



BSI Standards Publication

Water quality — General requirements and performance test procedures for water monitoring equipment — Measuring devices

National foreword

This British Standard is the UK implementation of EN 17075:2018+A1:2023. It supersedes BS EN 17075:2018, which is withdrawn.

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opératoires d'essai de performance pour les
équipements de surveillance de l'eau - Dispositifs de
mesure en continu

Wasserbeschaffenheit - Allgemeine Anforderungen und
Testverfahren zur Leistungsprüfung von Geräten zum
Wassermonitoring - Messgeräte

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European foreword

This document (EN 17075:2018+A1:2023) has been prepared by Technical Committee CEN/TC 230 “Water analysis”, 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of an identical text or by endorsement, at the latest by October 2023, and conflicting national standards shall be withdrawn at the latest by October 2023.

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

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This document supersedes EN 17075:2018.

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Introduction

This document defines general requirements and test procedures for verifying the performance of $\square_{A1}$ continuous measuring devices (CMDs) $\langle A1 \rangle$ used to monitor the quality of a wide range of waters including drinking waters, waste waters, and natural waters. It covers both portable $\square_{A1}$ continuous measuring devices (PCMDs) $\langle A1 \rangle$ and fixed position $\square_{A1}$ continuous measuring devices (FCMDs) $\langle A1 \rangle$. These devices include: sensors, single and multi-parameter instruments, discrete and batch instruments, probes and sondes. It excludes chemical test kits. For the purposes of this document the acronym $\square_{A1}$ CMD(s) $\langle A1 \rangle$ is used except where it is necessary to be specific about the particular type (e.g. $\square_{A1}$ PCMDs, FCMDs $\langle A1 \rangle$) or component of a $\square_{A1}$ CMD $\langle A1 \rangle$ (e.g. sensor).

This document is associated with EN 16479 [1] which covers automated sampling devices (samplers) for water and waste water.

The general requirements include several features that are necessary to meet users' applications and information that has to be included in associated documents.

The performance tests comprise testing carried out under laboratory and field conditions. They are designed to determine, in a systematic and consistent way, the capability of $\square_{A1}$ CMDs $\langle A1 \rangle$ to make reliable measurements. The testing focuses on key performance characteristics. Statistical procedures are defined for evaluation of the test data.

The range of measurements over which the test procedures will be applied, the test range, is not specified. It is for the $\square_{A1}$ CMD $\langle A1 \rangle$ manufacturer and/or the user to decide on the test range. Similarly, it is for the $\square_{A1}$ CMD $\langle A1 \rangle$ manufacturer and/or the user to decide on the intended uses (applications) which will inform the design of the field trial.

Water monitoring equipment is widely used for compliance monitoring purposes under national and European regulations. This document supports the requirements of the following EU Directives:

- Industrial Emissions Directive (2010/75/EU) [2];
- Water Framework Directive (2000/60/EC) [3];
- Marine Strategy Framework Directive (2008/56/EC) [4];
- Drinking Water Directive (98/83/EC) [5];
- Technical Specifications for Chemical Analysis and Monitoring of Water Status (2009/90/EC) [6].

1 Scope

This document specifies general requirements and performance test procedures for portable and fixed position $\boxed{A_1}$ continuous measuring devices $\langle A_1 \rangle$ that are used in an in-line or online operating position to measure physical and chemical measurands in water. It excludes chemical test kits and laboratory analysers.

The general requirements include functional facilities that $\boxed{A_1}$ CMDs $\langle A_1 \rangle$ need to meet users' applications and information that needs to be included in associated documents.

The test procedures specify uniform methods to be used when determining key performance characteristics of $\boxed{A_1}$ CMDs $\langle A_1 \rangle$. The performance tests comprise testing carried out under laboratory and field conditions. It is recognized that for some devices certain test procedures are not applicable.

Statistical procedures are defined for evaluation of the test data.

Example values for performance characteristics for a selection of $\boxed{A_1}$ CMDs $\langle A_1 \rangle$ for monitoring waste water effluents and receiving waters are detailed in Annex A for guidance.

This document requires the manufacturer of a $\boxed{A_1}$ CMD $\langle A_1 \rangle$ to provide more technical data for verification than does EN ISO 15839:2006 [7]. Consequently, EN ISO 15839 [7] will be of greater assistance to manufacturers wishing to characterize a new device whereas this document is more focussed on user requirements for the verification of manufacturer's claims.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 ISO 5814:2012, *Water quality - Determination of dissolved oxygen - Electrochemical probe method (ISO 5814:2012)*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

$\boxed{A_1}$

3.1 continuous measuring device CMD

component or a group of components, used in an in-line or on-line operating position, which continuously (or at a given frequency) gives an output signal proportional to the value of one or more measurands in waters which it measures

Note 1 to entry: The device can be portable or fixed in position.

