BRITISH STANDARD

BS EN 15859:2010

Air Quality — Certification of automated dust arrestment plant monitors for use on stationary sources — Performance criteria and test procedures

ICS 13.040.01

British Standards

National foreword

This British Standard is the UK implementation of EN 15859:2010.

The UK participation in its preparation was entrusted to Technical Committee EH/2/1, Stationary source emission.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2010.

ISBN 978 0 580 63639 4

Amendments/corrigenda issued since publication

Date	Comments

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 15859

April 2010

ICS 13.040.01

English Version

Air Quality - Certification of automated dust arrestment plant monitors for use on stationary sources - Performance criteria and test procedures

Qualité de l'air - Certification des analyseurs automatiques pour la surveillance des systèmes de réduction des poussières à l'émission des sources fixes - Spécifications de performance et modes opératoires d'essai

Luftbeschaffenheit - Zertifizierung von automatischen Geräten zur Überwachung von Staubabscheidern an stationären Quellen - Mindestanforderungen und Prüfprozeduren

This European Standard was approved by CEN on 11 March 2010.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 15859:2010: E

Contents

Page

Foreword

This document (EN 15859:2010) has been prepared by Technical Committee CEN/TC 264 “Air quality”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2010, and conflicting national standards shall be withdrawn at the latest by October 2010

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

0 Introduction

0.1 General

CEN has established standards for the certification of automated measuring systems (AMS) used for monitoring emissions from stationary sources. This certification is based on the following four sequential stages:

a) performance testing of an AMS;

b) initial assessment of the AMS manufacturer's quality management system;

c) certification;

d) post certification surveillance.

This European Standard defines the performance criteria and procedures for performance testing of automated dust arrestment plant monitors used on stationary sources.

The following two types of dust arrestment plant monitor are covered by this standard:

— a *filter dust monitor* which can be calibrated in mass concentration units (e.g. mg/m^3) and used for dust arrestment control purposes;

— a *filter leakage monitor* which indicates a change in the emissions level or a change in the magnitude of the dust pulses created by the cleaning process.

For the purposes of this standard, the term *instrument* is used to encompass both types of dust arrestment plant monitor. The terms *filter dust monitor* and *filter leakage monitor* are only used where it is necessary to distinguish between the two types.

0.2 Processes

Field-testing of an instrument is ordinarily carried out on the most highly demanding industrial process in the range of applications for which a manufacturer seeks certification. The premise is that if the instrument performs acceptably on this process, then experience has shown that the instrument generally performs well on the majority of other processes. However, there are always exceptions and it is the responsibility of the manufacturer in conjunction with the user to ensure that the instrument performs adequately on a specific process.

0.3 Performance characteristics

A combination of laboratory and field testing is detailed within this European Standard. Laboratory testing is designed to assess whether an instrument can meet, under controlled conditions, the technical requirements of the relevant performance criteria. Field testing, over a minimum three month period, is designed to assess whether an instrument can continue to work and meet the relevant performance criteria in a real application. Field testing is carried out on an industrial process representative of the intended application for the instrument for which the manufacturer seeks certification.

The main instrument performance characteristics are:

— response or detection time;

— influence of ambient conditions;

- influence of variations of the waste gas velocity;
- susceptibility to physical disturbances;
- cross-sensitivity to likely interferents contained in the waste gas;
- performance and accuracy of the filter dust monitor against a standard reference method (SRM), under field conditions;
- performance and accuracy of the filter leakage monitor against a certified particulate AMS tested according to EN 15267-3, under field conditions;
- drift of automatic internal zero and reference points;
- availability and maintenance interval under field conditions;
- reproducibility from two instruments under identical field conditions.

Measurements made by instruments certified to the requirements of this standard do not necessarily fulfil the uncertainty requirements of the EU Directives for Large Combustion Plant and Waste Incineration or the QAL3 functionality of EN 14181:2004.

1 Scope

This European Standard provides the performance criteria and test procedures for filter dust monitors and filter leakage monitors used to ensure that dust arrestment plants used on stationary sources are working satisfactorily.

A filter dust monitor is a dust arrestment plant monitor which can be calibrated in mass concentration units (e.g. mg/m^3) and used for dust arrestment control purposes.

A filter leakage monitor is a dust arrestment plant monitor which indicates a possible problem with the dust arrestment plant by monitoring a change in the emissions level or a change in the magnitude of the dust pulses created by the cleaning process.

This standard is intended for use with the certification procedure for automated measuring systems described in EN 15267-1 and EN 15267-2.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13284-2, *Stationary source emissions — Determination of low range mass concentration of dust – Part 2: Automated measuring systems*

EN 14181:2004, *Stationary source emissions — Quality assurance of automated measuring systems*

EN 15259, *Air quality – Measurement of stationary source emissions — Requirements for measurement sections and sites and for the measurement objective, plan and report*

EN 15267-3, *Air quality – Certification of automated measuring systems — Part 3: Performance criteria and test procedures for automated measuring systems for monitoring emissions from stationary sources*

EN 50160, *Voltage characteristics of electricity supplied by public distribution networks*

EN 60529, *Degrees of protection provided by enclosures (IP code) (IEC 60529:1989)*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005)*

IEC 60068-1, *Environmental testing — Part 1: General and guidance*

IEC 60068-2 (all tests), *Environmental testing — Part 2: Tests*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
dust
particles, of any shape, structure or density, dispersed in the gas phase at the sampling point conditions which may be collected by filtration under specified conditions after representative sampling of the gas to be analysed

NOTE Adapted from EN 13284-1:2001, 3.1.

3.2
dust arrestment plant monitor
filter dust monitor or filter leakage monitor and additional devices for obtaining a result

NOTE Apart from the actual measuring device (the analyser), an instrument may include further components, like purge air blowers or external displays.

3.3
instrument
dust arrestment plant monitor

3.4
filter dust monitor
instrument, which can be calibrated in mass concentration units and used for dust arrestment control purposes, but does not fulfil the uncertainty demands according to EN 14181, or does not have reference materials for linearity test and QAL3 procedure according to EN 14181:2004

NOTE A mass concentration unit is e.g. mg/m^3.

3.5
filter leakage monitor
instrument, which indicates a possible problem with the dust arrestment plant

NOTE These instruments may either monitor a change in the emissions level or a change in the magnitude of the dust pulses created by the cleaning process.

3.6
reference method
RM
measurement method taken as a reference by convention, which gives the accepted reference value of the measurand

NOTE 1 A reference method is fully described.

NOTE 2 A reference method can be a manual or an automated method.

NOTE 3 Alternative methods can be used if equivalence to the reference method has been demonstrated.

[EN 15259:2007, 2.8]

3.7
standard reference method
SRM
reference method prescribed by European or National standard

NOTE Standard reference methods are used e.g. to calibrate and validate instrument and for periodic measurements to check compliance with limit values.

[EN 15259:2007, 2.9]

3.8
measurement
set of operations having the object of determining a value of a quantity

[VIM:1993, 2,1]

3.9
paired measurement
simultaneous recording of results of measurement at the same measurement point

NOTE Adapted from EN 15267-3:2007, 3.5.

3.10
measurand
particular quantity subject to measurement

[VIM:1993, 2.6]

NOTE The measurand is a quantifiable property of the waste gas under test, for example mass concentration of a measured component, temperature, velocity, mass flow, oxygen content and water vapour content.

3.11
measured component
constituent of the waste gas for which a defined measurand is to be determined by measurement

[EN 15259:2007, 2.6]

NOTE Measured component is also called determinand.

3.12
interferent
substance or phenomenon present in the waste gas under investigation, other than the measured component, that affects the response

NOTE Adapted from EN 15267-3:2007, 3.8.

3.13
calibration
determination of a calibration function with (time) limited validity applicable to an instrument at a specific measurement site

NOTE Adapted from EN 15267-3:2007, 3.9.

3.14
calibration function
relationship between the values of the SRM and the instrument with the assumption of a constant residual standard deviation

NOTE 1 Adapted from EN 15267-3:2007, 3.10.

