1.2 Weighing performance test for nonautomatic (static) operation

The following weighing test shall be performed in nonautomatic (static) operation as an alternative to automatic operation during influence factor testing (6.2), provided the conditions of R 51-1, 9.4.5 are met.

Apply test loads from zero up to and including Max, and similarly remove the test loads back to zero. When determining the initial intrinsic error, at least 10 different test loads shall be selected, and for other weighing tests at least 5 shall be selected. The test loads selected shall include Max and Min, and at values close to, but not above, those at which the maximum permissible error changes.

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

If the instrument is provided with an automatic zero-setting or zero-tracking device, it may be in operation during the tests, except for the temperature test. The error at zero point is then determined according to 3.10.2.1.

5.1.3 Supplementary weighing test

For instruments with an initial zero-setting device with a range greater than 20 % of Max, a supplementary weighing test shall be performed using the upper limit of the range as zero point.

5.2 Warm-up time test (R 51-1, 7.2.3)

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 zero and span errors (R 51-1, 4.4.3.10) comply with the requirements during the first 30 minutes of operation. Zero-tracking and automatic zero-setting shall be disabled, unless if the zero operates as part of every automatic weighing cycle then this function shall be enabled or simulated as part of the test.

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

(1) Disconnect the instrument from the supply for a period of at least 8 hours prior to the test.
(2) Reconnect the instrument and switch on while observing the indication.
(3) Check that it is not possible to initiate automatic weighing until the indicator has stabilized (R 51-1, 6.4.1).
(4) As soon as the indication has stabilized, set the instrument to zero if this is not done automatically.
(5) Determine the error at zero by the method of 3.10.2.1, 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.
(6) Apply a static load close to Max. Determine the error by the method of 3.10.2.1 and 3.10.2.2.
(7) Verify that:
- zero indication error (E_{0I}) is not greater than 0.25 e (R 51-1, 6.5.2),
- span error is not greater than the maximum permissible error specified in R51-1, Table 6 for initial verification.

(8) Repeat steps (5) and (6) after 5, 15 and 30 minutes.
(9) After each time interval verify that:
- zero variation error ($E_0 - E_{0I}$) is not greater than 0.25 e $*$ p_i,
- span error is not greater than the maximum permissible error specified in R51-1, Table 6 for initial verification

5.3 Range of dynamic setting (R 51-1, 6.2.3)

5.3.1 Range

If the dynamic setting facility is specified for a limited weighing range (or ranges) then the standard weighing test shall be done at load values close to the limits of the range for at least one of the nominal load values specified in 5.1.1.

5.3.2 Out of range interlock

If the dynamic setting facility is specified for a limited weighing range (or ranges) then it shall be verified that operation and print out outside of the specified range is inhibited, by attempting to weigh loads that are close to but outside the range.

5.4 Zero-setting (R 51-1, 6.5)

5.4.1 Modes of zero-setting

To test the automatic zero-setting device it is necessary to allow the instrument to operate through the appropriate part of the automatic cycle and then to halt the instrument 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 instrument is halted.

5.4.2 Range of zero-setting

5.4.2.1 Initial zero-setting

(a) Positive range
With the load receptor empty, set the instrument to zero. Place a test load on the load receptor and switch the instrument off and then back on. Continue this process until, after placing a load on the load receptor and switching the instrument off and on, 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 instrument to zero. Then, if possible, remove any non-essential components of the load receptor. If, at this point, the instrument can be reset to zero by switching it off and back on, the mass of the non essential components is used as the negative portion of the initial zero-setting range.
(2) If the instrument cannot be reset to zero with the non-essential components removed, add weights to any live part of the scale until the instrument indicates zero again.
(3) Then remove weights and, after each weight is removed, switch the instrument off and back on. The maximum load that can be removed while the instrument can still be reset to zero by switching it off and on 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 instrument, the instrument may be temporarily re-calibrated with a test load applied before proceeding to step (3) above. (The test load applied for the temporary re-calibration 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 initial zero-setting range need be considered.
(7) Reassemble or recalibrate the instrument for normal use after the above tests

5.4.2.2 Nonautomatic and semi-automatic zero-setting

This test is performed in the same manner as described in 5.4.2.1, except that the zero-setting device is used rather than switching the instrument on and off.

5.4.2.3 Automatic zero-setting

Remove the non-essential parts of the load receptor or re-calibrate the instrument as described in 5.4.2.1 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 instrument to operate through the appropriate part of the automatic cycle so as to see if the instrument is reset to zero automatically.

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

5.4.3 Accuracy of zero-setting

The accuracy of zero-setting shall be tested in nonautomatic (static) operation, by incrementing load weights by a small amount as described below.

(1) Set the instrument to zero and then disable the zero-setting functions. If the instrument has a zero-tracking device the indication must be brought out of the zero-tracking range (e.g. by loading with 10 e).
(2) Apply loads to the load receptor. Increment each successive load by a small amount (≤ 0.2 e) to determine the additional load at which the indication changes from zero to one scale interval above zero (or from one scale interval to the next above if a load of 10 e was added to disable zero-tracking).
(3) Calculate the error at zero by the method of 3.10.2.1.

Note: For practical reasons it may not be possible to determine the accuracy of the automatic zero-setting device using the method detailed above. However, the functionality of the device shall be checked by applying a load within the zero-setting range to a static part of the load receptor before an operational test. The effect of the automatic zero-setting device and its accuracy will thus be proven by the standard operational test in 5.1.1.

5.5 Stability of zero and frequency of automatic zero-setting (R 51-1, 6.5.4)

This test is applicable for instruments with programmable automatic zero-setting and does not need to be performed for instruments that have automatic zero-setting as part of every automatic weighing cycle.

To verify that an automatic zero-setting facility will operate sufficiently often to ensure that zero error is not greater than 0.5 e, apply the following method:

(1) Determine the maximum permissible time interval by selecting the smaller of the two values below:
- the maximum time interval specified by the manufacturer in accordance with R 51-1, 6.5.4,
- 3 minutes (classes XI and Y(I) instruments) or 15 minutes (all other classes), divided by the maximum zero-change in fractions of e determined from 6.2.2 (Temperature effect on no-load indication).
  e.g. maximum zero-change = 0.33 e per 5 °C (class Y(a) instrument)
  15 minutes / 0.33 = 45 minutes (0.75 hour)

(2) Allow the instrument to be reset to zero automatically.
(3) After an interval close to the maximum permissible zero-setting interval established in (1) but before a further automatic zero-setting, carry out the test of 5.4.3 (accuracy of zero-setting).
(4) Stages (2) and (3) shall also be carried out as soon the instrument is operable after switch-on, i.e. immediately after the normal warm-up time.

Note: the value of 3 or 15 minutes in (1) is determined by the following calculations:

(a) the maximum allowable rate of change of a steady ambient temperature is 5 °C per hour.

(b) R 51-1, 6.5.2 gives the maximum allowable zero-setting error:

$$Ezsmax \leq 0.25\ e$$

R 51-1, 6.5.5 gives the maximum allowable zero-checking error:

$$Ezcmax \leq 0.5\ e$$

this gives the maximum allowable zero-variation:

$$Ezcmax - Ezsmax = 0.25\ e$$

For classes XI and Y(I) instruments:
6.2.2 requires the maximum allowable zero-variation:

$$\Delta zmax \text{ per } 1\ °C \leq e$$

with 5 °C per hour for steady ambient temperature (a)

$$\Delta zmax \text{ per } 0.2\ h \leq e$$

with maximum allowable zero-variation (b)

$$\Delta zmax \text{ per 3 minutes} \leq 0.25\ e$$

For all other instruments:
6.2.2 requires the maximum allowable zero-variation:

$$\Delta zmax \text{ per } 5\ °C \leq e$$

with 5 °C per hour for steady ambient temperature (a)

$$\Delta zmax \text{ per hour} \leq e$$

with maximum allowable zero-variation (b)

$$\Delta zmax \text{ per 15 minutes} \leq 0.25\ e.$$

5.6 Tare (R 51-1, 6.6)

The normal mode(s) of tare setting shall be tested. Other methods which verify the requirements of R 51-1, 6.6 may be used where appropriate.

