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Water quality — On-line sensors/analysing equipment for water — Specifications and performance tests

Qualité de l'eau — Matériel d'analyse/capteurs directs pour l'eau — Spécifications et essais de performance

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 15839 was prepared by Technical Committee ISO/TC 147, *Water quality*.

Water quality — On-line sensors/analysing equipment for water — Specifications and performance tests

WARNING — Persons using this International Standard should be familiar with normal laboratory practice. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions.

1 Scope

This International Standard describes the performance testing of on-line sensors/analysing equipment for water. The standard is applicable to most sensors/analysing equipment, but it is recognized that, for some sensors/analysing equipment, certain performance tests cannot be carried out. This International Standard

— defines an on-line sensor/analysing equipment for water quality measurements;

— defines terminology describing the performance characteristics of on-line sensors/analysing equipment;

— specifies the test procedures (for laboratory and field) to be used to evaluate the performance characteristics of on-line sensors/analysing equipment.

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.

ISO 5725-1:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*

ISO 6879:1995, *Air quality — Performance characteristics and related concepts for air quality measuring methods*

ISO 8466-1:1990, *Water quality — Calibration and evaluation of analytical methods and estimation of performance characteristics — Part 1: Statistical evaluation of the linear calibration function*

ISO/TR 13530:1997, *Water quality — Guide to analytical quality control for water analysis*

3 Terms and definitions

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

3.1
accepted reference value
value that serves as an agreed reference value for comparison, and which is derived as:

a) an assigned or certified value based on experimental work of some national or international organization;

b) a consensus or certified value based on collaborative experimental work;

c) a theoretical or established value based on scientific principles;

d) when a), b) and c) are not available, the expectation of the (measurable) quantity, i.e. the mean of a number of measurements.

[Adapted from ISO 5725-1:1994]

3.2
accuracy
closeness of agreement between a measured value and the accepted reference value

NOTE The term accuracy, when applied to a set of measured values, involves a combination of random components and a common systematic error or bias component.

[Adapted from ISO 5725-1:1994]

3.3
analytical chain
set of instruments and actions covering all the steps involved in determining a reference value in a field test, including sampling, fractioning, conditioning, storage and transportation of the sample to the laboratory for analysis

3.4
availability
⟨measurement chain⟩ percentage of the full measurement period during which the measurement chain is available for making measurements

NOTE The full measurement period is the period which includes all specified automatic or manual maintenance operations at least once

cf. **up-time** (3.42)

3.5
bias
consistent deviation of the measured value from an accepted reference value

NOTE Bias is the total systematic error as contrasted to random error. There may be one or more systematic error components contributing to the bias. A larger systematic difference from the accepted reference value is reflected by a larger bias value.

[Adapted from ISO 5725-1:1994]

3.6
blank solution
solution, free of determinand, to which the on-line sensor/analysing equipment is exposed in the same way as calibration or sample solutions

NOTE The value of the measurement is known as the “blank value”.

3.7
calibration solution
solution containing a substance or mixture of substances giving a defined value of the determinand and used for calibration of the on-line sensor/analysing equipment

cf. **reference material** (3.30)

3.8
calibration procedure
set of operations that establishes, under specified conditions, the relationship between the amount or quantity of calibrant and the response indicated by the on-line sensor/analysing equipment

3.9
coefficient of variation
ratio of the standard deviation of the on-line sensor/analysing equipment to the mean of the working range of the equipment

[Adapted from ISO 8466-1:1990]

3.10
day-to-day repeatability
precision under day-to-day repeatability conditions

3.11
day-to-day repeatability conditions
conditions whereby independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment and reagents over several days

3.12
delay time
time interval between the instant when the on-line sensor/analysing equipment is subjected to an abrupt change in determinand value and the instant when the readings pass (and remain beyond) 10 % of the difference between the initial and final value of the abrupt change

