INTERNATIONAL RECOMMENDATION

OIML R 144-2

Edition 2013 (E)

Instruments for continuous measurement of CO, NO_x in stationary source emissions.

Part 2: Test procedures

Instruments pour le mesurage continu de CO et NO_x dans les émissions de sources fixes.

Partie 2: Procédures d'essais

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY

Contents

Foreword

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This publication – reference OIML R 144-2:2013 (E) – was developed by OIML Technical Subcommittee TC 16/SC 1/p 1 *Air pollution*. It was approved for final publication by the International Committee of Legal Metrology at its 48th meeting in Ho Chi Minh City, Viet Nam, in October 2013 and will be submitted to the International Conference on Legal Metrology in 2016 for formal sanction. OIML R 144 is published in three parts: Part 1: Metrological and technical requirements, Part 2: Metrological and performance tests and Part 3 Test report format.

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Instruments for continuous measurement of CO, NOx in stationary source emissions

Part 2 – Test procedures

1 Performance tests for type evaluation

1.1 General

Prior to the type evaluation tests, the referenced documents shall be studied.

1.2 Error determination

For a linear calibration characteristic, the error of a gas analytical system shall be determined for at least three points within the measuring range and sub-range. It is recommended to use calibration gas mixtures (CGM) with the following values of volume fractions for the components to be determined:

- minimum value of the measuring range + 10 %;
- average value ± 10 %;
- maximum value of the measuring range – 10 %.

For a nonlinear calibration characteristic, the error shall be determined for at least five points uniformly distributed within the measuring range and sub-range.

Measurements at each point of the measurement range shall be repeated at least three times, and no errors shall be greater than the specified limits.

1.3 Stability with time or drift

This test shall be conducted for a period of seven days following the warm-up time. The measurements shall be performed at least every 24 hours under reference conditions using a CGM with the largest and the smallest volume fractions for the components to be determined according to 1.2. During the tests the requirements of R 144-1, 4.8 shall be met.

1.4 Repeatability (R 144-1, 4.4)

The test procedure specified in R 144-1, 8.3 shall be carried out with each of the CGMs recommended in 1.2.

An estimate of the standard deviation is given by the formula:

$$s = \sqrt{\frac{\sum_{i=1}^{n} \left(Y_i - \overline{Y} \right)^2}{n-1}}$$

where:

n is the number of measurements, $n = 20$;

Y_i is the i^{th} indication of the gas analytical system;

$\overline{Y}$ is the arithmetic mean of the n values.

During the tests, the requirements of R 144-1, 4.4 shall be met.

1.5 Dry heat

1.5.1 Conditions

The gas analytical system (or its separate units) is exposed to a temperature of 40 °C (or at the maximum operating temperature specified by the manufacturer) for 2 hours. The time duration begins after the gas analytical system (or its separate units) has reached temperature stability. The change in temperature shall not exceed 1 °C/min during heating up and cooling down, and the relative humidity shall not exceed 50 %.

1.5.2 Tests

The calibration gas mixture shall be supplied to the sampling probe at ambient pressure (with a deviation of ± 0.8 kPa). During the test, one set of measurements shall be performed every half-hour using each of CGMs recommended in 1.2.

1.5.3 References

IEC 60068-2-2 [4], IEC 60068-3-1 [18] and OIML D 11:2013 [2] 10.1.

1.6 Cold

1.6.1 Conditions

The gas analytical system (or its separate units) is exposed to a temperature of 5 °C (or at the minimum operating temperature specified by the manufacturer) for 2 hours. The time duration begins after the gas analytical system (or its separate units) has reached temperature stability. The change in temperature shall not exceed 1 °C/min during cooling down and heating up. The relative humidity shall not exceed 50 %.

1.6.2 Tests

The CGM shall be supplied to the sampling probe at ambient pressure (with a deviation of ±0.8 kPa). During the test one measurement shall be performed every half-hour using each of the CGMs recommended in 1.2.

1.6.3 References

IEC 60068-2-1 [3], IEC 60068-3-1 [18] and OIML D 11:2013 [2] 10.1.

1.7 Damp heat, steady state

1.7.1 Conditions

The gas analytical system (or its separate units) is exposed to a temperature of 30 °C and a constant relative humidity of 85 % for 2 days. The exposure shall be such that water does not condense on the gas analytical system. The temperature is deemed to be steady when the difference between the extreme temperatures does not exceed 5 °C, and the rate of change does not exceed 5 °C/h.

1.7.2 Tests

The CGM shall be supplied to the sampling probe at ambient pressure (with a deviation of ± 0.8 kPa). During the test one measurement shall be performed every day using each of the CGMs recommended in 1.2.

1.7.3 References

IEC 60068-2-78 [8], IEC 60068-3-4 [19] and OIML D 11:2013 [2] 10.2.