NOTE 2 The calibration function describes the statistical relationship between the starting variable (measured signal) of the measuring system and the associated result of measurement (measured value) simultaneously determined at the same point of measurement using a SRM.

3.15
automatic internal zero point
output of the instrument in response to an internally generated function, intended to represent absence of the measured component

3.16
automatic internal reference point
output of the instrument in response to an internally generated function, intended to represent a defined amount of the measured component

3.17
measured signal
output from an instrument in analogue or digital form which is converted into the measured value with the aid of the calibration function

NOTE Adapted from EN 15267-3:2007, 3.15.

3.18
output
reading, or digital or analogue electrical signal generated by an instrument in response to a measured object

NOTE Adapted from EN 15267-3:2007, 3.16.

3.19
independent reading
reading that is not influenced by a previous individual reading by separating two individual readings by at least four response times

[EN 15267-3:2007, 3.17]

3.20
individual reading
reading averaged over a time period equal to the response time of the instrument

NOTE Adapted from EN 15267-3:2007, 3.18.

3.21
performance characteristic
quantity assigned to an instrument in order to define its performance

NOTE 1 Adapted from EN 15267-3:2007, 3.19.

NOTE 2 A performance characteristic is described by values, tolerances and ranges.

3.22
accuracy
closeness of agreement between a single measured value of the measurand, and the true value (or an accepted reference value)

[EN 15267-3:2007, 3.20]

3.23
availability
fraction of the total monitoring time for which data of acceptable quality have been collected

[EN 15267-3:2007, 3.21]

3.24
averaging time
period of time over which an arithmetic or time-weighted average of concentrations is calculated

[EN 15267-3:2007, 3.22]

3.25
interference
negative or positive effect that a substance or phenomenon has upon the output of the instrument, when that substance or phenomenon is not the measured component

NOTE Derived from EN 15267-3:2007, 3.24.

3.26
cross-sensitivity
response of the instrument to substances and phenomena other than those that it is designed to measure

NOTE See interference.

3.27
drift
monotonic change of the calibration function over a stated period of unattended operation, which results in a change of the measured value

[EN 15267-3:2007, 3.26]

3.28
internal zero drift
change in the automatic internal zero point over a stated period of unattended operation

3.29
internal reference drift
change in the automatic internal reference point over a stated period of unattended operation

3.30
maintenance interval
maximum admissible interval of time for which the performance characteristics remain within a pre-defined range without external servicing, e.g. refill, calibration, adjustment

NOTE This is also known as the period of unattended operation.

[EN 15267-3:2007, 3.29]

3.31
response time
t_{90}
time interval between the instant of a sudden change in the value of the input quantity to an instrument and the time as from which the value of the output quantity is reliably maintained above 90 % of the correct value of the input quantity

NOTE 1 Adapted from EN 15267-3:2007, 3.31.

NOTE The response time is also referred to as the 90 % time or t_{90} time.

3.32
detection time
time interval between the onset of an event, and the instrument providing the defined change in output

3.33
reproducibility
R_f
measure of the agreement between two identical measuring systems applied in parallel in field tests at a level of confidence of 95 % using the standard deviation of the difference of the paired measurements

[EN 15267-3:2007, 3.33]

NOTE Reproducibility is determined by means of two identical instruments operated side by side. It is an instrument performance characteristic for describing the production tolerance specific to that instrument. The reproducibility is calculated from the half-hour averaged output signals (raw values as analogue or digital outputs) during the three-month field test.

3.34
uncertainty
parameter associated with the result of a measurement, which characterises the dispersion of the values that could reasonably be attributed to the measurand

[ENV 13005:1999, B.2.18]

3.35
test laboratory
laboratory accredited to EN ISO/IEC 17025 for carrying out the tests defined in this standard

NOTE 1 Adapted from EN 15267-3:2007, 3.37.

NOTE CEN/TS 15675 provides an elaboration of EN ISO/IEC 17025 for application to emission measurements which should be followed when using standard reference methods.

3.36
field test
test for at least three months on a plant appropriate to the field of application of the instrument

NOTE Adapted from EN 15267-3:2007, 3.38.

3.37
certification range
range over which the filter dust monitor is tested and certified for compliance with the relevant performance criteria

NOTE Adapted from EN 15267-3:2007, 3.39.

3.38
emissions limit value
ELV
limit values given in regulations such as EU Directives, ordinances, administrative regulations, permits, licences, authorisations or consents

NOTE ELV can be stated as concentration limits expressed as half-hourly, hourly and daily averaged values, or mass flow limits expressed as hourly, daily, weekly, monthly or annually aggregated values.

[EN 15267-3:2007, 3.40]

3.39
plant
installation
industrial facility on which an instrument is installed

NOTE Adapted from EN 15267-3:2007, 3.41.

4 Symbols and abbreviations

4.1 Symbols

b_f sensitivity coefficient of sample gas flow

b_t sensitivity coefficient of ambient temperature

b_v sensitivity coefficient of supply voltage

n number of measurements, number of parallel measurements

r_1 nominal flow rate

r_2 lowest specified flow rate

R_f reproducibility under field conditions

R^2	determination coefficient of calibration function
s_D	standard deviation from paired measurements
s_r	repeatability standard deviation of the measurement
σ_0	uncertainty requirement
$t_{n-1; 0,95}$	two-sided Student t-factor at a confidence level of 95 % with a number of degrees of freedom $n - 1$
t_d	is the relative difference between the response times determined in rise and fall mode
t_r	response time determined in rise mode
t_f	response time determined in fall mode
t_o	outage time
t_{tot}	total operating time
T	temperature (absolute)
T_i	ith temperature
U_1	minimum voltage specified by the manufacturer
U_2	maximum voltage specified by the manufacturer
V	availability
x	measured signal
x_i	ith measured signal; average of the measured signals for substance i
$x_{1,i}$	ith measured signal of the first measuring system
$x_{2,i}$	ith measured signal of the second measuring system
$\bar{x}$	average of measured signals x_i

4.2 Abbreviations

AMS	automated measuring system
AST	annual surveillance test
CR	certification range
ELV	emission limit value
QAL	quality assurance level
QAL1	first quality assurance level
QAL2	second quality assurance level
QAL3	third quality assurance level

SRM standard reference method

5 General requirements

5.1 Application of performance criteria

The test laboratory shall test at least two identical instruments. All instruments tested shall meet the performance criteria specified in this document.

5.2 Ranges to be tested

5.2.1 General

The instrument shall be tested over a specified certification range and, if applicable, over supplementary ranges.

NOTE The ranges of a filter leakage monitor can be expressed in units defined by the manufacturer.

5.2.2 Certification range for filter dust monitor

The certification range over which the instrument is to be tested shall comprise minimum and maximum values and the coverage shall be fit for the intended application of the instrument.

The minimum value of the certification range shall be the detection limit certified during the test. A filter dust monitor shall be able to measure instantaneous values in a range that is at least two times the upper limit of the certification range, in order to measure the half-hour values correctly. If it is necessary to use more than one range setting of the instrument to achieve this requirement, supplementary ranges require additional testing (see 5.2.3).

NOTE Manufacturers can choose other ranges for different applications.

The certification range(s) and the performance criteria tested for each range shall be stated in the test report.

The test laboratory shall choose for the field test an industrial plant with challenging measuring conditions. This means that the instrument can also be used in less demanding measuring conditions.

5.2.3 Supplementary ranges for filter dust monitors

If a manufacturer wishes to demonstrate performance over one or more supplementary ranges larger than the certification range some limited additional testing is required over all the supplementary ranges. This additional testing shall at least include evaluations of the response time as specified in 10.8.

The supplementary range(s) and the performance criteria tested for these ranges shall be stated on the certificate.