For a static tare, place the tare load on the load receptor and allow the tare function to operate (refer to the manufacturers instructions for the exact method).

For a dynamic tare, pass the load to be tared over the load receptor to allow the tare function to operate (refer to manufacturers instructions).

5.6.1 Weighing test

5.6.1.1 Automatic operation

The tests shall be carried out in automatic operation. Zero-setting functions shall be in operation. Operational tests (according to 5.1.1) shall be performed with at least two different tare values. At least two test load values shall be selected, one value close to Min and one close to the maximum possible net load.

If the instrument is equipped with an additive tare device one of the weighing tests shall be performed with a tare value close to the maximum additive tare effect.

5.6.1.2 Nonautomatic (static) operation

Weighing tests (loading and unloading according to 5.1.2) shall be performed with at least two different tare values. At least 5 load steps shall be selected. The steps shall include values close to Min, the values at which the MPE changes and the value close to the maximum possible net load.

If the instrument is equipped with an additive tare device one of the weighing tests shall be performed with a tare value close to the maximum additive tare effect.

5.6.2 Accuracy of tare setting

The accuracy of the tare device shall be established in a manner similar to the test (accuracy of zero-setting) described in 5.4.3 with the indication set to zero using the tare device.

5.6.2.1 Static tare

Allow the tare device to operate, then increment the tare load by using change point weights until the indication has definitely changed by one scale interval. Verify by the method of 3.10.2.1 that the tare setting accuracy is better than ± 0.25 e with a deviation of not more than 0.25 e.

5.6.2.2 Dynamic tare

Allow the tare device to operate, halt the instrument, and determine the accuracy as per 5.6.2.1 above or, if this method is impractical, the accuracy of the dynamic tare setting shall be tested by the operational tests in 5.6.1 to verify that the value of the net load is within the MPE.

5.7 Eccentricity (R 51-1, 5.7.1 and 9.4.4)

5.7.1 Eccentric test for instruments that weigh dynamically

The instrument shall be under conditions of normal operation. The test shall be carried out during automatic operation. Zero-setting and zero-tracking functions shall be in operation. Dynamic setting may be performed before each new value of test load is used.

Apply a load equal to 1/3 Max (plus the additive tare capacity, if applicable) across the load receptor with the load at the centre of each of the following bands where:

Band 1 is from the centre of the load receptor to one edge of the transport system,
Band 2 is from the centre of the load receptor to the opposite edge of the transport system.

The load is passed across the load receptor the specified number of times (R 51-1, 9.1.2). The errors shall not exceed the appropriate maximum permissible errors for influence factor tests.

5.7.2 Eccentric test for instruments that weigh statically

Apply a load equal to 1/3 Max (plus the additive tare capacity, if applicable) in each of the four quarter segments of the stationary load transport system. On an instrument with a load transport system having n points of support with n > 4 the fraction 1/(n – 1) of Max (plus the additive tare capacity, if applicable) shall be applied to each point of support.

The load shall be applied centrally in the segment if a single weight is used, but applied uniformly over the segment, if several small weights are used.

The errors shall not exceed the appropriate maximum permissible errors for influence factor tests.

5.8 Alternative operating speeds (R 51-1, 9.1.4)

The test procedure shall be as follows.

Start the automatic weighing system, including the surrounding equipment which is normally used when the instrument is in use. The test shall be carried out during automatic operation. Zero-setting functions shall be in operation. Dynamic setting may be performed before each new value of test load is used.

Two test load values are selected, one value close to Min and one value close to Max. One test load is used at each of the above load values.

The number of test weighings depends on mass of the test load (R 51, 9.1.2).

The load transport system shall be set to its maximum speed of operation and also at a speed approximately midway through the operating range (R 51-1, 9.1.4).

If the instrument is specified for alternative maximum capacities corresponding to alternative operating speeds then each speed must be tested with the correct load. In this case it is not necessary to retest minimum and critical load values for each speed.

The test load is passed across the load receptor the specified number of times and the results are noted. Maximum permissible errors shall be as specified in R 51-1, 5.5.1 as appropriate.

5.9 Test for the stability of equilibrium (R 51-1, 6.4.1)

This test is applicable only to instruments that weigh statically.

Check the documentation of the manufacturer; whether the following stable equilibrium functions are described in detail and sufficiently:

- The basic principle, the function and the criteria for stable equilibrium.
- All adjustable and not adjustable parameters of the stable equilibrium function (time interval, number of measuring cycles, etc.).
- Securing of these parameters.
- Definition of the most critical adjustment of the stable equilibrium.

Apply a load up to 50 % of Max or up to a load included in the range of operation of the relevant function. Manually disturb the equilibrium by one single action and initiate the command for printing, data storage, or other function, as soon as possible. In the case of printing or data storage, read the indicated value 5 seconds after printing. Stable equilibrium

is considered to be achieved when no more than two adjacent values are indicated, one of which being the printed final weight value (R 51-1, 4.3.2.4.3). In the case of zero-setting or tare setting, check the accuracy as per 5.4.3 and 5.6.2. Perform the test 5 times.

Check whether under continuous disturbance of the equilibrium no functions can be performed that require stable equilibrium, e.g. printing, storing, or zero operations.

5.10 Agreement between indicating and printing devices (R 51-1, 5.7.2)

During the tests verify that for the same load, the difference between any two indicating devices having the same scale interval is as follows:

- zero for digital indicating or printing devices;
- not greater than the maximum permissible error for analogue devices.

5.11 Securing of components and pre-set controls (R 51-1, 6.2.6)

Verify that it is not possible to make unauthorised adjustments or resetting of components, interfaces, software devices and pre-set controls without any access becoming automatically evident.

6 Influence factor and disturbance tests during type evaluation

6.1 Test conditions

Further guidance on the metrological performance testing requirements for influence quantities and disturbances is provided in the appropriate reference standards as indicated for each test and in the OIML International Document D 11 [3].

6.1.1 General requirements

Influence factor and disturbance tests are intended to verify that electronic instruments can perform and function as intended in the environment and under the conditions specified. Each test indicates, where appropriate, the reference condition under which the intrinsic error is determined.

The influence factors tests shall be applied to a complete instrument under normal operation in accordance with R 51-1, 9.4.5. Where it is not possible to apply influence factor tests to fully operational equipment in their normal operational state (i.e. where size and/or configuration of the instrument does not permit testing as a whole) the instrument may be subjected to influence factor tests under simulated operation. If simulated operation is not possible, the instrument may be subjected to influence factor tests under static conditions as specified in R 51-1, 9.4.5.1.

Disturbances shall be applied to the instrument under static conditions. If the instrument cannot be subjected to disturbances under static conditions, then simulated operation may be permitted. The permissible effects of the disturbances, under these conditions, are specified for each test in 6.3.

When the effect of one influence factor is being evaluated, all other factors are to be held relatively constant, at a value close to normal.

Where parts of the instrument are examined separately, errors shall be apportioned in accordance with R 51-1, 8.2.3.4.

The operational status of the instrument or simulator shall be recorded for each test.

When an instrument is connected in other than a normal configuration, the procedure shall be mutually agreed by the metrological authority and the applicant.

6.1.2 Simulator requirements

6.1.3 General

Where permitted, the simulator used for influence factor and disturbances tests should include all electronic devices of the weighing system.