$\langle A_1 \rangle$

3.2**portable continuous measuring device
PCMD**

continuous measuring device  that can be moved from one measuring point to another and used in an in-line or on-line operating position

3.3**fixed continuous measuring device
FCMD**

continuous measuring device  that can be fixed in position and used in an in-line or on-line operating position

3.4**sensor**

electronic device that senses a physical condition or chemical compound and delivers an electronic signal proportional to the observed characteristic

[SOURCE: ISO/IEC 19762:2016 [8], 06.02.08]

3.5**in-line measuring device
in situ measuring device**

system of automatic measurement in which at least the sensor is sited in the body of water

[SOURCE: ISO 6107-2:2006[9], 54, modified — term “analysis” replaced by term “measuring device” and within definition “analysis” replaced by “measurement”]

3.6**on-line measuring device**

system of automatic measurement in which the sample is taken from the body of water through a probe to the measuring device by means of an appropriate conduit

Note 1 to entry: Sometimes referred to as an extractive measuring device.

[SOURCE: ISO 6107-2:2006+A1:2012 [10], 71, modified — term “analysis” replaced by term “measuring device”, within definition “analysing equipment” replaced by “measuring device” and Note 1 to entry added]

3.7**percentage error**

error in measurement expressed as a percentage of the reference value

3.8**measurement bias****bias**

estimate of a systematic measurement error

[SOURCE: ISO/IEC Guide 99:2007 [11], 2.18]

3.9
measurement repeatability
repeatability

precision under a set of repeatability conditions of measurement

[SOURCE: ISO/IEC Guide 99 [11], 2.21]

Note 1 to entry: In this standard the ability of a $\boxed{A_1}$ CMD $\langle A_1 \rangle$ to provide closely similar indications for repeated measurements of the same measurand under the same conditions of measurement.

3.10
limit of quantification
LOQ

stated multiple of the limit of detection, for example two or three times the limit of detection, at a concentration of the measurand that can reasonably be determined with an acceptable level of accuracy and precision

Note 1 to entry: Limit of quantification can be calculated using an appropriate standard or sample, and may be obtained from the lowest calibration point on the calibration curve (excluding the blank). See ISO 6879 [12].

[SOURCE: ISO 6107-2:2006+A1:2012 [10], 61]

3.11
linearity

degree to which there is a straight-line relationship between the (mean) result of measurement (signal) and the quantity (concentration) of the component to be determined

[SOURCE: EN ISO 11885:2009 [13], 3.9, modified]

3.12
drift

slow change of output, at a constant input, of a measuring system

[SOURCE: EN ISO 15796:2005 [14], 2.8]

3.13
response time (t_{90})

time interval between the instant when a continuous measuring device is subjected to an abrupt change in measurand value and the instant when the readings cross the limits of (and remain inside) a band defined by the 90 % and the 110 % of the difference between the initial and final value of the abrupt change

[SOURCE: EN ISO 15839:2006 [7], 3.3, modified]

3.14
performance characteristics

set of parameters describing the performance of a $\boxed{A_1}$ CMD $\langle A_1 \rangle$

[SOURCE: EN ISO 15839:2006 [7], 3.27, modified]

3.15**measurement error**
error of measurement
error

measured quantity value minus a reference quantity value

Note 1 to entry: The concept of “measurement error” can be used both:

- a) when there is a single reference quantity value to refer to, which occurs if a calibration is made by means of a measurement standard with a measured quantity value having a negligible measurement uncertainty or if conventional quantity value is given, in which case the measurement error is known; and
- b) if a measurand is supposed to be represented by a unique true quantity value or a set of true quantity values of negligible range, in which case the measurement error is not known.

Note 2 to entry: Measurement error should not be confused with production error or mistake.

[SOURCE: ISO/IEC Guide 99:2007 [11], 2.16]

3.16**measurement uncertainty**
uncertainty of measurement
uncertainty

non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used

Note 1 to entry: The parameter may be, for example, a standard deviation called standard measurement uncertainty (or a specified multiple of it), or the half-width of an interval, having a stated coverage probability.