5.2.4 Type of arrestment plant for filter leakage monitors

The manufacturer shall agree with the test laboratory the type of arrestment plant for which the certification application is made. This shall be stated on the test certificate and shall include the type of filter (e.g. electrostatic precipitator or bagfilter) and in the case of arrestment plant monitors also include whether the instrument operation requires a change in the magnitude of the dust pulses created by the cleaning process to operate or a change in the emissions level. Also for arrestment plant monitors, the manufacturer shall agree with the test laboratory the type of bagfilter cleaning mechanisms for which the instrument is applicable.

NOTE The bagfilter cleaning mechanism influences the dynamic dust profile from a bagfilter. For example bagfilter which are cleaned with a compartment off line have a different dust emission profile to a single compartment bagfilter which is cleaned on line.

The test laboratory shall choose a field test location which reflect the type of arrestment plant.

5.2.5 Expression of performance criteria with respect to ranges

The performance criteria presented in Clause 8 are expressed in terms of a percentage of the upper limit of the certification range. A performance criterion is a value that corresponds to the largest permitted deviation allowed for each test, regardless of the sign of the deviation determined in the test.

5.2.6 Ranges of optical in-situ instrument with variable optical length (cross-stack)

The certification range for optical in situ instrument with variable optical length (cross-stack) shall be defined in units of the dust concentration multiplied by the length of the optical path, e.g. $mg/m^3 \cdot m$.

The path length used for testing shall be stated on the certificate.

5.3 Manufacturing consistency and changes to instrument design

Certification is specific to the instrument version, which has undergone performance testing. Subsequent design modifications that might affect the performance of the instrument can invalidate the certification.

NOTE Design modifications apply to both hardware and software.

Manufacturing consistency and changes to instrument design are described in EN 15267-2.

5.4 Qualifications of test laboratories

Test laboratories shall be accredited to EN ISO/IEC 17025 and the appropriate test standards for carrying out the tests defined in this standard. Test laboratories shall have knowledge on the uncertainties attributed to the individual test procedures applied during performance testing.

CEN/TS 15675 provides an elaboration of EN ISO/IEC 17025 for application to emission measurements which should be followed when using standard reference methods.

6 Performance characteristics for laboratory testing

6.1 Instrument for testing

All instruments submitted for testing shall be complete. These specifications do not apply to the individual parts of an instrument. The report shall be issued for a specified instrument with all its parts listed.

6.2 CE labelling

The instrument shall comply with the requirements for CE labelling specified in applicable EU Directives.
These include, for example:

— Electromagnetic Compatibility Directive 2004/108/EC;

— Low-voltage Directive 2006/95/EC covering electrical equipment designed for use within certain voltage limits.

Instrument manufacturers or suppliers shall supply verifiable and traceable evidence of compliance with the requirements of the relevant EU Directives applicable to the equipment.

6.3 Security

The instrument shall have a means of protection against unauthorised access to control functions.

6.4 Output ranges and zero-point

The instrument shall have a data output signal such that both negative and positive readings can be displayed.

Analogue output shall have a live zero point.

The instrument shall have a display that shows the measurement response. The display may be external to the instrument.

6.5 Additional outputs on filter leakage monitors

Filter leakage monitors shall be provided with at least two alarm outputs, with alarm delay capability in addition to the data output.

6.6 Display of operational status signals

The instrument shall have a means of displaying its operating status.

NOTE Status signals cover, for example, normal operation, stand-by, maintenance mode, malfunctions.

The instrument shall also have a means of communicating the operational status to a data handling and acquisition system.

6.7 Degrees of protection provided by enclosures

Instruments limited to be mounted in ventilated rooms or cabinets, where any kind of precipitation cannot reach the instrument, shall meet at least IP40 specified in EN 60529:1991.

Instruments limited to be mounted in areas, where some kind of shelter against precipitation is in place, e.g. a porch roof, but precipitation may reach the instrument due to wind etc., shall meet at least IP54 specified in EN 60529.

Instruments which are designed to be used in the open air and without any weather protection shall at least meet the requirements of standard IP65 specified in EN 60529:1991.

6.8 Response time

A filter dust monitor shall meet the performance criteria for response time specified in Table 1.

6.9 Detection time

A filter leakage monitor shall meet the performance criteria for detection time specified in Table 1.

6.10 Repeatability standard deviation at automatic internal zero point

The instrument shall meet the performance criteria for repeatability standard deviation at the automatic internal zero point specified in Clause 8.

6.11 Repeatability standard deviation at automatic internal reference point

The instrument shall meet the performance criteria for repeatability standard deviation at the automatic internal reference point specified in Clause 8.

6.12 Automatic internal zero and reference point checks

The manufacturer shall provide a description of the technique used by the instrument to determine the automatic internal zero and reference points.

The test laboratory shall assess that the mechanisms for determining the automatic internal zero and reference points are as comprehensive as is practical for the measurement technique used, but does not necessarily check the complete measurement path.

The manufacturer shall provide details in the manual of how to ensure the correct operation of the parts of the measurement path not tested by the automatic internal zero and reference point checks.

6.13 Influence of ambient temperature

The deviations of the instrument readings at the automatic internal zero and reference points shall not exceed the performance criteria specified in Clause 8 when the ambient temperature varies from –20 °C to +50 °C, unless assemblies are installed indoors where the temperatures do not fall below +5 °C or rise above +40 °C, in which case the test range shall be +5 °C to +40 °C.

The manufacturer submitting an instrument for testing may specify wider ambient temperature ranges to those above.

NOTE Temperature ranges tested are indicated in the certificate.

6.14 Influence of sample gas flow for extractive instrument

The deviation of the instrument reading at the automatic internal reference point shall not exceed the performance criterion specified in Table 1, when the sample gas flow is changed in accordance with the manufacturer's specification.

A status signal for the lower limit of the sample gas flow shall be provided.

6.15 Influence of voltage variations

The deviation of the instrument reading at the automatic internal zero and reference points shall not exceed the performance criterion specified in Table 1, when the voltage supply to the instrument varies from –15 % to +10 % from the nominal value of the supply. The instrument shall be capable of operating at a voltage which meets the requirements of EN 50160.

6.16 Influence of vibration

The instrument shall be unaffected by the levels of vibration typically expected during installation at an industrial plant. The influence of vibration is acceptable if the deviations of the instrument readings at the automatic internal zero and reference points do not exceed the performance criteria specified in Table 1.

6.17 Cross-sensitivity

The manufacturer shall describe any known sources of interference. The test laboratory shall assess and report on relevant interferents.

6.18 Excursion of measurement beam of cross-stack in situ instruments

In the event of an excursion of the measurement beam within an instrument, the deviation of the instrument reading shall not exceed the performance criterion specified in Table 1 for the maximum allowable deviation angle specified by the manufacturer. This shall not be smaller than 0,3°.

6.19 Detection limit

The detection limit of the filter dust monitor shall be determined, assessed and documented in the test report.

The detection limit should be lower than 25 % of the normal emission concentration from the type of arrestment plant for which certification is requested.

NOTE 1 The detection limit is two times the repeatability standard deviation at zero.

NOTE 2 The quantification limit is four times the repeatability standard deviation at zero.

7 Performance characteristics for field testing

7.1 Calibration function for filter dust monitors

The calibration function shall be determined by parallel measurements carried out using a SRM. The calibration function shall have at least a determination coefficient R^2 of the regression as specified in Table 2.

The variability attached to the calibration function and determined in accordance with EN 14181 shall meet the performance criterion in Table 2.

NOTE This test involves regression analysis of 15 paired measurements at the beginning and end of the field test and an assessment of the change in the calibration function using the AST criterion.

7.2 Functional test of filter leakage monitor

7.2.1 General

During the field test, instruments shall be tested after typical arrestment plant for which certification is sought. The test laboratory shall select a suitably demanding installation.

Two filter leakage monitors and a particulate AMS shall be installed on the same outlet from the arrestment plant and the outputs recorded for the duration of the field test.

The particulate AMS shall be certified in accordance with EN 15267-3 for the field test application conditions and adjusted to a suitably short averaging time, enabling it to follow the fast changes in dust concentration, associated with arrestment plant dynamics.