6.1.4 Weight simulator

The simulator should also include the load cell and a means to apply test loads. Where this is not possible, e.g. for high capacity instruments such as vehicle mounted catchweighers, then a load cell simulator may be used or alternatively the load cell interface may be modified to incorporate a scaling factor to give the design output for a small test load.

The simulator must be capable of providing a minimum input signal, μV/d (minimum input voltage per scale interval).

Repeatability and stability of a load cell simulator should make it possible to determine the performance of the instrument with at least the same accuracy as when the instrument is tested with weights.

6.1.5 Documentation

Simulators shall be defined in terms of hardware and functionality by reference to the instrument under test, and by any other documentation necessary to ensure reproducible test conditions. This information shall be attached to, or traceable from, the test report.

6.2 Influence factor tests

Summary of tests

§	Test	Characteristic under test	Conditions applied
6.2.1	Prescribed temperatures test (dry heat and cold)	Influence factor	mpe
6.2.2	Temperature effect on no-load indication	Influence factor	mpe
6.2.3.1	Damp heat, steady-state (non condensing)		mpe
6.2.3.2	Damp heat, cyclic test (condensing)		mpe

6.2.4	AC mains voltage variation	Influence factor	mpe
6.2.5	DC mains voltage variation	Influence factor	mpe
6.2.6	Low voltage of internal battery (not connected to the mains supply)	Influence factor	mpe
6.2.7	Power from external 12V and 24V road vehicle batteries	Influence factor	mpe
6.2.8	Tilting	Influence factor	mpe

NOTE: Although IEC Standards are mentioned, the requirements of OIML R 51 have to be fulfilled. Differences should be taken into account.

6.2.1 Prescribed temperatures (R 51-1, 5.8.1.1)

Prescribed temperatures for static tests are carried out according to according to Table 2.1.

Supplementary information to the IEC test procedures:

Table 2.1 Temperature test (dry heat and cold)	
Applicable standards	IEC 60068-2-1 [1], IEC 60068-2-2 [2], IEC 60068-3-1 [3]
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 51-1, 5.5.3 under conditions of high and low temperature specified in R 51-1, 5.8.1.1
Precondition	The electrical power of the EUT is switched on for at least a 16 hours time period while taking into account the warm-up time specified by the manufacturer.
Condition of the EUT	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 test on temperature effect on no-load indication. In such 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 to the specified high temperature under “free air” conditions during the period of at least 2 hours (the period specified is the period following the moment at which the EUT has reached temperature stability). “Free air” conditions meaning sufficient air circulation to keep the temperature at a stable level. 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/m3. When tests are performed at temperatures below 35 °C, the relative humidity shall not exceed 50 %. Sequence: 1. Reference temperature of T_R 2. Specified high temperature T_H 3. Specified low temperature T_L 4. Intermediate temperature T_I 5. Reference temperature T_R				
Test levels	The following high temperature test levels may be specified:				
Level index high (I_H)	1	**2**	3	4	Unit
Temperature (T_H)	30	**40**	55	70	°C
	The following low temperature test levels may be specified:				
Level index low (I_L)	-1	**-2**	-3	-4	
Temperature (T_L)	5	**-10**	-25	-40	°C
NOTES	I_H concerns the index for T_H; I_R concerns the index for T_R; I_I concerns the index for T_I; I_L concerns the index for T_L. By default: T_R = 20 °C and I_R = 0, I_H = 2, I_I = 1 and I_L = -2 $I_R = (I_H + I_L)/2$ (rounded to an integer by deleting the mantissa) and $I_I = (I_R - 1)$				
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 51-1, 5.5.3				

6.2.2 Temperature effect on no-load indication (R 51-1, 5.8.1.3)

Table 2.2 Temperature test at no load condition (dry heat and cold)

Applicable standards	IEC 60068-2-1 [1], IEC 60068-2-2 [2], IEC 60068-3-1 [3]
Test method	Gradual exposure to high and low temperatures not allowing condensation to occur
Applicability	General applicable. This test should not be performed for instruments that have automatic zero - setting as part of every automatic weighing cycle. This test may be combined with the general temperature test specified in Table 2.1.

Object of the test	Verification of compliance with the provisions in R 51-1, 5.5.3 under conditions of high and low temperature specified in R 51-1, 5.8.1.3				
Precondition	The electrical power of the EUT is switched on for at least a 16 hours time period while taking into account the warm-up time specified by the manufacturer.				
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall not be enabled.				
Test procedure in brief	The test comprises exposure to the specified high and low 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). 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/m3. When tests are performed at temperatures below 35 °C, the relative humidity shall not exceed 50 %. Sequence: 1. Reference temperature of T_R; 2. Specified high temperature T_H 3. Specified low temperature T_L 4. Intermediate temperature T_I 5. Reference temperature T_R After the first time setting at reference temperature and stabilization the EUT is set to zero.				
Test levels	The following high temperature test levels may be specified:				
Level index high (I_H)	1	**2**	3	4	Unit
Temperature (T_H)	30	**40**	55	70	°C
	The following low temperature test levels may be specified:				
Level index low (I_L)	-1	**-2**	-3	-4	
Temperature (T_L)	5	**-10**	-25	-40	°C
NOTES	I_H concerns the index for T_H; I_R concerns the index for T_R; I_I concerns the index for T_I; I_L concerns the index for T_L. By default: T_R = 20 °C and I_R = 0, I_H = 2, I_I = 1 and I_L = -2 $I_R = (I_H + I_L)/2$ (rounded to an integer by deleting the mantissa) and $I_I = (I_R - 1)$				
EUT performance	Determine the error at zero, each time just before changing to a 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 51-1, 5.5.3 for the instrument.

6.2.3 Damp heat test (R 51-1, 7.1.7)

The tests in 6.2.3.1 or 6.2.3.2 may be performed alternatively in accordance with R 51-1, 7.1.7, the option chosen being mentioned in the type approval certificate.

6.2.3.1 Damp heat, steady state

Damp heat, steady state test are carried out according to Table 2.3.

Table 2.3 - Damp heat, steady-state (non condensing)

Applicable standards	IEC 60068-2-78 [4], IEC 60068-3-4 [5]	
Test method	Exposure to damp heat in steady-state	
Applicability	This test is considered general applicable where the measuring instrument 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 51-1, 5.5.3 and 7.1.1 under conditions of high humidity and constant temperature specified in R 51-1, 7.1.7.	
Precondition	The electrical power of the EUT is switched on for at the warm-up time specified by the manufacturer.	
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.	
Test procedure in brief	The test comprises exposure to the specified high level temperature and the specified constant relative humidity for a certain fixed period of time as defined by the test level chosen. The EUT shall be handled such that no condensation of water occurs on it. Climate test sequence: 1. Set at reference temperature and at 50 % relative humidity, 2. Maintain for 3 hours at reference temperature and 50 % humidity, 3. Set at specified high temperature at 85 % humidity, 4. Maintain during 48 hours this high temperature and 85 % relative 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**	**2**
unit	%	24-hours period
EUT performance	After stabilization at the relevant temperature and humidity at no load and subsequently at test load condition record the following data: a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance	
Permitted maximum deviation	The error of the EUT is determined once per day under test conditions and at the end of the test after a recovery period of one hour. All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in R 51-1, 5.5.3	

6.2.3.2 Damp heat, cyclic test (condensing)

Damp heat, cyclic tests are carried out according to Table 2.4.