Note 2 to entry: In general, for a given set of information, it is understood that the measurement uncertainty is associated with a stated quantity value attributed to the measurand. A modification of this value results in a modification of the associated uncertainty.

Note 3 to entry: Measurement uncertainty includes components arising from systematic effects, such as components associated with corrections and the assigned quantity values of measurement standards, as well as the definitional uncertainty. Sometimes estimated systematic effects are not corrected for but, instead, associated measurement uncertainty components are incorporated.

Note 4 to entry: Measurement uncertainty comprises, in general, many components. Some of these may be evaluated by Type A evaluation of measurement uncertainty from the statistical distribution of the quantity values from series of measurements and can be characterized by standard deviations. The other components, which may be evaluated by Type B evaluation of measurement uncertainty, can also be characterized by standard deviations, evaluated from probability density functions based on experience or other information.

[SOURCE: ISO/IEC Guide 99:2007 [11], 2.26]

3.17**standard measurement uncertainty**
standard uncertainty of measurement
standard uncertainty

measurement uncertainty expressed as a standard deviation

[SOURCE: ISO/IEC Guide 99:2007 [11], 2.30]

3.18

combined standard measurement uncertainty

combined standard uncertainty

standard measurement uncertainty that is obtained using the individual standard measurement uncertainties associated with the input quantities in a measurement model

Note 1 to entry: In case of correlations of input quantities in a measurement model, covariances must also be taken into account when calculating the combined standard measurement uncertainty, see also ISO/IEC Guide 98-3:2008 [15], 2.3.4.

[SOURCE: ISO/IEC Guide 99:2007 [11], 2.31]

3.19

expanded measurement uncertainty

expanded uncertainty

product of a combined standard measurement uncertainty and a factor larger than the number one

Note 1 to entry: Expanded measurement uncertainty is termed “overall uncertainty” in paragraph 5 of Recommendation INC-1 (1980) (see the GUM) and simply “uncertainty” in IEC documents.

Note 2 to entry: The factor depends upon the type of probability distribution of the output quantity in a measurement model and on the selected coverage probability.

Note 3 to entry: The term “factor” in this definition refers to a coverage factor.

[SOURCE: ISO/IEC Guide 99:2007 [11], 2.35]

3.20

combined performance characteristic

combination of individual performance characteristics expressed as an expanded measurement uncertainty (with a coverage factor of 2)

3.21

test range

measuring range over which the $\langle A_1 \rangle$ CMD $\langle A_1 \rangle$ is tested

3.22

output

reading, or a digital, analogue, wired or wireless electrical signal, generated by a $\langle A_1 \rangle$ CMD $\langle A_1 \rangle$ in response to a measurand

3.23

rated operating condition

operating condition that must be fulfilled during measurement in order that a measuring instrument or measuring system perform as designed

Note 1 to entry: Rated operating conditions generally specify intervals of values for a quantity being measured and for any influence quantity.

[SOURCE: ISO/IEC Guide 99:2007 [11], 4.9]

3.24**interferent**

physical, biological or chemical property of the sample, excluding the measurand, that affects the output signal

[SOURCE: EN ISO 15839:2006 [7], 3.16, modified]

3.25**adjustment of a measuring system****adjustment**

set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

Note 1 to entry: Types of adjustment of a measuring system include zero adjustment of a measuring system, offset adjustment, and span adjustment (sometimes called gain adjustment).

Note 2 to entry: After an adjustment of a measuring system, the measuring system usually needs to be recalibrated.

Note 3 to entry: Adjustment of a measuring system should not be confused with calibration, which is a prerequisite for adjustment.

[SOURCE: ISO/IEC Guide 99:2007 [11], 3.11]

3.26**reference method**

method to be used to obtain the measurand value of the test waters, against which the readings from the $\boxed{A_1}$ CMD $\boxed{A_1}$ under test can be compared

3.27**measurand**

quantity intended to be measured

[SOURCE: ISO/IEC Guide 99:2007 [11], 2.3, modified]

3.28**reference operating condition**

operating condition prescribed for evaluating the performance of a measuring instrument or measuring system or for comparison of measurement results

[SOURCE: ISO/IEC Guide 99:2007 [11], 4.11]

3.29**flow cell**

housing within which a sensor can be held and through which the test water can be directed

3.30**up-time**

fraction of the total time for which usable measuring data are available from the $\boxed{A_1}$ CMD $\boxed{A_1}$