7.2.2 Plant failure detection test

The filter leakage monitor shall detect any failure that occurs during the field test (as confirmed by the AMS).

For instruments monitoring mean emission level, failure is deemed to have occurred if emissions reach the plant emission limit value.

For instruments monitoring the change in dust pulse magnitude, failure is deemed to have occurred if pulse height increases by a factor agreed between the manufacturer and test laboratory.

The filter leakage monitor shall discriminate between failure conditions and normal operation.

7.2.3 Simulated filter failure test

The instruments tested in 7.2.2 shall be subjected to a simulated arrestment plant failure condition lasting for 5 min at least five times over the field test. No more than three tests shall be conducted on one day and the tests should be conducted at both the beginning and end of the field test period.

Simulated failure conditions shall be applicable to the instrument under test and shall meet the criteria specified in 7.2.2.

7.3 Maintenance interval

The minimum maintenance interval of the instrument shall meet the performance criterion specified in Table 2.

7.4 Drift of automatic internal zero point and automatic internal reference point

The drift of automatic internal zero point and automatic internal reference point within the maintenance interval shall not exceed the performance criteria specified in Table 2.

7.5 Availability

The instrument shall have an availability which meets the requirements of applicable regulations, and in any case the performance criterion specified in Table 2, during the field test.

If the instrument is not measuring the measurand, then it is not considered as being available. The instrument can be unavailable due to malfunctions, servicing, any kind of internal zero, reference point evaluation, correction. Periods when the monitored process is not operating are excluded.

7.6 Reproducibility

Instrument shall meet the performance criterion for reproducibility under field conditions specified in Table 2.

For filter leakage monitors reproducibility shall be calculated between the two filter leakage monitors and shall not include the particulate AMS.

8 Performance criteria

This section defines the performance criteria to be achieved during laboratory and field testing. The values for individual parameters given in these sections are expressed as a percentage of the upper limit of the certification range of the instrument under test, with the exception of availability and calibration function.

Where regulations specify uncertainty requirements, the instrument shall meet both the individual performance criteria specified in this document and the uncertainty requirements required by the applicable regulations.

The maximum allowable deviations (as absolute values) of the measured signals are given as percentages of the upper limit of the certification range.

Table 1 details the performance criteria, which are tested in the laboratory. Table 2 details the performance criteria, which are tested during the three month field test.

Table 1 — Performance criteria for laboratory tests

Performance characteristic	Filter dust monitor	Filter leakage monitor	Test in
Response time	≤ 200 s	not applicable	10.8
Detection time	not applicable	≤ 200 s	10.9
Repeatability standard deviation at automatic internal zero point	≤ 2,0 % [a]	≤ 2,0 % [a]	10.10
Repeatability standard deviation at automatic internal reference point	≤ 2,0 % [a]	≤ 2,0 % [a]	10.10
Influence of ambient temperature change from 20 °C within specified range	≤ 5,0 % [a]	≤ 5,0 % [a]	10.11
Influence of sample gas flow (extractive systems only)	≤ 2,0 % [a]	≤ 2,0 % [a]	10.12
Influence of voltage at –15 % and at +10 % from nominal supply voltage	≤ 2,0 % [a]	≤ 2,0 % [a]	10.13
Influence of vibration	≤ 2,0 % [a]	≤ 2,0 % [a]	10.14
Cross-sensitivity	to be reported	to be reported	10.15
Influence of misalignment (cross-stack instruments only)	≤ 2,0 % [a]	≤ 2,0 % [a]	10.16
Detection limit	to be reported	not applicable	10.17
[a] Percentage of the upper limit of the certification range.			

Table 2 — Performance criteria for field tests

Performance characteristic	Filter Dust monitor	Filter leakage monitor	Test in
Determination coefficient of calibration function, R^2 a) for concentrations > 20 mg/m^3 b) for concentrations ≤ 20 mg/m^3	 ≥ 0,70 ≥ 0,60	not applicable	12.1
Uncertainty, σ_0	≤ 30 % [a]	not applicable	12.1
Success rate in detecting failure condition	not applicable	100 %	12.2.1, 12.2.2
False alarm rate	not applicable	0 %	12.2.1
Minimum maintenance interval	8 days	8 days	12.3
Drift of automatic internal zero point during maintenance interval	≤ 3,0 %[a]	≤ 3,0 %[a]	12.4
Drift of automatic internal reference point during maintenance interval	≤ 3,0 %[a]	≤ 3,0 %[a]	12.4
Availability	≥ 95,0 %	≥ 95,0 %	12.5
Reproducibility, R_f a) for concentrations > 20 mg/m^3 b) for concentrations ≤ 20 mg/m^3	 ≤ 2,0 %[a] ≤ 3,3 % [a]	≤ 10,0 % [a]	12.6
[a] Percentage of the upper limit of the certification range.			

9 General test requirements

The test laboratory shall perform all relevant tests on two identical instruments. These two instruments have to be tested in the laboratory and field.

Changes in the environmental and test conditions shall not have a significant influence on the performance characteristic tested. Therefore, all environmental and test conditions which have an influence on the instrument shall be kept stable as far as practicable. The environmental and test conditions shall be recorded during the test. All test results shall be reported at standard conditions (0 °C, 1013 hPa, dry gas).

The test laboratory shall evaluate the performance of the instruments at the lowest certification range possible for the intended application, which is chosen by the manufacturer. If the instrument is to be used for industrial plants requiring assurance over higher measurement ranges, then the test laboratory shall perform selected additional tests to demonstrate satisfactory performance over higher ranges.

NOTE 1 Certification range is selected by the manufacturer in consultation with the test laboratory.

The test requirements specified in Clause 10 to Clause 12 are the minimum requirements. The tests are divided into two sections, covering general test requirements for all instruments, followed by measured component specific test requirements. They include:

— description of the test method;

— evaluation procedure;

— assessment of performance against the relevant performance criterion;

— where appropriate, information on any specialised test equipment.

If a test requires two or more test cycles and the instruments meets the performance criterion by a factor of two or more for the first test, then any subsequent testing for this performance characteristic may be omitted.

If a test requires several readings, the average of these readings shall be determined. If a test has to be repeated (several test cycles), the averages of the individual test cycles shall be determined and meet the applicable performance criteria.

Tests do not have to be performed in the numerical order in this document, as the selection of tests and their order depend on the characteristics and type of individual instrument.

NOTE 2 The field test is usually carried out after all laboratory tests are passed.

NOTE 3 A short-term drift test performed after the response time test can show that drift is not influencing the results of the other tests. As a guideline, a short-term drift test could be 24 h long, where a drift at zero point of more than 2 % of the upper limit of the certification range indicates that the instrument will not be sufficiently stable for the remainder of the tests.

The test laboratory shall document whether the instruments meets all of the relevant performance criteria, and shall record all environmental conditions pertaining during testing.

10 Test procedures for laboratory tests

10.1 Instrument for testing

The test laboratory shall check whether the instruments are complete and identical, by examining the appropriate parts, as specified in the manufacturer's documentation.

The test laboratory shall check that extractive instruments have appropriate provisions for effective control of liquid water entering the system.

The test laboratory shall include diagrams and photographs of both instruments in the test report, and copies of the operating manual(s) for the instrument.

NOTE 1 In addition to the analyser, an instrument can include the sampling probe, the sampling hose, any special test components and the operating instructions.

The hardware used shall be photographed and the software version established. Changes in the instrument configuration are not permitted during testing.

NOTE 2 Minor repairs needed to perform the test but without influence on the instruments performance can be carried out, and the test be continued.

10.2 CE labelling

If the instrument needs to comply with the requirements for CE labelling as specified in applicable EU Directives, then the test laboratory shall verify whether there is traceable evidence of compliance.

10.3 Security

The instruments shall be set up according to the operating instructions. The test laboratory shall then activate the security mechanisms provided by the instrument manufacturer to prevent inadvertent and unauthorised maladjustment. A check shall then be carried out to establish whether the security mechanisms operate effectively.