Table 2.4 Damp heat, cyclic (condensing)	
Applicable standards	IEC 60068-2-30 [15], IEC 60068-3-4 [5]
Test method	Exposure to damp heat with cyclic temperature variation
Applicability	Applicable where condensation is concerned and/or when the penetration of vapour is expected which especially applies to outdoor used instruments.
Object of the test	Verification of compliance with the provisions in R 51-1, 5.5.3, and 7.1.1 under conditions of high humidity combined with cyclic temperature changes specified in R 51-1, 7.1.7.
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.
Test procedure in brief	The test comprises exposure to 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	**40**	**55**	°C
Duration	**2**		24-hour cycle(s)
EUT performance	After the exposure to damp heath, at no load and subsequently at test load condition record the following data: a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance		
Permitted maximum deviation	The error of the EUT is determined once per day under test conditions and at the end of the test after a recovery period of one hour. All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in R 51-1, 5.5.3		

6.2.4 AC mains voltage variation (R 51-1, 5.8.2)

AC mains voltage variation tests are carried out according to Table 2.5.

Table 2.5 AC mains voltage variation	
Applicable standards	IEC/TR3 61000-2-1 [6], IEC 61000-4-1 [7]
Test method	Applying low and high level AC mains power voltage (single phase)
Applicability	Applicable for measuring instruments 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 51-1, 5.5.3 under conditions of AC mains network voltage changes between upper and lower limit specified in R 51-1, 5.8.2.	
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 three phase power supply, the voltage variation shall apply for each phase successively.	
Test level	Upper limit	$\boldsymbol{U_{nom1}}$ **+** 10 **%** [1)]
	Lower limit	$\boldsymbol{U_{nom2}}$ − 15 **%** [1)]
NOTES	[1)] The values of U_{nom} are those as marked on the measuring instrument. If a range is specified U_{nom1} concerns the highest and U_{nom2} concerns the lowest value. If only one nominal mains voltage value (U_{nom}) is specified then $U_{nom1} = U_{nom2} = U_{nom}$. The reference voltage level is equal to ($U_{nom1} + U_{nom2}$) / 2.	
Permitted maximum deviation	The errors shall be determined when the breath alcohol analyzer 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 51-1, 5.5.3	

6.2.5 DC mains voltage variation (R 51-1, 5.8.2)

Instruments operating from DC mains power supply shall fulfil the tests in 6.2, with the exception of 6.2.5 which is to be replaced by the test to Table 2.7.

Table 2.7 - DC mains voltage variations test

Environmental phenomena	Test specification		Test set-up
DC mains voltage variations	U_{nom}		I EC 60654-2
	Upper limit:	U_{max}	
	Lower limit:	minimum operating voltage (5.8.2)	

	U_{nom}	
Note:	In case a voltage-range is marked, use the average value as nominal U_{nom}	

Supplementary information to the IEC test procedures:

Object of the test:	To verify compliance with the provisions in R 51-1, 5.5.3, and R 51-1, 7.1.1 under conditions of DC mains voltage variations in supply, including rechargeable battery if battery is fully (re)charged during the operation of the instrument as specified in R 51-1, 5.8.2.
Test procedure in brief:	The test consists of exposure to the specified voltage supply voltage condition for a period sufficient for achieving temperature stability and for performing the required measurements.
Preconditioning:	None
Condition of the EUT:	EUT is connected to the voltage supply and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test.
Number of test cycles:	At least one cycle.
Weighing test:	The EUT shall be tested with one test load selected from R 51-1, 9.1.1 at a critical value. The test shall be carried out in automatic operation (5.1.1), or optionally in nonautomatic (static) operation (5.1.2). Changes in barometric pressure shall be taken into account. Stabilize the EUT at the nominal voltage and record the following data at no load and with one load or simulated load: a) date and time; b) temperature; c) relative humidity; d) supply voltage; e) test load; f) indications (as applicable); g) errors; h) functional performance Reduce the voltage to the EUT until the instrument ceases to function properly according to the specifications and metrological requirements, and record the indications.
Maximum allowable variations:	All functions shall operate as designed. All indications shall be within the maximum permissible errors specified in R 51-1, 5.5.3.

6.2.6 Low voltage of internal battery (not connected to the mains power) (R 51-1, 5.8.2)

Instruments supplied by internal battery shall fulfil the tests in 6.2, in accordance with Table 2.8.

Table 2.8 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 measuring instruments supplied by internal battery
Object of the test	Verification of compliance with the provisions in R 51-1, 5.5.3 during low battery voltage specified in R51-1, 5.8.2
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 instrument. In case of simulating the battery, by using an alternative power supply, the internal impedance of the specified type of battery shall also to be simulated. The alternative power supply shall be capable of delivering sufficient current at the applicable supply voltage. The test sequence is as follows: 1) Let the power supply stabilize at a voltage as defined within the rated operating conditions and apply the measurement and/or loading condition. 2) Record: a) the data defining the actual measurement conditions including date, time and environmental conditions, b) the actual power supply voltage. 3) Perform measurements and record the error (-s) and other relevant performance parameters. 4) Verify compliance with R 51-1, 5.5.3 5) Repeat the above procedure with actual supply voltage at U_{bmin} and again at 0,9 U_{bmin} Verify compliance with R 51-1, 5.5.3.
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	After stabilization at the relevant voltage at no load and subsequently at test load condition record the following data: a) date and time, b) temperature,

	c) relative humidity, d) supplied voltage e) test load value, f) indicated values, g) error values, h) functional performance
Permitted maximum deviation	All errors shall be within the maximum permissible errors specified in R 51-1, 5.5.3 For voltages at and above U_{bmin}, all functions shall operate as designed; for voltages below U_{bmin}, the instrument may automatically resume normal operation. During all phases of the test the loss of any previous measurement data is not acceptable.

6.2.7 Power from external 12 V and 24 V road vehicle batteries (R 51-1, 5.8.2)

Road vehicle battery operated instruments shall fulfil the tests in 6.2, with the exception of 6.2.4 and 6.2.5 which is to be replaced by the following test conducted in accordance with ISO 16750-2 [16] and according to Table 2.9.

Table 2.9 Voltage variations

Applicable standard	ISO 16750-2 [16]				
Test method	Variation in supply voltage				
Applicability	Applicable to all measuring instruments 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 51-1, 5.5.3 under conditions of high while charging) and low battery voltage specified in R51-1, 5.8.2				
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.				
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.				
Test procedure in brief	The test comprises exposure to the specified maximum and minimum power supply voltage conditions for a period sufficient for achieving temperature stability and performing the required measurements at these conditions.				
Nominal battery voltage	**U_{nom} = 12**		**U_{nom} = 24**		V
	Lower limit	Upper limit	Lower limit	Upper limit	
Test level	**9**	**16**	**16**	**32**	V
EUT performance	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	All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in R 51-1, 5.5.3

6.2.8 Tilting (R 51-1, 5.8.3)

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 instruments that will not be permanently installed. This test is not required for transportable instruments with a levelling device and a level indicator if it can be established that the tilt can be adjusted to 1 % or less.

An instrument not intended for installation in a fixed position that does not have a levelling device and a level indicator, or an instrument mounted on or incorporated in a vehicle, shall be tested as follows:

Test information:

Object of the test:	To verify compliance with the provisions in R 51-1, 5.8.3.
Test procedure in brief:	The test consists of exposure to the specified voltage supply condition for a period sufficient for achieving temperature stability and for performing the required measurements.
Preconditioning:	None required.
Condition of the EUT:	Voltage supply «on» for a time period equal to or greater than the warm-up time specified by the manufacturer. Voltage is to be «on» for the duration of the test. The zero-setting and zero-tracking facilities shall be enabled as for normal operation. Zero-setting and zero-tracking shall be in operation.
Number of test cycles:	At least one cycle.
Test severity:	Operational tests with a load close to Min and Max at 5 % tilt. For vehicle mounted or incorporated catchweighers the tests shall be performed at 10 % tilt, or at a reduced value specified by manufacturer where the instrument is fitted with a tilt limiting device. Where applicable, a test of the operation of the tilt limiting device shall be performed.
Weighing test:	The test consists of conducting the operational tests as described in R 51-1, 8.2.3.1 (but only using loads close to Min and Max) at each of the following positions. The test shall be carried out during automatic operation except where specified in R 51-1, 9.4.5. Re-zero at each new position prior to conducting the operational test: a) reference position b) t % longitudinally forward

c) t % longitudinally backwards
d) t % transversely forward
e) t % transversely backwards
f) reference position

where

t % = value of tilt specified in test severity above.