3.31**warm-up period**

interval between switching on power to the measurement circuit and the instant when the $\boxed{A_1}$ CMD $\boxed{A_1}$ produces a stable value when measuring a stable measurand

4 Symbols

For the purposes of this document, the following symbols apply.

b	Bias
t_{90}	Response time
X_L	$\boxed{A_1}$ Maximum deviation in linearity $\langle A_1 \rangle$
S_r	Repeatability
X_{IN}	Change in error due to variations in interferences
X_{SC}	Change in error due to incorrect salinity compensation
X_{LX}	Change in error due to variations in incident light
X_T	Change in error due to variations in ambient temperature
X_{RH}	Change in error due to variations in relative humidity
X_{ST}	Change in error due to variations in sample temperature
X_{SQ}	Change in error due to variations in sample flow-rate
X_{SP}	Change in error due to variations in sample pressure
X_O	Change in error due to variations in output impedance
X_V	Change in error due to variations in supply voltage
X_D	Change in error due to variations in drift
$\boxed{A_1}$ <i>deleted text</i> $\langle A_1 \rangle$	
U_C	Combined performance characteristic

5 Principles

The general requirements are based on experience of users' needs when operating a $\boxed{A_1}$ CMD $\langle A_1 \rangle$ in online or in-line measuring positions in a range of applications.

The performance characteristics are parameters that identify the capability of $\boxed{A_1}$ CMD $\langle A_1 \rangle$ to provide reliable measurements. They are determined as measurement uncertainty and expressed as percentage error (see 3.7) except for bias and repeatability which are expressed as relative values in percentage. For low concentration measurements where the reading approaches zero the percentage error value becomes inapplicable. At low concentrations the uncertainty should be expressed as an absolute value. The tables at Annex A list example values relevant to monitoring waste water effluents and receiving waters.

Measurement reliability includes:

- the $\boxed{A_1}$ CMD's $\langle A_1 \rangle$ measurement bias, LOQ, linearity, drift, repeatability and response time;
- operational influences arising from variations in supply voltage, output impedance, sample temperature, sample flow-rate and sample pressure;
- environmental influences arising from variations in ambient temperature, relative humidity, interferences and incident light.

The overall measurement reliability of a $\boxed{A_1}$ CMD $\langle A_1 \rangle$ is captured by bringing the individual performance characteristics together in the form of a combined performance characteristic expressed as measurement uncertainty.

The laboratory performance tests are designed to determine the values for the specified performance characteristics in a systematic and consistent way. Laboratory testing is used to determine each performance characteristic in turn in a controlled environment.

Statistical procedures are defined for evaluation of the laboratory test data to calculate the individual performance characteristic measurement standard uncertainties, u , and the combined performance characteristic measurement uncertainty, U_C . They are based on ISO/IEC Guide 98-3 to the Expression of Uncertainty in Measurement (GUM). The procedure for calculating the combined performance characteristic measurement uncertainty involves converting the individual performance characteristic uncertainties to standard uncertainties. This takes account of the probable distribution of errors. In the GUM, standard uncertainties are combined using a root sum of squares with due account taken of the contribution of each component through the use of sensitivity co-efficients. To determine sensitivity co-efficients, it is necessary to know the functions by which each component contributes to overall error. In the case of $\boxed{A_1}$ CMD $\langle A_1 \rangle$ testing this will rarely be known. Hence for the purposes of this standard, the sensitivity co-efficients are all taken as 1.

The combined performance characteristic, U_C , is expressed as an expanded uncertainty. The expanded uncertainty, (U), is obtained by multiplying the standard uncertainty by a coverage factor. The coverage factor is determined by the confidence level. This Standard uses a 95 % confidence with a coverage factor assumed to be 2.

Field testing is carried out to demonstrate the $\boxed{A_1}$ CMD's $\langle A_1 \rangle$ performance is maintained under representative operational conditions. $\boxed{A_1}$ FCMD $\langle A_1 \rangle$ field testing is carried out on an application that is representative of the intended use of the $\boxed{A_1}$ FCMD $\langle A_1 \rangle$. $\boxed{A_1}$ PCMD $\langle A_1 \rangle$ field testing involves the repeated use of the $\boxed{A_1}$ PCMD $\langle A_1 \rangle$ on several applications that are representative of the intended use of the $\boxed{A_1}$ PCMD $\langle A_1 \rangle$. A field trial can be a dedicated trial, or part of an acceptance trial, or in the case of $\boxed{A_1}$ FCMD $\langle A_1 \rangle$, be carried out on a device that has already been installed and is in operational use. The field performance tests are designed to determine the $\boxed{A_1}$ CMD's $\langle A_1 \rangle$ measurement error, the change in response time and variation in sensitivity between the beginning and end of the trial, the maintenance requirements and up-time. Response time and variation in sensitivity are indicators of how a $\boxed{A_1}$ CMD $\langle A_1 \rangle$ performs in real conditions.