NOTE 1 Adjustment can include zero adjustments, deletion of data sets, changing averaging times and altering ranges.

NOTE 2 Security mechanisms can include a key or security codes, which are keyed into the instruments before adjustments are permitted.

10.4 Output ranges and zero point

The test laboratory shall check whether the output ranges on the instrument can be changed and whether such ranges are appropriate for the intended applications.

The test laboratory shall check that the indicated zero point on the measurement display and output of the instruments is a true live zero, and that the instrument can display both positive and negative readings.

10.5 Additional outputs on filter leakage monitors

The test laboratory shall verify that the filter leakage monitor is equipped with at least two alarm outputs and that these alarms function correctly.

NOTE The two alarms are normally used to provide advance warning of, and indication of, arrestment plant failure.

10.6 Display of operational status signals

The test laboratory shall assess that the instrument has a means of displaying and providing data for recording the relevant operational status (e. g. standby, service, malfunction), and that it is operating correctly.

10.7 Degrees of protection provided by enclosures

The instrument manufacturer shall provide to the test laboratory the report of testing of the enclosure according to EN 60529. The test laboratory shall assess this test report to ensure compliance with the requirements of 6.7.

10.8 Response time

The test laboratory shall determine the response time of the filter dust monitor by the use of surrogates.

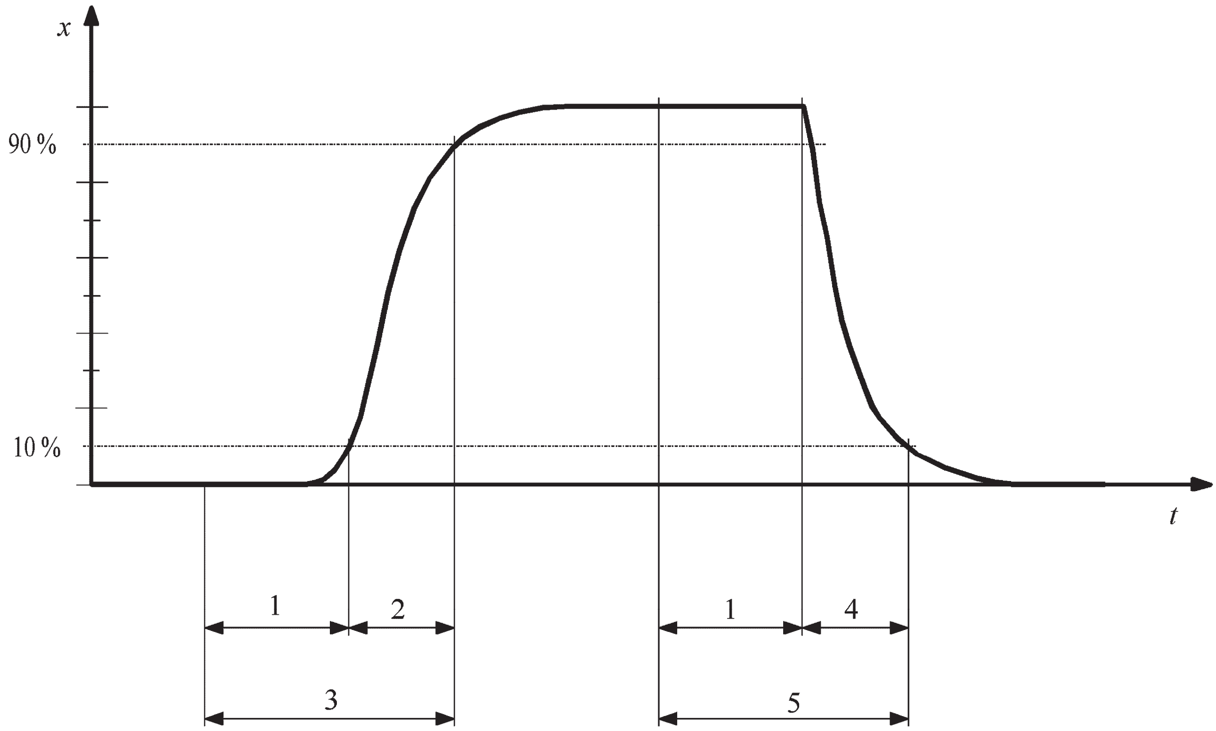
NOTE This test provides the initial stabilisation period, which is then used in other tests described in this European Standard.

The elapsed time (response time) between the start of the step change and reaching of 90 % of the instrument final stable reading of the applied concentration shall be determined for both the rise and fall modes.

The whole cycle shall be repeated four times with a time elapsed between two experiments of four times the response time. If the instrument meets the performance criterion by a factor of two or more for the first test then any subsequent testing may be omitted.

The average of the response times (rise) and the average the response times (fall) shall be calculated.

The larger value of the response time (rise) and the response time (fall) shall be used as the response time of the instrument and be compared with the applicable performance criteria specified in Table 1.



Key

1	lag time	x	measured signal
2	rise time	t	time
3	response time (rise), t_r		
4	fall time		
5	response time (fall), t_f		

Figure 1 — Diagram illustrating the response time

The relative difference in response times shall be calculated according to Equation (1):

$$t_d = \left| \frac{t_r - t_f}{t_r} \right| \quad (1)$$

where

t_d is the relative difference between the response times determined in rise and fall mode;

t_r is the response time in rise mode;

t_f is the response time in fall mode.

The values of t_d, t_r and t_f shall be reported individually in the test report.

10.9 Detection time

The test laboratory shall determine the detection time of the filter leakage monitor by the use of surrogates.

NOTE This test provides the initial stabilisation period, which is then used in other tests described in this European Standard.

The elapsed time (detection time) between the start of the step change and the instrument providing the defined response shall be determined for both the rise and fall modes.

The whole cycle shall be repeated four times with a time elapsed between two experiments of four times the detection time. If the instrument meets the performance criterion by a factor of two or more for the first test then any subsequent testing may be omitted.

The average of the detection times (rise) and the average the detection times (fall) shall be calculated.

The larger value of the detection time (rise) and the detection time (fall) shall be used as the detection time of the instrument and be compared with the applicable performance criteria specified in Table 1.

10.10 Repeatability standard deviation at automatic internal zero and reference points

The measured signals of the instrument at zero and reference points shall be determined after application of the internal reference by waiting the time equivalent to one independent reading and then recording 20 consecutive individual readings in each case.

These data are then used to determine the repeatability standard deviation at automatic internal zero and reference points using Equation (2):

$$s_r = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \qquad (2)$$

where

s_r is the repeatability standard deviation;

x_i is the ith measured signal;

$\bar{x}$ is the average of the measured signals x_i;

n is the number of measurements, n = 20.

The repeatability standard deviation at automatic internal zero and reference points shall meet the performance criterion specified in Clause 8.

The individual readings and the repeatability standard deviation at automatic internal zero and reference points shall be reported.

10.11 Influence of ambient temperature

The test laboratory shall determine how the automatic internal zero point and automatic internal reference point values of the instrument are influenced by changes in ambient temperature by using a climatic chamber which can control ambient temperature from –20 °C to +50 °C, within limits of ±1,0 K.

If a measurement at zero is possible, this may be used instead of the automatic internal zero point.

In the case of instrument installed outdoors, the following temperatures shall be set in the climatic chamber in the given order of sequence:

20 °C → 0 °C → -20 °C → 20 °C → 50 °C → 20 °C.

In the case of instrument installed at temperature-controlled locations, the following temperatures shall be set in the given order of sequence:

20 °C → 5 °C → 20 ° C → 40 °C → 20 °C.

After a sufficient equilibration period, the measured signals of the instruments at automatic internal zero point and at automatic internal reference point shall be determined at each temperature by waiting the time equivalent to one independent reading and then recording three consecutive individual readings. The three individual readings shall be averaged.