Record:

a) date and time;
b) temperature;
c) relative humidity;
d) supply voltage;
e) test load;
f) indications (as applicable);
g) errors;
h) functional performance

Maximum allowable variations:

All functions shall operate as designed.
All indications shall be within the maximum permissible errors specified in R 51-1, 5.5.3.

6.3 Disturbance tests (R 51-1, 7.1.3)

Summary of disturbance tests

§	Test	**Condition applied**
6.3.1	AC mains voltage dips, short interruptions and reductions	Significant fault
6.3.2.1	Electrical bursts (fast transient tests) on AC and DC mains	Significant fault
6.3.2.2	Electrical bursts (fast transient tests) on signal, data and control lines	Significant fault
6.3.3.1	Electrical surges on AC and DC mains power lines	Significant fault
6.3.3.2	Electrical surges on signal, data and control lines	Significant fault
6.3.4.1	Immunity to radiated (RF) electromagnetic fields	Significant fault
6.3.4.2	Immunity to conducted electromagnetic fields	Significant fault
6.3.5	Electrostatic discharge	Significant fault
6.3.6.1	Electrical transient conduction along supply lines for 12 V or 24 V road vehicle batteries	Significant fault
6.3.6.2	Electrical transient conduction via lines other than supply lines for 12 V or 24 V road vehicle batteries	Significant fault
6.3.6.3	Battery voltage variations during starting up of a vehicle engine	Significant fault
6.3.6.4	Ripple on DC mains power	Significant fault
6.3.6.5	Load “dump” test	Significant fault
NOTE 1:	Tests shall be conducted to the appropriate classification for electrical tests. The severity level stated in the tests 6.3.1 to 6.3.6 apply to instruments installed and used in locations with significant or high levels of electromagnetic disturbances corresponding to those likely to be found in industrial environments, class E2 of OIML D11 [3].	
NOTE 2:	If there are interfaces on the instrument (or simulator), the use of these interfaces to other equipment shall be simulated in the tests. For this purpose, either an appropriate peripheral device or 3 m of interface cable to simulate the interface impedance of the other equipment shall be connected to each different type of interface.	
NOTE 3:	In case of transient faults due transient disturbances it shall be considered whether these could make the instrument detect that the preset value of the fill is reached. To that end the preset value of the fill may be set to a value that exceeds the test load by exactly the significant fault. In case of the occurance of a significant fault the instrument would signal that the preset value has been reached by e.g. setting a digital output. Thus a significant fault due to transient disturbances can be detected.	

6.3.1 AC mains voltage dips, short interruptions and reductions

AC mains voltage dips and short interruptions tests are carried out according to Table 2.10.

Table 2.10 - AC mains voltage dips, short interruptions and reductions

Applicable standards	IEC 61000-4-11 [13], IEC 61000-6-1 [19], IEC 61000-6-2 [20]			
Test method	Introducing short-time reductions of mains voltage using the test set-up defined in the applicable standard			
Applicability	Applicable for measuring instruments 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 51-1, 7.1.3 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 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 to occur.

6.3.2 Electrical bursts (fast transient tests) on mains power lines and on signal, data and control

Electrical bursts tests (fast transient tests) are carried out according to Tables 2.11 and Table 2.12.

6.3.2.1 Electrical bursts (transients) on AC and DC mains

Table 2.11 - Bursts (transients) on AC and DC mains

Applicable standards	IEC 61000-4-4 [10]
Test method	Introducing transients on the mains power lines
Applicability	Applicable for electronic measuring instruments 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 51-1, 7.1.3 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 to bursts of voltage spikes for which the output voltage on 50 Ω and 1000 Ω load are defined in the referred standard. Both positive and negative polarity of the bursts shall be applied. The duration of the test shall not be less than 1 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 to occur. It is acceptable when during the disturbance test the instrument is not providing a measurement result.	

6.3.2.2 Electrical bursts (transients) on signal, data and control lines

Table 2.12 - Bursts (transients) on signal, data and control lines

Applicable standards	IEC 61000-4-4 [10]
Test method	Introducing transients on signal, data and control lines
Applicability	Applicable for electronic measuring instruments 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 51-1, 7.1.3 during conditions where electrical bursts are superimposed on I/O and communication ports.
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.
Test procedure in brief	A burst generator as defined in the referred standard shall be used The characteristics of the generator shall be verified before connecting the EUT. The test comprises exposure to bursts of voltage spikes for which the output voltage on 50 □ and 1000 □□load are defined in the referred standard. Both positive and negative polarity of the bursts shall be applied. The duration of the test shall not be less than 1 min for each

	amplitude and polarity. A capacitive coupling clamp as defined in the standard shall be used for the coupling of the bursts into the I/O and communication lines,	
	Test level	unit
Amplitude (peak value)	**1**	kV
Repetition rate	**5**	kHz
EUT performance	Sequentially during and after the exposure to the Bursts Record the following parameters: a) date and time, b) temperature, c) relative humidity, d) value of the measurand e) exposed conductors, f) indicated values, g) error values, h) functional performance	
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur. It is acceptable when during the disturbance test the instrument is not providing a measurement result.	

6.3.3 Electrical surges on AC and DC mains power lines and on signal, data and control lines

Electrical surge tests are carried out according to Tables 2.13 and Table 2.14.

6.3.3.1 Electrical surges on AC and DC mains power lines

Table 2.13 - Surges on AC and DC mains power lines	
Applicable standard	IEC 61000-4-5 [11]
Test method	Introducing electrical surges on the mains power lines
Applicability	Applicable for electronic measuring instruments which are temporarily or permanently connected to a mains power network while in operation This test is not applicable to instruments connected to a local power source through an indoor network
Object of the test	Verification of compliance with the provisions in R 51-1, 7.1.3 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 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 synchronised with the AC supply frequency and shall be repeated such that injection of surges on all the 4 phase shifts: 0°, 90°, 180° and 270° compared to the mains phase is covered. 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**	V
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 to occur. It is acceptable when during the disturbance test the instrument is not providing a measurement result.				

6.3.3.2 Electrical surges on signal, data and control lines

Table 2.14 - Surges on signal, data and control lines	
Applicable standard	IEC 61000-4-5 [11]
Test method	Introducing electrical surges on signal, data and control lines
Applicability	Applicable for electronic measuring instruments 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 instruments connected to a local power source through an indoor network.
Object of the test	Verification of compliance with the provisions in R 51-1, 7.1.3 during conditions where electrical surges are superimposed on

<table>
<tr><td></td><td colspan="5">I/O and communication ports.</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">A surge generator as defined in the referred standard shall be used. The characteristics of the generator shall be verified before connecting the EUT.
The test comprises exposure to electrical surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and the minimum time interval between two successive pulses are defined in the referred standard.
At least 3 positive and 3 negative surges shall be applied. The applicable injection network depends on the kind of wiring the surge is coupled into and is defined in the referred standard.</td></tr>
<tr><td></td><td colspan="2">Unsymmetrical lines</td><td>Symmetrical lines</td><td>Shielded I/O and communication lines</td><td></td></tr>
<tr><td rowspan="2">Test Level</td><td>Line to line</td><td>Line(s) to ground</td><td>Line(s) to ground</td><td>Line(s) to ground</td><td>Unit</td></tr>
<tr><td>1.0</td><td>2.0</td><td>2.0</td><td>2.0</td><td>kV</td></tr>
<tr><td>EUT performance</td><td colspan="5">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</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 to occur.
It is acceptable when during the disturbance test the instrument is not providing a measurement result.</td></tr>
</table>

6.3.4 Immunity to electromagnetic fields

6.3.4.1 Immunity to radiated (RF) electromagnetic fields

Radiated, radio frequency electromagnetic immunity tests are carried out according to Table 2.15.