During the field test the measurement error test is carried out by comparison with a reference method. Statistical procedures are defined for the evaluation of the measurement error test data. For each measurement pair the difference between the reference value and the $\boxed{A_1}$ CMD's $\langle A_1 \rangle$ reading is calculated as % error (except for pH and temperature for which absolute values apply). The value of the measurement error corresponding to the 90th percentile is calculated.

6 General requirements

6.1 Requirements for $\boxed{A_1}$ CMDs $\langle A_1 \rangle$

Unless otherwise stated a $\boxed{A_1}$ CMD $\langle A_1 \rangle$ shall have the following:

- a) a unique designation that unambiguously identifies it (e.g. model, serial number);
- b) for a $\boxed{A_1}$ FCMD $\langle A_1 \rangle$ a means of protection against inadvertent or unauthorized access to the control functions;
- c) an output signal and/or display;
- d) the units of measurement should be appropriate to the measurand being measured and should not require reference to a calibration chart or table or visual comparison;

- e) a means of indicating and/or communicating its operating status, for example, stand-by, maintenance mode or malfunction;
- f) for a $\boxed{A_1}$ FCMD $\langle A_1 \rangle$, a means of communicating fault conditions to an external system;
- g) for a $\boxed{A_1}$ CMD $\langle A_1 \rangle$ operating from an external power supply, a method of indicating loss of power supply (e.g. a relay that fails open);
- h) a method of indicating when the power supply voltage is below its normal operating limit (applies only to a $\boxed{A_1}$ CMD $\langle A_1 \rangle$ operating from a battery);
- i) a means of retaining all pre-set data, including calibration and alarm set points and adjustments, for a minimum period of 30 days for $\boxed{A_1}$ FCMDs $\langle A_1 \rangle$ and for 1 h for $\boxed{A_1}$ PCMDs $\langle A_1 \rangle$ after disconnection of the power supply;
- j) for a $\boxed{A_1}$ PCMD $\langle A_1 \rangle$, a means of calibration in the field, or where this is impractical, functionality checks that can be carried out in the field to verify correct operation;
- k) for a $\boxed{A_1}$ PCMD $\langle A_1 \rangle$, a self-contained power supply that consists of primary cells, rechargeable cells or any other power source that is capable of providing the necessary power under all operating conditions. An external power source can be used for recharging and / or operating the $\boxed{A_1}$ PCMD $\langle A_1 \rangle$, for example in a laboratory;
- l) a means of supporting the sensor unit (e.g. a chain) for $\boxed{A_1}$ CMDs $\langle A_1 \rangle$ that utilize a remote sensor (intended to be lowered into a watercourse, chamber or tank etc.).

6.2 Requirements for $\boxed{A_1}$ CMDs $\langle A_1 \rangle$ associated documents

Unless otherwise stated a $\boxed{A_1}$ CMD $\langle A_1 \rangle$ shall have associated documents which include the following information:

- a) a statement of the intended use (application) of the $\boxed{A_1}$ CMD $\langle A_1 \rangle$;
- b) operating instructions which cover the full functionality and measurement principle of the $\boxed{A_1}$ CMD $\langle A_1 \rangle$;
- c) a statement of the Limit of Quantification, where relevant to the measurement principle, the method by which it has been determined and the related measurement range for the $\boxed{A_1}$ CMD $\langle A_1 \rangle$;

NOTE 1 The expected method for the determination of LOQ is the one specified in this European standard at 9.3.2, however, it may not be applicable to all $\boxed{A_1}$ CMDs $\langle A_1 \rangle$ (e.g. pH).

- d) a statement about the storage life of scheduled consumable spares and reagents;
- e) identification of any special conditions (including advice from the supplier) necessary for the storage of consumable spares and reagents;
- f) a statement of installation conditions; including any requirements for sample pre-conditioning (e.g. filtration);
- g) a statement of the rated operating conditions for the power supply and / or battery;
- h) a statement of the rated operating conditions for the signal load impedance on any analogue output;

- i) a statement of the rated operating conditions for sample flow-rate, temperature and pressure, as appropriate;
- j) a statement of the rated operating conditions for ambient temperature and relative humidity;

NOTE 2 Guidance on the ambient temperature and relative humidity, by usage group, which A_1 CMDs A_1 are likely to be subject to is given in EN 60746-1:2003 [16].