The test laboratory shall wait at least 6 h between each temperature change in the environmental chamber, to allow the instrument to equilibrate, before taking further readings.

Alternatively, the test laboratory may monitor the reading from the instrument following each temperature change. If the instrument stabilises in less than 6 h, then the test laboratory may reduce the equilibration period. However, the test laboratory shall record objective and verifiable evidence to support this.

The instruments shall remain switched on when varying the ambient temperature in the environmental chamber.

The deviations between the average reading at each temperature and the average reading at 20 °C shall be determined. The deviations shall meet the applicable performance criteria specified in Clause 8 for all temperatures.

The test shall be repeated three times. If the instrument meets the performance criterion by a factor of two or more for the first test then any subsequent testing may be omitted.

The individual readings, averages and deviations at each temperature as well as the maximum deviation at automatic internal zero point and at automatic internal reference point shall be reported.

In addition, the test laboratory shall determine and report the maximum sensitivity coefficient for the temperature dependence. The sensitivity coefficients at each temperature shall be calculated by Equation (3):

$$b_\mathrm{t} = \frac{(x_i - x_{i-1})}{(T_i - T_{i-1})} \tag{3}$$

where:

b_t is the sensitivity coefficient of ambient temperature;

x_i is the average reading at temperature T_i;

x_{i-1} is the average reading at temperature T_{i-1};

T_i is the current temperature in the test cycle;

T_{i-1} is the previous temperature in the test cycle.

NOTE A graph showing the results of the examination can be provided in the report.

10.12 Influence of sample gas flow for extractive instruments

The instrument shall initially be operated with the flow rate prescribed by the manufacturer. This flow rate shall then be changed to the lowest flow rate specified by the manufacturer.

NOTE Influence of the sample gas flow typically applies to extractive instrument, since in situ instrument mostly are not influenced by flow rate.

If the manufacturer's documentation permits only minor tolerances these are binding and shall not be extended.

The measured signals at the automatic internal reference point shall be determined at both flow rates by waiting the time equivalent to one independent reading and then recording three consecutive individual readings. The three individual readings shall be averaged.

The deviation between the average readings at both flow rates shall be determined. The deviation shall meet the applicable performance criteria specified in Table 1.

This test shall be repeated three times at the automatic internal reference point. If the instrument meets the performance criterion by a factor of two or more for the first test then any subsequent testing may be omitted.

The individual readings, averages and the deviations as well as the maximum deviation shall be reported.

The functionality of the status signal shall be tested at the same time.

In addition, the test laboratory shall determine and report the sensitivity coefficient for the flow rate dependence. The sensitivity coefficient shall be calculated by Equation (4):

$$b_{\mathrm{f}} = \frac{(x_2 - x_1)}{(r_2 - r_1)} \tag{4}$$

where

b_{f} is the sensitivity coefficient of sample gas flow;

x_1 is the average reading at flow rate r_1;

x_2 is the average reading at flow rate r_2;

r_1 is the nominal flow rate;

r_2 is the lowest specified flow rate.

10.13 Influence of voltage variations

The supply voltage to the instrument shall be varied, using an isolating transformer, in steps of 5 % from the nominal supply voltage to at least the upper and the lower limits specified in Table 1. The measured signals of the instrument at automatic internal zero point and at automatic internal reference point shall be determined at each voltage by waiting the time equivalent to one independent reading and then recording three consecutive individual readings. The three individual readings shall be averaged.

If a measurement at zero is possible, this may be used instead of the automatic internal zero point.

NOTE After changes in voltage the instrument can need time to stabilize.

The deviations between the average reading at each voltage and the average reading at the nominal supply voltage shall be determined. The deviations shall meet the applicable performance criteria specified in Clause 8 for all voltages.

This test shall be repeated three times. If the instrument meets the performance criterion by a factor of two or more for the first test then any subsequent testing may be omitted.

The individual readings, averages and deviations at each voltage as well as the maximum deviation at automatic internal zero point and at automatic internal reference point shall be reported.

In addition, the test laboratory shall determine and report the sensitivity coefficient for the voltage dependence. The sensitivity coefficient shall be calculated by Equation (5):

$$b_{\mathrm{v}} = \frac{(x_2 - x_1)}{(U_2 - U_1)} \quad (5)$$

where

- b_{v} is the sensitivity coefficient of supply voltage;
- x_1 is the average reading at voltage U_1;
- x_2 is the average reading at voltage U_2;
- U_1 is the minimum voltage specified by the manufacturer;
- U_2 is the maximum voltage specified by the manufacturer.

For reporting the voltage dependence, the highest value of the results at zero and internal reference point shall be taken.

10.14 Influence of vibration

The instrument shall be examined in the laboratory and in the field in respect of whether normal vibrations affect the performance of the instrument. If the conditions of use specified by the manufacturer demand that a vibration test be performed, the measured signals of the instrument at automatic internal zero point and at automatic internal reference point shall be determined before and after the vibration test by waiting the time equivalent to one independent reading and then recording three consecutive individual readings.

If a measurement at zero is possible, this may be used instead of the automatic internal zero point.

The vibration test, if required, shall be applied to duct-mounted parts of the instrument only and shall be made with reference to IEC 60068-1 and the appropriate parts of IEC 60068-2. The instrument shall be subjected to vibration on three perpendicular axes in turn, with a swept range of frequencies from 10 Hz to 160 Hz at one octave per minute and at a vibration acceleration chosen by the manufacturer and assessed by the test laboratory to be proper for the application that the instrument is intended for.

If any resonant frequencies are observed, a vibration test shall be carried out at each observed frequency for a period of 2 min. If no resonant frequencies are observed, a vibration test shall be made at a frequency of 25 Hz for a period of 2 min.

The vibration test shall be followed by a functional test. Any influence on the instrument from vibrations and from the service position at the site of installation shall be assessed. Remedial measures having proved necessary in field testing shall be described.

The deviations between the average readings before and after the vibration tests shall be determined. All deviations shall meet the applicable performance criteria specified in Table 1.

The individual readings, averages and deviations at each vibration test as well as the maximum deviation shall be reported.

10.15 Cross-sensitivity

The nature and magnitude of relevant interferents shall be assessed by the test laboratory and included on the test report. At least the following interferents shall be considered:

- influence from particulate grain size;
- influence from duct gas velocity;
- influence of particle material;
- influence from particle static charge;
- influence from moisture in the duct gas (water vapour);
- influence from aerosols in the duct gas (water droplets);
- influence from duct gas temperature.

10.16 Excursion of measurement beam of cross-stack in situ instruments

The test laboratory shall gradually and precisely deflect the transmitter and receiver assemblies of the instrument in the horizontal and vertical planes, and then record the measured signals using reference materials.

NOTE 1 This test typically applies to cross-stack in-situ optical techniques. The test also applies to extractive instrument with separate transmitter and receiver assemblies.

NOTE 2 This testing requires calibration standards (e.g. reference filters) and an optical bench.

NOTE 3 Typically the experimental path length for this test is 2 m to 3 m, although the test should be performed at the maximum path length practical.

Deflections shall be carried out for the zero point over two typical measurement path lengths. The deflection is to be performed in incremental steps of approximately 0,05° in the angle range demanded.

The range of deflection shall be equal to at least twice the angle specified by the manufacturer. It should also be tested as far as the deflection limit permitted by the assemblies - if necessary in larger increments.

The efficiency of any manual optical adjustment facilities shall be examined at least in qualitative terms. Automatic adjustment processes shall be activated and included in the test.

The measured signals obtained for the various test steps shall be included in tabular form in the test report. These measured signals shall be paired up with the deflection angles.

The maximum permissible deflection angles shall be stated within which the instrument satisfies the performance criterion. In the case of automatically aligning instrument, the manner of operation shall be described and verified by test results.

10.17 Detection limit

The measured signals of the filter dust monitor at zero point shall be determined after simulating a zero dust concentration by waiting the time equivalent to one independent reading and then recording 20 consecutive independent individual readings.