Table 2.15 Radiated RF electromagnetic fields				
Applicable standard	IEC 61000-4-3 [9]; IEC 61000-4-20 [14]			
Test method	Exposure to radiated radio frequency electromagnetic fields			
Applicability	Applicable for electronic measuring instruments containing active electronic circuits			
Object of the test	Verification of compliance with the provisions in R 51-1, 7.1.3 while exposed to electromagnetic fields.			
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.			
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.			
Test procedure in brief	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 set-up the use of which is limited by the dimensions of the EUT and the frequency range of the facility.			
Test level	Frequency range	RF amplitude	AM, sine wave modulation	
	(26) 80 - 3000	**10**	80	1
	MHz	V/m	%	kHz
NOTES	The tests according to IEC 61000-4-3 and IEC 61000-4-6 are complementary test. It implies that in the range 26 MHz up to 80 MHz the type evaluation authority may decide to choose a transition frequency in this range for instruments equipped with external electrical wiring (mains power, signal, data and control lines) In such case beneath this chosen transition frequency the test method according to IEC 61000-4-6 described in the above Table 2.15 is to be applied be applied at least down to 26 MHz.			
EUT performance	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			

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

6.3.4.2 Immunity to conducted electromagnetic fields

Conducted, radio frequency, electromagnetic field immunity tests are carried out according to Table 2.16.

Table 2.16 - Conducted (common mode) currents generated by RF EM fields				
Applicable standard	IEC 61000-4-6 [12]			
Test method	Injection of RF currents representing exposure to RF electromagnetic fields			
Applicability	Applicable for electronic measuring instruments containing active electronic circuits and equipped with ports for throughput or connection of external electrical wiring (mains power, signal, data and control lines)			
Object of the test	Verification of compliance with the provisions in R 51-1, 7.1.3 while exposed to electromagnetic fields.			
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.			
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.			
Test procedure in brief	An RF EM current, simulating the influence of EM fields shall be coupled or injected into the power ports and I/O ports of the EUT using coupling/decoupling devices as defined in the referred standard. The characteristics of the test equipment consisting of an RF generator, (de-)coupling devices, attenuators, etc. shall be verified before connecting the EUT. If the EUT comprises several devices the tests shall be performed at each extremity of the cable if both of the elements are part of the EUT.			
	Frequency range	RF amplitude	AM, sine wave modulation	
Test level	0.15 – 80	10	80	1
Unit	MHz	V (e.m.f.)	%	kHz
EUT performance	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,			

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

6.3.5 Electrostatic discharge

Electrostatic discharge tests are carried out with test signals and conditions as given in Table 2.17.

Table 2.17 Electrostatic discharge	
Applicable standard	IEC 61000-4-2 [8]
Test method	Exposure to electrostatic discharge (ESD)
Applicability	Applicable to all electronic measuring instruments
Object of the test	Verification of compliance with the provisions in R 51-1, 7.1.3 in case of direct exposure to electrostatic discharges or such discharges in the neighbourhood of the EUT.
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.
Test procedure in brief	The test comprises exposure of the EUT to electrical discharges. An ESD generator as defined in the referred standard shall be used and the test set-up shall comply with the dimensions, materials used and conditions as specified in the referred standard. Before starting the tests, the performance of the generator shall be verified. 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

<table>
<tr><td></td><td colspan="3">spark discharge occurs.
Indirect application:
The discharges are applied in the contact mode only on coupling planes mounted in the vicinity of the EUT.
Conventionally 3 cycles of tests are performed starting each test at a different moment of the measuring cycle.</td></tr>
<tr><td></td><td colspan="3">One of the following test levels may be specified:</td></tr>
<tr><td></td><td></td><td>Charge voltage</td><td>unit</td></tr>
<tr><td rowspan="2">Test level</td><td>Contact discharge</td><td>6</td><td>kV</td></tr>
<tr><td>Air discharge</td><td>8</td><td>kV</td></tr>
<tr><td>EUT performance</td><td colspan="3">Five measurements shall be performed at each surface exposed to the disturbance. 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</td></tr>
<tr><td>Permitted maximum deviation</td><td colspan="3">Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur.
It is acceptable when during the disturbance test the instrument is not providing a measurement result.</td></tr>
</table>

6.3.6 Special EMC requirements for instruments powered from a road vehicle power supply

6.3.6.1 Electrical transient conduction along supply line of external 12 V and 24 V batteries

The test consists in exposing the EUT to conducted transient disturbances along supply lines.

Test equipment: See ISO 7637-2 [17]
Test set-up: See ISO 7637-2 [17]
Test procedure: See ISO 7637-2 [17]
Applicable standard: ISO 7637-2 [17]

Before any test, stabilize the EUT under constant environmental conditions.

The EUT shall be exposed to conducted disturbances of the strength and character as specified by the severity level.

The test shall be performed with one small test load only.

Test pulses : Test pulses: 2a+2b, 3a+3b, 4
Objective of the test : To verify compliance with the provisions mentioned under "maximum allowable variations" 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);
- voltage reductions caused by energizing the starter-motor circuits of internal combustion engines (pulse 4).

Test severity: Level IV of 7637-2 [17]:

Battery voltage	Test pulse	Conducted voltage
12 V	2a	+50 V
	2b	+10 V
	3a	-150 V
	3b	+100 V
	4	-7 V
24 V	2a	+50 V
	2b	+20 V
	3a	-200 V
	3b	+200 V
	4	-16 V

Maximum allowable variations: Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur.
It is acceptable when during the disturbance test the instrument is not providing a measurement result.

6.3.6.2 Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines for 12 V or 24 V road vehicle batteries

The test consists in exposing the EUT to conducted disturbances along lines other than supply lines.

Test equipment: See ISO 7637-3 [18]
Test set-up: See ISO 7637-3 [18]
Test procedure: See ISO 7637-3 [18]
Applicable standard: ISO 7637-3 [18]

Before any test, stabilize the EUT under constant environmental conditions.

The EUT shall be exposed to conducted disturbances of the strength and character as specified by the severity level.

The test shall be performed with one small test load only.

Test severity: according to ISO 7637-3 [18]

Test pulses : Test pulses: a and b
Objective of the test : To verify compliance with the provisions mentioned under

"maximum allowable variations" under conditions of transients which occur on other lines as a result of the switching processes (pulses a and b)

Test severity: Level IV of ISO 7637-3 [18]

Battery voltage	Test pulse	Conducted voltage
12 V	a	-60 V
	b	+40 V
24 V	a	-80 V
	b	+80 V

Maximum allowable variations: Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur.
It is acceptable when during the disturbance test the instrument is not providing a measurement result.

6.3.6.3 Battery voltage variations during starting up a vehicle engine

Table 2.18 - Battery voltage variations during starting up a vehicle engine

Applicable standard	ISO 16750-2 [16]					
Test method	Supply voltage variation due to energizing the starter motor of a vehicle					
Applicability	Measuring instruments powered by on board DC battery and may be in operation while the vehicle engine is started					
Object of the test	Verification of compliance with the provisions in R 51-1, 7.1.3 under conditions of starting the vehicle engine (during and after cranking)					
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.					
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.					
Test procedure in brief	The test comprises exposure to a typical supply voltage characteristic simulating the voltage variation while cranking the engine using a DC electrical starter motor.					
	U_{nom} [1)]	**12**		**24**		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
NOTES	[1)] U_{nom} = nominal battery voltage [2)] As specified in ISO 16750-2					
EUT performance	Sequentially during and after the exposure to the disturbance					

	record the following parameters: a) date and time, b) temperature, c) relative humidity, d) test load value, e) indicated values, f) error values, g) functional performance
Permitted maximum deviation	Either significant faults do not occur or checking facilities detect and act on potential significant faults, thus preventing such faults to occur. It is acceptable when during the disturbance test the instrument is not providing a measurement result.