NOTE 3 The influence of ambient temperature and relative humidity on the performance of a A_1 CMD A_1 is tested (see 9.3.4) over the rated environmental operating conditions.

- k) a statement of known chemical, biological and physical interferences to the measurement method and the maximum amounts at which the interferences remain acceptable for intended applications;

NOTE 4 Knowledge of interferences should be available from understanding of the operating principle, testing and practical applications of A_1 CMDs A_1 .

- l) for a A_1 CMD A_1 , recommendations for maintenance to ensure reliable operation can be made;

NOTE 5 A_1 Automatic A_1 routines for cleaning, maintenance, adjustment or recalibration can be used to maintain performance between manual interventions. It is the responsibility of the user to ensure that a suitable regime is adopted for a site-specific application.

- m) a statement of the ingress protection (IP) rating.

NOTE 6 Guidance on ingress protection is given in EN 60529 [17].

7 Performance characteristics

7.1 Performance characteristics determined by laboratory testing

The relevant characteristics are expressed as bias (b), change in error (X), or expanded uncertainty (U) as shown in Table 1. Annex B describes in detail how the values are calculated for each characteristic. Annex C provides example calculations.

Table 1 — Summary of performance characteristics determined by laboratory tests

Characteristic	Expression of characteristic	Test
Response time	The mean response times, t_{90} , for an increasing and decreasing step change.	9.3.1
Bias	The bias, b , measured at each test point	9.3.2
Linearity	The maximum deviation, X_L , from a straight line fitted to the measured values across the test range	9.3.2
Repeatability	The standard deviation, S_r , at each test point of the measurement values	9.3.2
Substance interference	The maximum change in error, X_{IN} , calculated in accordance with B.7.1 in Annex B.	9.3.3.2
Salinity compensation for dissolved oxygen A_1 CMDs A_1	The change in error, X_{SC} , calculated in accordance with B.7.1 in Annex B.	9.3.3.3

Characteristic	Expression of characteristic	Test
Incident light	The change in error, X_{LX} , calculated in accordance with B.7.1 in Annex B.	9.3.3.4
Ambient temperature	The change in error, X_T , calculated in accordance with B.7.3 in Annex B.	9.3.4
Relative humidity	The change in error, X_{RH} , calculated in accordance with B.7.2 in Annex B.	9.3.4
Sample temperature	The change in error, X_{ST} , calculated in accordance with B.7.3 in Annex B.	9.3.5
Sample flow-rate	The change in error, X_{SQ} , calculated in accordance with B.7.3 in Annex B.	9.3.6
Sample pressure	The change in error, X_{SP} , calculated in accordance with B.7.3 in Annex B.	9.3.7
Output impedance	The maximum change in error, X_O , calculated in accordance with B.7.1 in Annex B.	9.3.8
Supply voltage	The maximum change in error, X_V , calculated in accordance with B.7.1 in Annex B.	9.3.9
7-day drift ($\square_{A1}$ FCMD $\square_{A1}$ only)	The maximum change in error, X_D , observed during the drift test	9.3.10
Combined performance characteristic	An expanded uncertainty, U_C ($2 \times$ combined uncertainty) obtained by combining individual performance characteristics in accordance with the statistical procedures detailed at B.8 in Annex B.	-
Loss of power ($\square_{A1}$ FCMD $\square_{A1}$ only)	Changes in values of pre-set data, calibration data or alarm set points following loss of power	9.3.11
Warm up drift ($\square_{A1}$ PCMD $\square_{A1}$ only)	$\square_{A1}$ The time necessary for stabilizing the output signal $\square_{A1}$	9.3.12

A $\square_{A1}$ CMD $\square_{A1}$ shall be tested using reference methods, devices or materials to determine all of the performance characteristics listed in Table 1 that are appropriate to the particular $\square_{A1}$ CMD $\square_{A1}$. The values for the performance characteristics should be expressed as a percentage of reading, except for $\square_{A1}$ CMDs $\square_{A1}$ that measure pH which should be in pH units, and $\square_{A1}$ CMDs $\square_{A1}$ that measure temperature which should be in °C.