This data is then used to determine the repeatability standard deviation at zero point using Equation (2).

The detection limit of the filter dust monitor shall be calculated by multiplying the repeatability standard deviation at zero point with a factor of two, and shall be assessed and documented in the test report.

11 Requirements for field tests

11.1 Provisions

The field test is an endurance test on an industrial facility appropriate to the instrument's field of application. When selecting the industrial facility, the test laboratory shall ensure that the mass concentrations of the measured component are available in a concentration sufficient to assess the measurement results. This is usually the case if the mass concentration is in the range of 20 % to about 50 % of the certification range to be tested.

The measurement site shall be selected in accordance with EN 15259.

NOTE Compliance with EN 15259 for the selection of the instrument sampling point eliminates or at least minimises any systematic deviation caused by spatial and temporary lack of homogeneity in the mass concentration or volumetric concentration of individual measured components.

The field test shall be performed with two complete and identical instruments. In the case of a filter leakage monitor, a certified particulate AMS, tested according to EN 15267-3 is also required. The instruments and the AMS, if required, shall be mounted so that they measure the same concentration.

Any additional equipment required is specified in the various test procedures.

11.2 Field test duration

The field test duration shall be at least three months and shall not be interrupted. Only in exceptional cases, which shall be justified (e.g. in the case of operation-related interruptions or change of site); shorter testing periods may be included in the field test. The total duration of the shorter testing periods shall be at least three months. During the field test, the performance criteria shall be determined under near-practice and realistic conditions.

The test laboratory shall document and maintain records of all data from the field test.

12 Test procedures for field tests

12.1 Calibration function for filter dust monitor

The test laboratory shall determine the calibration function of the filter dust monitor during the field test, by performing parallel measurements with the SRM. The calibration function shall be determined on the basis of at least 15 parallel measurements in accordance with EN 14181.

The calibration function shall be determined twice, once at the beginning and once again at the end of the field test. Both calibration functions shall meet the performance criterion for the uncertainty specified in Table 2. The variability shall be assessed according to Equation (11) of EN 14181:2004. The peripheral parameters (e.g. moisture content, temperature and oxygen content) used to standardise the measured results should be the same for dust monitor and SRM measured values to calculate the variability only for the tested dust monitor without influence of peripheral parameters. Furthermore, the validity of the second calibration function shall be assessed according to Equation (18) of EN 14181:2004 by use of all results of the parallel measurements.

NOTE It is advantageous to use the zero point in the calibration in order to avoid an inadequate calibration function.

If any effects of waste gas temperature and pressure are observed during the field tests, the test laboratory shall note these effects in the test report.

12.2 Functional test of filter leakage monitor

12.2.1 Plant failure detection test

The test laboratory shall record the output from the filter leakage monitor and the particulate AMS and assess that the filter leakage monitor has detected any failure that occurred during the field test (as confirmed by the AMS). For that purpose, the particulate AMS shall be installed and checked as well as calibrated by means of parallel measurements with a SRM in accordance with EN 14181 and EN 13284-2.

For instruments monitoring mean emission level, failure is deemed to have occurred if emissions reach the plant emission limit value.

For instruments monitoring the change in dust pulse magnitude, failure is deemed to have occurred if pulse height increases by a factor agreed between the manufacturer and test laboratory.

The test laboratory shall assess that the filter leakage monitor does not give false signals during the field test.

12.2.2 Simulated filter failure test

The test laboratory shall subject the filter leakage monitor to a simulated arrestment plant failure condition lasting for 5 min at least five times over the field test. No more than three tests shall be conducted on one day and the tests should be conducted at both the beginning and end of the field test period. The test laboratory shall assess that the instrument detects all simulated filter conditions.

Simulated failure conditions shall be applicable to the instrument under test.

NOTE Failure conditions can be simulated by one of the following procedures:

— injection of particulate;

— using a defective bag;

— changing voltage on EP plates;

— opening a bypass around the filter.

12.3 Maintenance interval

The test laboratory shall determine the maintenance work that is necessary for the instrument to work properly as well as the intervals at which such maintenance work shall be performed. The recommendations of the instrument manufacturer should be taken into account.

The procedure given by the manufacturer to ensure the correct operation of the parts of the measurement path not tested by the internal zero and reference point checks shall be evaluated by the test laboratory.

If the instrument does not require any service, the maintenance interval is determined by the drift behaviour.

In order to determine drift behaviour, the instrument shall be adjusted at the start of testing. The instruments shall be checked at regular intervals (e.g. once a week) during the further course of testing. The maintenance interval shall be defined as the time period between the start of the test and the last time when the deviation remained within the permissible drift.

The maintenance interval shall be derived from the shortest interval between the requisite maintenance work operations. This also includes manual as well as automatic checks.

The maximum allowable maintenance interval for a three-month field test shall be one month. Extending the maintenance interval to one year necessitates long-term studies as specified in Table 3. The test laboratory has to describe the minimum amount of maintenance work to be performed within the maintenance interval.

Table 3 — Maximum allowable maintenance intervals

Field test duration	Maximum allowable maintenance interval
3 months	1 month
6 months	3 months
12 months	6 months
24 months	12 months

12.4 Drift of automatic internal zero point and automatic internal reference point

The internal zero and reference point shall be tested for drift during the field test.

Once every four weeks the measured signals of the instrument at zero and reference points shall be recorded. The automatic internal reference system shall be operated ten times, at a time interval equivalent to one independent reading.

The mean value of the ten consecutive readings as well as the repeatability standard deviation, as described in 10.10, shall be reported for each. If the drift exceeds the value given in Table 2, the maintenance interval shall be reduced to the time when the limit given in Table 2 was not exceeded.

Manual re-adjustment of the instrument during the test is not permitted according to EN 15267-3.

In the case of an instrument with automatic zero-point and reference-point correction facility, the maximum technically permissible amount of correction shall be specified or determined from the test results.

12.5 Availability

The test laboratory shall determine the availability of the instrument by recording the duration of the field test and all interruptions to the normal monitoring functionality of the instrument.

NOTE Interruptions include e.g. malfunctions, servicing work and automatic internal zero and reference point checks.

The availability V in per cent shall be determined using Equation (6) with the aid of the total operating time t_{tot} and the outage time t_o:

$$V = \frac{t_{tot} - t_o}{t_{tot}} \times 100\ \% \qquad (6)$$

The results shall be summarised in tabular form. Table 4 provides an example.

Table 4 — Summary of availability test results

		Instrument 1	Instrument 2
Total operating time t_{tot}	h		
Outage time t_o			
– Instrument internal setting times	h		
– Instrument malfunction and repairs	h		
– Maintenance, adjustment	h		
Availability V	%		

The test records with the raw data and results shall be documented.

12.6 Reproducibility

Reproducibility shall be determined during the three-month field test from simultaneous, continuous measurements by means of two identical instrument at the same measurement point (paired measurements) and an electronic data recording system with a memory capacity of at least four weeks and a sampling rate of at least four times during the instrument averaging period.

The test shall be carried out in the smallest measuring range under test. When selecting the plant, it is preferable that in the range of 30 % to about 100 % of the upper limit of the certification range the mass concentrations of the measured component are available in a concentration sufficient to assess the measured results.

The measured signals of both instruments (raw values as analogue or digital output signals without any conversion) shall be recorded as individual values (e.g. minute mean values) on an electronic data register. The relevant status signals, such as measurement, malfunction and maintenance, shall also be recorded. Taking into account status signals, the individual values shall be condensed into half-hour mean values, provided that for each half-hour at minimum 20 min are covered by individual values. Measured signals from malfunction, maintenance or test cycles taking place in the instrument shall not be taken into consideration for evaluation.

In specific cases, shorter averaging time of measured value pairs, e.g. 10 min, may be used, if the measured component has to be evaluated on this averaging time or if higher concentrations of the measured component are not available over prolonged intervals as a result of the dynamics of the emission profile.