6.3.6.4 **“Load dump” test**

Table 2.19 - “Load dump” test

Applicable standard	ISO 16750-2 [16]					
Test method	Supply voltage variation due to disconnecting a discharged battery					
Applicability	Measuring instruments powered by on board DC battery and may be in operation while the vehicle engine is running					
Object of the test	Verification of compliance with the provisions in R 51-1, 7.1.3 under conditions of disconnecting a discharged vehicle battery while the charging alternator is running.					
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.					
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test except for a reset when a significant fault has been indicated.					
Test procedure in brief	The test comprises exposure to a typical pulse on the supply voltage, simulating the voltage peak due to the impedance of connected loads when disconnecting the battery.					
	$\boldsymbol{U}_{\mathbf{nom}}$[1)]	**12**		**24**		V
	Test pulse shape[2)]	**I**	**II**	**I**	**II**	
	U_S	**80**	**100**	**150**	**200**	V
	R_i	**0,5**	**4**	**1**	**8**	V
	t_r	**10**	**10**	**10**	**10**	ms
	t_d	**40-400**	**40-400**	**100-350**	**100-350**	ms
NOTES	[1)] U_{nom} = nominal battery voltage [2)] As specified in ISO 16750-2					
EUT performance	Sequentially during and after the exposure to the disturbance record the following parameters: a) date and time, b) temperature, c) relative humidity,					

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

6.3.6.5 Ripple on DC mains power

Table 2.20 - Ripple on DC mains power		
Applicable standard	IEC 61000-4-17 [22]	
Test method	Introducing a ripple voltage on the DC input power port.	
Applicability	Applicable for measuring instruments which are temporarily or permanently connected to a DC mains power network (distribution system) supplied by external rectifier systems while in operation and generally only applicable in industrial environment. This test is only applicable to equipment powered by DC mains supply and is not applicable to equipment powered by a road vehicle battery.	
Object of the test	Verification of compliance with the provisions in R 51-1, 7.1.3 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 instruments connected to battery charger systems with incorporated switch mode converters.	
Precondition	The electrical power of the EUT is switched on for at least the warm-up time specified by the manufacturer.	
Condition of the EUT	The electrical power supplied to the EUT shall not be switched off and the EUT shall not be readjusted at any time during the test. The automatic zero-setting or zero-tracking, where available, shall be enabled as for normal operation.	
Test procedure in brief	A test generator as defined in the referred standard shall be used. Before starting the tests, the performance of the generator shall be verified. The test comprises subjecting the EUT to ripple voltages such as those generated by traditional rectifier systems and/or auxiliary service battery chargers overlaying on DC power supply sources. The frequency of the ripple voltage is the applicable power frequency or a multiple (2, 3 or 6) dependant on the rectifier system used for the mains. The waveform of the ripple, at the output of the test generator, has a sinusoid-linear character. The test level is a peak-to-peak voltage expressed as a percentage of the nominal DC voltage, UDC.	
Test level	Percentage of the nominal DC voltage	**2** %
EUT performance	After stabilization at the relevant a) date and time, b) temperature, c) relative humidity,	

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

7 Span stability test (R 51-1, 9.5.3)

This test is not applicable to classes XI and Y(I) instruments

Test method:	Span stability.
Object of the test:	To verify compliance with the provisions in R 51-1, 9.5.3 after the EUT has been subjected to the performance tests.
Reference to standard:	No reference to international standards can be given at the present time.
Test procedure in brief:	The test consists of observing the variations of the 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. For instruments with incorporated span adjustment device the device shall be activated during this test before each measurement in order to assess its stability and its intended use. 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 mains voltage supply, or battery supply where fitted, two times for at least 8 hours during the period of the test. The number of disconnections may be increased if so specified by the manufacturer or at the discretion of the metrological authority in the absence of any specification. In the conduct of this test, the operating instructions for the instrument 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 severity:	Test duration: 28 days or the time period necessary to conduct the performance test, whichever is less. Time (t) between tests: $0.5 \leq t \leq 10$ (days), with a fairly even distribution of the measurements over the total duration of the test. Test load: a static test load near maximum capacity (Max); the same test weights shall be used throughout the test.
Maximum allowable variations:	All functions shall operate correctly. The variation in the indication of the test load shall not exceed 1/2 the absolute value of the MPE specified in R 51-1, Table 6 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, i.e. the errors continue to increase or decrease in the same direction, conduct additional tests until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.
Preconditioning:	None required.
Test equipment:	Verified mass standards.
Condition of EUT:	EUT is connected to the voltage supply and «on» for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to a zero indication as practicable before each test. The automatic zero-tracking should be made inoperative during the test (if the EUT is so equipped).
Test sequence:	Stabilize all factors at reference conditions. Changes in barometric pressure shall be taken into account. 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) functions performance, i) changes in test location. 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 is more than 0.1 e. Allow full recovery of the EUT before any other tests are performed.

Annex A
Additional examinations and tests for software-controlled digital devices and instruments
(Mandatory)

A.1 Devices and instruments with embedded software

Review the descriptive documents according to R 51-1, 6.1.1 and check whether the manufacturer has described or declared that the software is embedded, i.e. that it is used in a fixed hardware and software environment and cannot be modified or uploaded via any interface or by other means after securing or sealing.

Check whether the securing means are described and provide evidence of an intervention.
Check whether there is a software identification that is clearly assigned to the legally relevant software and the legally relevant functions it performs as described in the documentation submitted by the manufacturer.
Check whether the software identification is easily provided by the instrument.

A.2 Computers and other devices with programmable or loadable software

A.2.1 Software documentation (R 51-1, 5.8)

Check that the manufacturer has supplied software documentation according to R 51-1, 5.8 containing all relevant information to examine the legally relevant software.

A.2.2 Software protection (R 51-1, 5.8.1)

A.2.2.1 Software with closed shell (no access to the operating system and/or programs possible for the user)

Check whether there is a complete set of commands (e.g. function keys or commands via external interfaces) supplied and accompanied by short descriptions.
Check whether the manufacturer has submitted a written declaration of the completeness of the set of commands.

A.2.2.2 Operating system and / or program(s) accessible for the user

Check whether a checksum or equivalent signature is generated over the machine code of the legally relevant software (program module(s) subject to legal control and type-specific parameters).
Check whether the legally relevant software cannot be started if the code is falsified using a text editor.

A.2.2.3 In addition to the cases in A.2.2.1 or A.2.2.2

Check whether all device-specific parameters are sufficiently protected, e.g. by a checksum.
Check whether there is an audit trail for the protection of the device-specific parameters and a description of the audit trail.
Perform some practical spot checks to test whether the documented protections and functions work as described.

A.2.3 Software interface(s)

Check whether the program modules of the legally relevant software are defined and separated from the modules of the associated software by a defined protective software interface.
Check whether the protective software interface itself is part of the legally relevant software.
Check whether the functions of the legally relevant software that can be released via the protective software interface are defined and described.
Check whether the parameters that may be exchanged via the protective software interface are defined and described.
Check whether the description of the functions and parameters are conclusive and complete.
Check whether each documented function and parameter does not contradict the requirements of this Recommendation.
Check whether there are appropriate instructions for the application programmer (e.g. in the software documentation) concerning the protectiveness of the software interface.