1.8 Ambient pressure

1.8.1 Conditions

The gas analytical system is exposed to extreme pressures specified in the rated operating conditions or extreme pressures specified by the manufacturer if they are outside the limits in R 144-1, 4.5.1. The extreme values shall be reached gradually from stable ambient pressure conditions and shall be kept at the stable maximum permissible level during 30 min before starting the measurements as specified in 1.8.2.

1.8.2 Tests

The calibration gas mixture shall be supplied to the sampling probe at ambient pressure (with a deviation of ± 0.8 kPa). At least two measurements shall be performed at each extreme pressure value using each of the CGMs recommended in 1.2.

Note: If automatic or semi-automatic pressure compensation is provided for in the gas analytical system, then care must be taken to ensure that measurements at both extreme pressure values are performed after completing this process.

1.9 Power supply variation (R 144-1, 8.4.1 e)

1.9.1 Conditions

The gas analytical system is exposed to extreme values of the nominal power supply voltage and nominal frequency according to R 144-1, 4.5.1 for a period long enough to perform the required measurement.

1.9.2 Tests

At each extreme value of the power supply parameters, at least two measurements shall be carried out using the CGM with the largest volume fraction for the components to be determined according to 1.2.

1.10 Influence of gas components other than CO, NO and NO_2 (cross sensitivity) (R 144-1, 8.4.2)

The influence shall be determined by registering the measuring signal when the following gas mixtures are supplied to the input:

- zero gas N_2; then
- each influencing gas alone in N_2; and finally
- each influencing gas together with CO, NO and NO_2 in N_2.

The list of influencing components and their limit content are established by the manufacturer.

The concentration (volume fraction) of a component to be determined shall correspond to 10 % of the upper level of the measurement range or subrange.

Note: The responsible legal authority may decide to include some other components in the test.

1.11 Mechanical vibrations and shock (R 144-1, 8.4.3)

1.11.1 Vibration

1.11.1.1 Test method

Random vibration.

1.11.1.2 Test procedure

For vibration testing, the gas analytical system or its separate units shall be mounted on a vibrating table and shall be fixed rigidly in the operating position. During the test, the gas analytical system shall be in the operating mode, the CGM with the largest volume fraction for the components to be determined according to 1.2 being supplied to the input. The vibration parameters shall correspond to those specified by the manufacturer. The testing conditions shall correspond to the reference conditions in clause 8 of R 144-1. Minimum requirements for vibration shall correspond to R 144-1, 4.5.3 (test level 1 of OIML D 11:2013 [2] 11.1).

1.11.2 Mechanical shock

1.11.2.1 Test method

Dropping onto a face.

1.11.2.2 Test procedure

For mechanical shock testing, the gas analytical system or its separate unit shall be placed in its normal position of use on a rigid surface. The gas analytical system or unit shall then be tilted on one bottom edge and allowed to fall freely onto the test surface. The following conditions shall be applied:

Height of fall: 25 mm;

Number of falls: 1 on each bottom edge.

1.11.2.3 Error determination

Before and after the test, the error of the gas analytical system shall be determined using the CGM with the largest volume fraction for the components to be determined according to 1.2.

1.11.3 References

IEC 60068-2-47 [6], IEC 60068-2-64 [7], IEC 60068-3-8 [9], IEC 60068-2-31[5] and OIML D 11:2013 [2] 11.2.

1.12 AC mains voltage dips, short interruptions and voltage variations (R 144-1, 8 n)

1.12.1 Test method

Short-time reductions in main voltages.

1.12.2 Test procedure

A test generator suitable to reduce the amplitude of the AC mains voltage is used. It shall be adjusted before being connected to the gas analytical system. The mains voltage interruptions and reductions shall be repeated ten times with an interval of at least 10 s between successive disturbances. The following conditions shall be applied:

Reduction factor	Duration
100 %	10 ms
40 %	30 ms

During the test, measurements shall be performed using the CGM with the largest volume fraction for the components to be determined according to 1.2.

1.12.3 References

IEC 61000-4-11 [15] and OIML D 11:2013 [2] 12.3.

1.13 Bursts (transients) on AC and DC mains (R 144-1, 8 o)

1.13.1 Test method

Electrical bursts.

1.13.2 Test procedure

A burst generator shall be used with the performance characteristics as specified in the IEC 61000-4-4 [12]. The characteristics of the generator shall be verified before connecting the EUT.

The test consists in affecting the gas analytical system with pulses of amplitude 1.0 kV, which has the form of a double exponent. Each pulse shall have a rise time of 5 ns and half amplitude duration of 50 ns. The pulse duration shall be 15 ms and the period of their repetition shall be 300 ms. The repetition frequency of the impulses and peak values of the output voltage on a 50 Ω load shall be (5 ± 1) kHz. The transient generator shall have an output impedance of 50 Ω and shall be adjusted before connecting the gas analytical system. At least ten positive and ten negative pulses randomly phased shall be applied. Insertion of blocking

filters in the cables to the gas analytical system may be necessary to prevent the pulse energy being dissipated in the mains.