As the value of the measurand becomes small it is increasingly difficult to determine the bias of a measurement, expressed as a percentage of reading, in any meaningful way. This is caused by limitations on the resolution or accuracy of reference methods.

7.2 Performance characteristics determined by field testing

Table 2 provides a summary of the performance characteristics determined by the field tests specified in Clause 10.

Table 2 — Summary of performance characteristics determined by field tests

Performance characteristic	Expression of performance characteristics	Test
Period of test	FCMDs $\langle A_1 \rangle$ — Between 1 and 3 months of recorded data demonstrating continuous operation. PCMDs $\langle A_1 \rangle$ — At least 120 measurements taken over a period between 1 and 3 months.	10.2
Error (X)	A minimum of 24 measurements with a simultaneous reference measurement.	10.3
Change in response time	Measured at the beginning and end of the trial.	10.4
Variation in sensitivity	Measured at the beginning and end of the trial.	10.5
Maintenance	Reported as detailed in 10.6.	10.6
Up-time (V)	FCMDs $\langle A_1 \rangle$ — As calculated in 10.7. PCMDs $\langle A_1 \rangle$ — Not applicable.	10.7

8 Performance testing

8.1 Quality requirements for testing

FCMD $\langle A_1 \rangle$ testing shall be carried out in accordance with good quality management system practices. If test results are to be widely acceptable then testing should be carried out in accordance with EN ISO/IEC 17025 [18] or other equivalent standards.

The reference method used to test the FCMD $\langle A_1 \rangle$ shall be an appropriate European, international or national method.

When selecting a reference method consideration should be given to the physical and chemical speciation of the measurand to be measured as various species might be measured by different methods. The following considerations should be taken into account:

- dissolved matter is defined by reference methods as everything that passes through a 0,45 µm membrane filter;
- physical speciation of substances can occur leading to partitioning between solids, colloids, surfaces and dissolved phases, and chemical speciation between free ions, complexes with inorganic and organic ligands, different oxidation states etc. IUPAC recommendations provide more information [19];
- some measurands are empirical (e.g. turbidity, COD) which means that the measurement is dependent on the analytical method. The analytical methods to be used for reference purposes shall be reported.

Reference solutions shall be prepared in accordance with good laboratory practice. The preparation of air saturated water (100 % DO) reference solutions should take into account published guidance [20][21][22].

Consideration shall be given to the likely stability of reference solutions during the course of the performance tests. Instability could be caused by the nature of the measurand (e.g. DO), the duration of the test (e.g. see 9.3.4), variations in sample temperature (e.g. see 9.3.5), and variations in sample pressure (see 9.3.7). The concentration of the measurand in the reference solution should be checked by a method independent of the FCMD $\langle A_1 \rangle$ under test at the start of each test procedure and where the above considerations apply further independent measurements should be made, for example, prior to each test run.

The use of simulated inputs or secondary standards should be recorded and justified in the test report.

The uncertainty of the reference method shall be included in the calculation of the results for all tests except where the uncertainty of the reference method is no more than 1/5 of the value of the performance characteristic being determined. Further information is given at Annex D.

Fewer measurements than required by an individual test can be made if this can be justified, (e.g. where a pattern of low variability is supported by statistical analysis). If this approach is adopted it should be recorded and justified in the test report.

8.2 General requirements for testing

All required reagents for the operation of the $\boxed{A_1}$ CMD $\langle A_1 \rangle$ shall be prepared and stored according to the $\boxed{A_1}$ CMD $\langle A_1 \rangle$ manufacturer's specifications. If possible, reagents from the same manufacturing batch should be used throughout the testing period. If this is not possible, then the output of the $\boxed{A_1}$ CMD $\langle A_1 \rangle$ immediately before and after changeover of reagents should be noted so as to isolate possible reagent effects.

Laboratory test procedures shall be carried out in accordance with the following generic procedure.

Before each test the $\boxed{A_1}$ CMD $\langle A_1 \rangle$ shall be set up, calibrated and adjusted in accordance with the manufacturer's instructions.

The $\boxed{A_1}$ CMD $\langle A_1 \rangle$ should not be adjusted during the course of the test.

Disable any self-cleaning mechanisms or other automatic maintenance functions during any laboratory test unless these are part of each measurement cycle or if the test procedure requires that cleaning or maintenance is performed.

NOTE 1 Some devices include some form of cleaning or flushing as part of their normal measurement cycle. For example, TOC measurement devices that use a high temperature combustion method.