At the end of the field test, the reproducibility shall be calculated on the basis of all valid paired values, i.e. the condensed measured signals from the instrument, accrued throughout the entire period of the field test with both instrument in accordance with Equation (7) using the standard deviation of the difference of the paired measurements as given by Equation (8) and with a statistical confidence of 95 % for the t-distribution (two-sided):

$$R_\mathrm{f} = t_{n-1;\,0,95} \times s_\mathrm{D} \quad (7)$$

$$s_\mathrm{D} = \sqrt{\frac{\sum_{i=1}^{n} \left(x_{1,i} - x_{2,i}\right)^2}{2n}} \quad (8)$$

where

R_f is the reproducibility under field conditions;

$t_{n-1;\,0,95}$ is the two-sided Student t-factor at a confidence level of 95 % with a number of degrees of freedom n–1;

s_D is the standard deviation from paired measurements;

$x_{1,\,i}$ is the ith measured signal of the first measuring system;

$x_{2,\,i}$ is the ith measured signal of the second measuring system;

n is the number of parallel measurements.

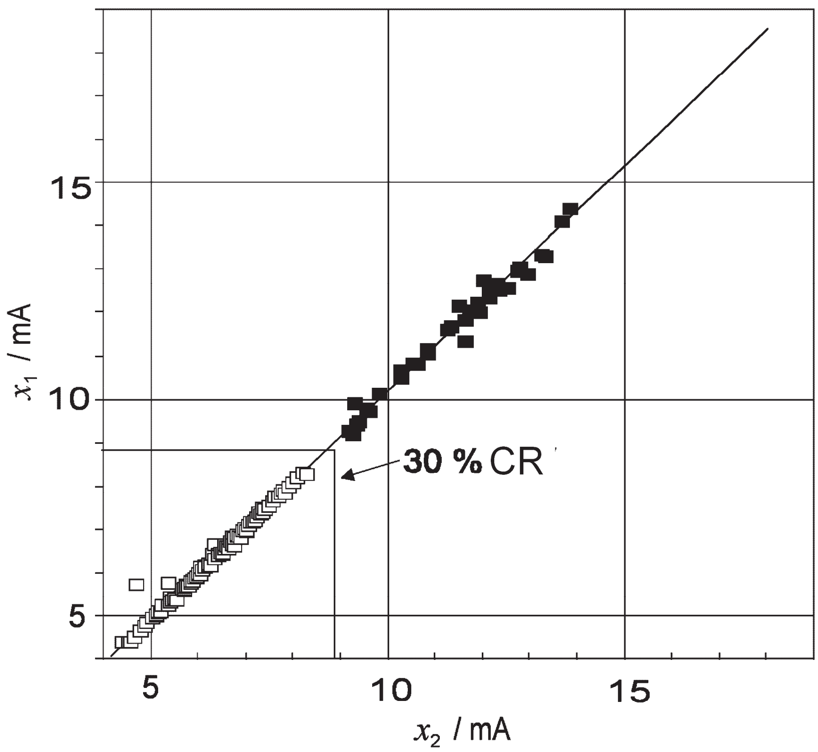
NOTE The determination of the reproducibility under field conditions is in accordance with ISO 5725-2.

In the report, the paired values shall be plotted on a graph in accordance with Figure 2. In the graph, the measured value pairs below 30 % of the certification range shall be identified separately.

The reproducibility calculation results shall deliver the following information in tabular form:

- concentration range of value pairs (e. g. in mg/m^3);
- number of value pairs above 30 % of the upper limit of the certification range;
- number of value pairs below 30 % of the upper limit of the certification range;
- total number of valid value pairs in the test period;
- reproducibility under field conditions, related to the measuring signal range (e. g. 4 mA to 20 mA for analogue outputs);
- certification range (e. g. signal range: 4 mA to 20 mA, concentration range: 0 mg/m^3 to 50 mg/m^3).

For calculating the uncertainty the standard deviation from the paired measurement values shall be documented.



Key

$x_{1,i}$, $x_{2,i}$	measured signals from the first and second instrument
CR	certification range (4 mA to 20 mA)
–	regression line
	measured signals < 30 % CR
■	measured signals > 30 % CR

Figure 2 — Graphical representation of measured signals used for determination of reproducibility under field conditions

13 Test report

The test report shall provide a comprehensive and detailed account of the testing and instrument performance.

Annex A gives an example of a suitable test report.

NOTE The test report is part of the documentation of the certified instrument.

Annex A
(informative)

Elements of recommended performance testing report

1. General

1.1 Certification proposal

1.2 Unambiguous instrument designation

1.3 Measured component(s)

1.4 Device manufacturer together with full address

1.5 Field of application

For example, the type of arrestment plant, its cleaning mechanism, and the possible presence of water droplets.

1.6 Measuring range for suitability test

1.7 Restrictions

For example if testing shows that the instrument does not cover the full scope of possible application fields.

1.8 Notes

Any preceding test reports and any equipment peculiarities.

1.9 Test laboratory

1.10 Test report number and date of compilation

2 Task definition

2.1 Nature of test

First test or supplementary testing.

2.2 Objective

Details of performance criteria tested;

Bibliography;

Scope of any supplementary tests.

3 Description of the instrument tested

3.1 Measuring principle

Description of metrological and scientific relationships.

3.2 Instrument scope and set-up

Description of all parts of the instrument covered in the scope of testing, if possible including a copy of an illustration or flow diagram showing the instrument. Statement of technical specifications, if appropriate in tabular form.

3.3 Manual Quality Control Procedures

Description of any manual procedures necessary to ensure correct operation of the entire instrument.

4 Test programme

Test programme, in relation to the instrument under test and in the case of supplementary or extended testing, the additional scope of testing Particularities of the test

4.1 Laboratory test / laboratory inspection

Statement of all test steps involved

4.2 Field test

Details on:

– all test steps involved;

– plant type on which the field test examinations were carried out;

– type of dust arrestment used during the test;

– instrument measuring range to be covered in the test;

– installation conditions and operating conditions for the instrument under test.

5 Standard reference method

5.1 Method of measurement

Variations from any method acknowledged as a standard reference method of measurement and described in European, international or national standards.

6 Test results

Comparison of the performance criteria placed on continuous emission instrument in the suitability test with the results attained.

Consecutive number and short title of performance criteria as heading.

6.1 Citation of performance criterion

6.2 Equipment

6.3 Method

6.4 Evaluation

6.5 Assessment

6.6 Detailed presentation of test results

Annex A Values measured and computed

Annex B Operating instructions

Bibliography

[1] EN 13284-1:2001, *Stationary source emissions — Determination of low range mass concentration of dust — Part 1: Manual gravimetric method*

[2] EN 15267-1, *Air quality — Certification of automated measuring systems — Part 1: General principles*

[3] EN 15267-2, *Air quality — Certification of automated measuring systems — Part 2: Initial assessment of the AMS manufacturer's quality management system and post certification surveillance for the manufacturing process*

[4] CEN/TS 15675, *Air quality — Measurement of stationary source emissions — Application of EN ISO/IEC 17025:2005 to periodic measurements*

[5] ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

[6] VIM, *International Vocabulary of basic and general terms in metrology* (BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML), 1993

This page has been intentionally left blank

BSI - British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001 Email: orders@bsigroup.com You may also buy directly using a debit/credit card from the BSI Shop on the Website http://www.bsigroup.com/shop

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact Information Centre. Tel: +44 (0)20 8996 7111 Fax: +44 (0)20 8996 7048 Email: info@bsigroup.com

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002 Fax: +44 (0)20 8996 7001 Email: membership@bsigroup.com

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsigroup.com/BSOL

Further information about BSI is available on the BSI website at http://www.bsigroup.com.

Copyright

Details and advice can be obtained from the Copyright and Licensing Manager. Tel: +44 (0)20 8996 7070 Email: copyright@bsigroup.com

BSI Group Headquarters 389 Chiswick High Road, London, W4 4AL, UK
Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
www.bsigroup.com/standards