During the test, measurements shall be performed using the CGM with the largest volume fraction for the components to be determined according to 1.2.

1.13.3 References

IEC 61000-4-4 [12], and OIML D 11:2013 [2] 12.3.

1.14 Bursts (transients) on signal, data and control lines (R 144-1, 8 l)

1.14.1 Test method

Electrical bursts.

1.14.2 Test procedure

A burst generator shall be used with the performance characteristics as specified in the IEC 61000-4-4 [12]. The characteristics of the generator shall be verified before connecting the EUT.

Before the test, the instruments shall be switched on for a time period equal to or greater than the warm-up time specified by the manufacturer.

The EUT shall not be readjusted at any time during the test except to reset it if a significant fault has been indicated.

The test consists in exposing the EUT to bursts of voltage spikes of 1 kV, with a repetition rate of 5 kHz.

At least ten positive and ten negative bursts randomly phased shall be applied.

The duration of the test shall not be less than 1 min for each amplitude and polarity.

1.14.3 References

IEC 61000-4-4 [12] and OIML D 11:2013 [2] 12.4.

1.15 Surges on signal, data and control lines (R 144-1, 8 m)

1.15.1 Test method

Electrical surges.

1.15.2 Test procedure

A surge generator shall be used with the performance characteristics as specified in the referenced standard. The test consists of exposure to surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and minimum time interval between two successive pulses are defined in the referenced standard.

The characteristics of the generator shall be verified before connecting the EUT.

At least three positive and three negative surges shall be applied.

Unbalanced lines	Line to line	1.0 kV
	Line to earth	2.0 kV
Balanced lines	Line to earth	2.0 kV

1.15.3 References

IEC 61000-4-5 [13] and OIML D 11:2013 [2] 12.4.

1.16 Electrostatic discharges (R 144-1, 8 j)

1.16.1 Test method

Electrostatic discharge.

1.16.2 Test procedure

A capacitor of 150 pF shall be charged by a suitable DC voltage source of 6 kV in contact mode and 8 kV in air mode. Then it shall be discharged through the gas analytical system (or its separate units) by connecting one terminal to the system's ground chassis and the other through a 330 Ω resistance to the system's surfaces that are normally accessible to the user. At least ten successive discharges shall be applied with a time interval between discharges of at least 10 s. A gas analytical system (or its separate units) not equipped with a grounding terminal (for which earthing is not provided) shall be placed on a grounded plane surface that projects beyond the gas analytical system (or its separate units) by at least 0.1 m on all sides. The associated grounded connection to the capacitor shall be as short as possible.

1.16.2.1 Direct application

In the contact discharge mode, to be carried out on the conductive surfaces, the electrode shall be in contact with the gas analytical system (or its separate units) and the discharge shall be actuated by the discharge switch of the generator.

In the air discharge mode, on insulating surfaces, the electrode is approached to the gas analytical system (or its separate units) and the discharge occurs by spark.

1.16.2.2 Indirect application

The discharges are applied in the contact mode to coupling planes mounted in the vicinity of the gas analytical system (or its separate units).

During the test, measurements shall be performed using the CGM with the largest volume fraction for the components to be determined according to 1.2.

1.16.3 References

IEC 61000-4-2 [10] and OIML D 11:2013 [2] 13.3.

1.17 Radiated, radio frequency, electromagnetic fields (R 144-1, 8 g)

1.17.1 Test method

Radiated electromagnetic fields.

1.17.2 Test procedure

The gas analytical system (or its separate units) shall be exposed to electromagnetic field strength as follows:

- frequency range: 26 MHz – 3 GHz;
- field strength: 10 V/m;
- modulation: 80 % AM, 1 kHz sine wave.

The field strength may be generated in different facilities.

The field strength shall be established prior to the actual testing (without the gas analytical system or its separate units in the field).

When the test is carried out in a shielded enclosure to comply with international laws prohibiting interference to radio communications, care shall be taken to handle reflections from walls. Anechoic shielding may be necessary.

During the test, measurements shall be performed using the CGM with the largest volume fraction for the components to be determined according to 1.2.

1.17.3 References

IEC 61000-4-3 [11], IEC 61000-4-6 [14], and OIML D 11 [2] 13.2.

1.18 Low voltage of internal battery (not connected to the mains power) (R 144-1, 8 r)

1.18.1 Test method

Variation in supply voltage.

1.18.2 Test procedure

The test consists of exposure to the specified condition of the battery(s) for a period sufficient for achieving temperature stability and for performing the required measurements.