A.2.4 Software identification

Check whether there is an appropriate software identification generated over the program module(s) of the legally relevant software and the type-specific parameters at runtime of the instrument.
Check whether the software identification is indicated on manual command and can be compared with the reference identification fixed at type approval.
Check whether all relevant program module(s) and type-specific parameters of the legally relevant software are included in the software identification.
Check also by some practical spot checks whether the checksums (or other signatures) are generated and work as documented.
Check whether an effective audit trail exists.

A.3 Data storage devices (R 51-1, 5.7)

Review the documentation submitted and check whether the manufacturer has foreseen a device - whether incorporated in the instrument or connected externally - that is intended to be used for long-term storage of legally relevant data. If so:
Check whether the software used for data storage is realized on a device with embedded software (A.1) or with programmable/ loadable software (A.2). Apply either A.1 or A.2 to examine the software used for data storage.

Check whether the data are stored and retrieved correctly.
Check whether the storage capacity and the measures to prevent inadmissible data loss are described by the manufacturer and are sufficient.
Check whether the data stored contain all relevant information necessary to reconstruct an earlier weighing (relevant information is: gross or net values and tare values (if applicable, together with a distinction of tare and preset tare), the decimal signs, the units (e.g. kg may be encoded), the identification of the data set, the identification number of the instrument or load receptor if several instruments or load receptors are connected to the data storage device, and a checksum or other signature of the data set stored.

Check whether the data stored are adequately protected against accidental or intentional changes.
Check whether the data are protected at least with a parity check during transmission to the storage device.
Check whether the data are protected at least with a parity check in the case of a storage device with embedded software.
Check whether the data are protected by an adequate checksum or signature (at least 2 bytes, e.g. a CRC-16 checksum with hidden polynomial) in the case of a storage device with programmable or loadable software.
Check whether the data stored are capable of being identified and displayed, that the identification number(s) is stored for later use and recorded on the official transaction medium, i.e. it is printed, for instance, on the print-out.
Check whether the data used for a transaction are stored automatically, i.e. not depending on the decision of the operating person.
Check whether stored data sets which are to be verified by means of the identification are displayed or printed on a device subject to legal control.

A.4 Test report format

The test report format in OIML R 51-3 shall contain all relevant information about the hardware and software configuration of the PC examined and the test results.

Annex B - BIBLIOGRAPHY

Below are references to Publications of the International Electrotechnical Commission (IEC), the International Organisation for Standardization (ISO) and the OIML, where mention is made in R 51-2.

Ref.	Standards and reference documents	Description
[1]	IEC 60068-2-1 (1990-05) with amendments 1 (1993-02) and 2 (1994-06) Environmental testing, Part 2: Tests, Test A: Cold	Concerns cold tests on both non heat dissipating and heat dissipating equipment under test (EUT)

Ref.	Standards and reference documents	Description
[2]	IEC 60068-2-2 (2007-07) Ed. 5.0 Environmental testing Part 2: Tests, Test B: Dry heat	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
[3]	IEC 60068-3-1 (1974-01) + Supplement A (1978-01): Environmental testing Part 3 Background information, Section 1: Cold and dry heat tests	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
[4]	IEC 60068-2-78 (2001-08) Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state (IEC 60068-2-78 replaces the following withdrawn standards: IEC 60068-2-3, test Ca and IEC 60068-2-56, test Cb)	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
[5]	IEC 60068-3-4 (2001-08) Environmental testing - Part 3-4: Supporting documentation and guidance - Damp heat tests	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
[6]	IEC/TR 61000-2-1 (1990-05) Electromagnetic compatibility (EMC) Part 2: Environment Section 1	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
[7]	IEC 61000-4-1 (2006-10) Ed. 3.0 Basic EMC Publication Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques. Section 1: Overview of IEC 61000-4 series	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
[8]	IEC 61000-4-2 (2009) with amendment 1 (1998-01) and amendment 2 (2000-11) Consolidated Edition: IEC 61000-4-2 (2001-04) Ed. 1.2	Electromagnetic Compatibility (EMC) - Part 4: Testing and measurement techniques - Section 2: Electrostatic discharge immunity test. Basic EMC Publication
[9]	IEC 61000-4-3 (2008-04) Ed. 3.1	Electromagnetic Compatibility (EMC) - Part 4: Testing and measurement techniques - Section 3: Radiated, radio-frequency, electromagnetic field immunity test

Ref.	Standards and reference documents	Description
[10]	IEC 61000-4-4 (2004-07) Ed 2.0 Electromagnetic compatibility (EMC) Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	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
[11]	IEC 61000-4-5 (2005-11) Ed. 2.0Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	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
[12]	IEC 61000-4-6 (2008-10) Ed. 3.0Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques. Section 6: Immunity to conducted disturbances, induced by radio-frequency fields	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.
[13]	IEC 61000-4-11 (2004-03) Ed 2.0 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
[14]	IEC 61000-4-20 Ed 2.0 (2010-08) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 20: Emission and immunity testing in transverse electromagnetic (TEM) waveguides Stability date: 2014	Provides radiated immunity test methods for electrical and electronic equipment using various types of transverse electromagnetic (TEM) waveguides. These types include open structures (for example, striplines and electromagnetic pulse simulators) and closed structures (for example, TEM cells).

Ref.	Standards and reference documents	Description
[15]	IEC 60068-2-30 (1980-01) with amendment 1 (1985-08) Environmental testing Part 2: Tests Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)	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.
[16]	ISO 16750-2 (2003)	Road vehicles - Environmental conditions and testing for electrical and electronic equipment – Part 2: Electrical loads
[17]	ISO 7637-2 (2004) 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).
[18]	ISO 7637-3 (1995) with correction 1 (1995) 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
[19]	IEC 61000-6-1 Ed. 2.0 (2005-3) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 6: Generic standards – Section 1: Immunity for residential, commercial and light-industrial environments Stability date: 2013	Defines the immunity test requirements in relation to continuous and transient, conducted and radiated disturbances, including electrostatic discharges, for electrical and electronic apparatus intended for use in residential, commercial and light-industrial environment, and for which no dedicated product or product-family standard exists. Immunity requirements in the frequency range 0 kHz to 400 GHz are covered and are specified for each port considered. This standard applies to apparatus intended to be directly connected to a low-voltage public mains network or connected to a dedicated DC source which is intended to interface between the apparatus and the low-voltage public mains network.
[20]	IEC 61000-6-2 Ed. 2.0 (2005-01) Basic EMC Publication – Electromagnetic compatibility (EMC) – Part 6: Generic standards – Section 2: Immunity for industrial environments Stability date :2013	Defines the immunity performance requirements for electrical and electronic apparatus intended for use in industrial environments, both indoor and outdoor and for which no dedicated product or product-family immunity standard exists. Immunity requirements in the frequency range 0 Hz to 400 GHz are covered, in relation to continuous and transient, conducted and radiated disturbances, including electrostatic discharges, and are specified for each port considered. This standard applies to apparatus intended to be connected to a power network supplied from a high or medium voltage transformer dedicated to the supply of an installation feeding manufacturing or similar plant, and intended to operate in or in proximity to industrial locations, as described below. This standard also applies to apparatus which are battery operated and intended to be used in industrial locations. Industrial locations are in addition characterised by the existence of one or more of the following: - industrial, scientific and medical (ISM) apparatus (as defined in CISPR 11); - heavy inductive or capacitive loads are frequently switched; - currents and associated magnetic fields are high.

Ref.	Standards and reference documents	Description
[21]	OIML D 31: 2008 E General requirements for software controlled measuring instruments	Provides guidance for establishing appropriate requirements for software related functionalities in measuring instruments covered by OIML Recommendations.
[22]	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.