For dip or immersion sensors, during all tests (except the response time test 9.3.1) that use more than one reference solution, treat the sensor as follows:

- step 1: Rinse the sensor with clean water (i.e. water that does not contain the measurand or possible interferents) prior to the test, then rinse with the next value of the reference solution and finally immerse in fresh reference solution of the same value;
- step 2: Rinse the sensor with the next value of the reference solution and then immerse in fresh reference solution of the same value;
- repeat step 2 as necessary;
- if applicable, make the measurements, in every case, in continuously stirred solutions. Stirring rates should be adjusted to prevent the creation of air bubbles and in the case of turbidity devices the possibility of changing the particle size distribution in the sample.

To test the effect of influence quantities on $\boxed{A_1}$ CMDs $\langle A_1 \rangle$ it will be necessary to ensure that the full measurement cycle is carried out with the influence quantity at the values specified in the test. Thus, if a change in an influence quantity is effected during a measurement cycle, the output from that cycle should be discarded, and that from the next cycle, where the influence quantity is being held constant for the full duration of the cycle, shall be used.

Readings shall be allowed to stabilize after any change in influence condition or measurand value. The time allowed for stabilization of the readings is typically either 2 min or 3 times the response time of the $\overline{A_1}$ CMD $\overline{A_1}$, whichever is the greater.

NOTE 2 Devices that use a batch process can respond completely after one batch cycle. For these devices, if it is clear from examination of the results of the response time test (9.3.1) that the step change has been completed within a batch cycle then a stabilization time of one batch cycle will be sufficient.

Process the data from tests in accordance with the calculation methods summarized in Annex B.

8.3 Test conditions

Laboratory test procedures shall be carried out using the following test point values and reference conditions as appropriate to the $\overline{A_1}$ CMD $\overline{A_1}$ under test.

Table 3 — Test point values

Test point	Measurand value
1	$(5 \pm 2,5)$ % of the test range
2	(25 ± 5) % of the test range
3	(50 ± 5) % of the test range
4	(75 ± 5) % of the test range
5	(95 ± 5) % of the test range

In situations where the test points cannot be easily achieved or for specific user requirements other test points may be used. In such cases details of the amended test points and justification for their use should be recorded in the test report.

Tests shall be carried out with all influence quantities at their reference values, unless where specifically varied in any one test.

Table 4 gives the reference operating conditions for possible influence quantities.

Table 4 — Reference conditions

Influence quantity	Reference value	Tolerance
Ambient temperature ^a	18 °C to 25 °C	
Ambient humidity at 20 °C	< 60 %	
Incident light	Existing local light level	—
Sample temperature ^a	18 °C to 25 °C	
Sample pressure	⌈A ₁ ⌋ CMD ⌈A ₁ ⌋ rated value	±5 %
Sample flow-rate ^b	⌈A ₁ ⌋ CMD ⌈A ₁ ⌋ rated value	±5 %
Supply voltage (a. c.)	230 V ^c (or 110 V)	±6 %
Supply voltage (d. c.)	⌈A ₁ ⌋ CMD ⌈A ₁ ⌋ rated value	±2 %
Output impedance	⌈A ₁ ⌋ CMD ⌈A ₁ ⌋ maximum rated value	±1 Ω
Presence of known interferents	non-detectable	—
Conductivity (pH and ⌈A ₁ ⌋ CMD ⌈A ₁ ⌋ with ion selective electrodes only)	> 200 µS/cm	—
^a The stability of the ambient temperature and sample temperature shall not exceed ± 2,5 °C within the permitted reference range of 18 °C to 25 °C. ^b Where flow is required for a particular test procedure a stable value within the ⌈A ₁ ⌋ CMD ⌈A ₁ ⌋ rated range shall be used. ^c EN 60038 [23].		

8.4 Reporting

Results from the performance testing should be clearly reported. The test report should provide a detailed description of the ⌈A₁⌋ CMD ⌈A₁⌋ and a comprehensive account of the performance of the ⌈A₁⌋ CMD ⌈A₁⌋ during the laboratory and field testing. An example report format is provided at Annex E.

9 Laboratory test procedures

9.1 Guidance for establishing a test plan

Not all of the laboratory test procedures are relevant to all ⌈A₁⌋ CMDs ⌈A₁⌋. Before testing is started a test plan should be drawn up. Table 5 provides guidance on the relevance of each test procedure to different types of ⌈A₁⌋ CMDs ⌈A₁⌋.