1.18.3 Test sequence

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

a) Date and time;

b) Temperature;

c) Power supply voltage;

d) Functional mode;

e) Measurements and/or loading condition;

f) Indications (as applicable);

g) Errors;

h) Functional performance.

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

i) Power supply voltage;

j) Indications;

k) Errors;

l) Other relevant responses of the instrument.

1.19 Warm-up time

1.19.1 Test procedure

At reference conditions and at 5 °C, the warm-up time test to verify compliance with R 144-1, 4.7 shall consist of the following steps:

a) stabilize the gas analytical system at each temperature;

b) let the gas analytical system warm up;

c) immediately after either the manufacturer's prescribed warm-up period has elapsed or an automatic warm-up lockout has been de-activated, perform a measurement of volume fraction for the components to be determined (with any necessary internal adjustment being performed prior to this measurement). Each of the CGMs recommended in 1.2 shall be used;

d) at time intervals of 2 min, 5 min and 15 min after warm-up, perform a measurement with each of the CGMs recommended in 1.2 as in step c).

Check that the difference between any of the four measured values in c) and d) above does not exceed the absolute value of the maximum permissible error on initial verification.

Note: At reference conditions, the warm-up time test may be included with the drift test.

1.20 Response time

1.20.1 When testing, the time required for a gas analytical system to be able to perform measurements with a given accuracy (R 144-1, 4.3.1) is determined when at the input of a sampling device ambient air is replaced with a sample containing the components to be determined. Some means shall be applied to perform such replacement. The gases shall be supplied to the sampling device at the ambient pressure (± 750 Pa). Check that the response time does not exceed the appropriate values specified in R 144-1, 4.6.

1.20.2 During the test, measurements shall be performed using the CGM with the volume fraction of components to be determined equal to 90 % of the maximum value of the measuring range and sub-range (see R 144-1, 4.6).

1.21 Spillover of gas flow rates

1.21.1 A measurement shall be performed with a calibration gas mixture that is initially supplied at the sampling device at a gas flow rate greater than the minimum required by the gas analytical system according to the manufacturer. During the measurement, the gas flow rate shall be reduced until the low flow indicator

responds according to the requirements of R 144-1, 5.1.5 and gives a signal according to the requirement of R 144-1, 5.5.2.

1.21.2 The test is repeated according to 1.18.1, but starting from a gas flow rate smaller than the maximum required by the gas analytical system according to the manufacturer. During the measurement, the gas flow rate shall be increased until the flow rate indicator responds according to the requirements of R 144-1, 5.1.5 and gives a signal according to the requirement of R 144-1, 5.5.2.

1.21.3 During the test, measurements shall be performed using each of the CGMs recommended in 1.2.

1.22 Leakproofness

The compliance of the leak-proofing requirements detailed R 144-1, 5.1.6, for the gas analytical system or its separate units, is determined using the pressure-gauge (compression or vacuum) method according to IEC 60068-2-17 [20] as described in the operating manual.

2 Procedure for initial verification

The initial verification of a gas analytical system should include the following tests:

2.1 Check the power supply voltage and frequency at the location of use to determine compliance with the manufacturer's specifications.

2.2 Check the activation of the warm-up lockout by attempting to make a measurement prior to the operating mode.

2.3 After the gas analytical system has warmed up, determine its error as described in R 144-1, 7.2.2.2.

2.4 Check the air-tightness of the gas analytical system by performing a leak check as described in 1.19.

2.5 Check for the activation of the gas flow rate device (unit) as described in 1.18.2.

2.6 Check the response time as described in 1.17.

Annex A

Procedure for subsequent verification

(Informative)

Subsequent verification of a gas analytical system at the same location may include the tests below.

A.1 For short-term subsequent verification, perform all tests included in the initial verification except for the power check and the warm-up check.

A.2 For short-term subsequent verification, determine the error using the number of CGMs required for initial verification, unless the responsible legal authority specifies fewer CGMs.

A.3 For long-term subsequent verification, perform all tests included in the initial verification.

A.4 When a gas analytical system has been moved to a new location, or has undergone repairs other than the replacement of its separate units (e.g. a sampling device or a filter) as defined in the manufacturer's operating manual, perform all tests included in the initial verification.

Annex B

Procedure for gas analytical system control under operating conditions

(Informative)

B.1 Perform an internal adjustment check of the gas analytical system that may include checking the gas flow rate, the temperature of the heated gas-mains at intervals specified by the responsible legal authority or recommended in the manufacturer's operating manual.

B.2 Determine the error of the gas analytical system and internal adjustment with one CGM at intervals specified by the responsible legal authority or recommended in the manufacturer's operating manual.

B.3 Perform a leak check of the gas handling system at least once a day. Repair any leakage/leak and perform a successful leak check before measurement.

B.4 Perform a leak check after each disassembly of the gas handling system (e.g. a sampling device or filter element replacement). Repair any leakage/leak and perform a successful leak check before measurement.