NOTE For on-line sensor/analysing equipment with a sample-handling system the delay time frequently depends on the time needed to convey the sample from the sampling point to the analyser inlet.

cf. **response time** (3.33)

3.13
determinand
property/substance that is required to be measured and to be reflected by/present in a calibration solution

3.14
fall time
difference between the response time and the delay time when the abrupt change in determinand value is negative

cf. **delay time** (3.12) and **response time** (3.33)

3.15
interference
undesired output signal caused by a property(ies)/substance(s) other than the one being measured

[ASTM D 3864-96]

3.16
interferent
component of the sample, excluding the determinand, that affects the output signal

3.17
limit of detection
LOD
lowest value, significantly greater than zero, of a determinand that can be detected

3.18
limit of quantification
LOQ
lowest value of a determinand that can be determined with an acceptable level of accuracy and precision

3.19
linearity
condition in which measurements made on calibration solutions having determinand values spanning the stated range of the on-line sensor/analysing equipment have a straight-line relationship with the calibration solution determinand values

3.20
long-term drift
slope of the regression line derived from a series of differences between reference and measurement values obtained during field testing, expressed as a percentage of the working range over a 24 h period

3.21
lowest detectable change
LDC
smallest significantly measurable difference between two measurements

3.22
period between maintenance operations
time between successive maintenance operations on the measurement chain

NOTE The shortest period between maintenance operations will typically be of the order of a few hours (between two automatic rinse operations). The longest period between maintenance operations will typically be of the order of a few months (between services).

3.23
measurement
mean value of at least 10 consecutive readings

cf. **reading** (3.29)

3.24
measurement chain
set of instruments and actions that covers all the steps involved in measuring a determinand, including the on-line sensor/analysing equipment, sampling and pretreatment, transportation and storage of the sample

3.25
memory effect
temporary or permanent dependence of readings on one or several previous values of the determinand

[Adapted from ISO 6879:1995]

3.26
on-line sensor/analysing equipment
automatic measurement device which continuously (or at a given frequency) gives an output signal proportional to the value of one or more determinands in a solution which it measures (see Annex B)

3.27
performance characteristics
set of parameters describing the performance of the on-line sensor/analysing equipment and measurement chain

3.28
precision
the closeness of agreement between independent measured values obtained under stipulated conditions

NOTE 1 Precision depends only on the distribution of random errors and does not relate to the true value or the specified value.

NOTE 2 The measure of precision is usually expressed in terms of imprecision and computed as a standard deviation of the test results. Less precision is reflected by a larger standard deviation.

[Adapted from ISO 5725-1:1994]

3.29
reading
manual or automatic registration of the on-line sensor/analysing equipment response

NOTE Readings are taken with a frequency which depends on the dynamics of the on-line sensor/analysing equipment (i.e. on the response time — see 3.33 and 5.1.2).

3.30
reference material
substance, or mixture of substances, the composition of which is known within specified limits, and one or more of the properties of which is sufficiently well established, over a stated period of time, to be used for the calibration of an instrument or the assessment of a measurement method

3.31
repeatability
precision under repeatability conditions

[ISO 5725-1:1994]

3.32
repeatability conditions
conditions where independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment and reagents within short intervals of time (e.g. one day)

[Adapted from ISO 5725-1:1994]

cf. **day-to-day repeatability conditions** (3.11)

3.33
response time
time interval between the instant when the on-line sensor/analysing equipment is subjected to an abrupt change in determinand value and the instant when the readings cross the limits of (and remain inside) a band defined by 90 % and 110 % of the difference between the initial and final value of the abrupt change (see 5.2.1)

NOTE In laboratory testing, the response time of the on-line sensor/analysing equipment is measured. In field testing, it is the whole measurement chain which is tested.

3.34
rise time
difference between the response time and the delay time when the abrupt change in determinand value is positive

cf. **response time** (3.33)

3.35
ruggedness
on-line sensor/analysing equipment stability when the equipment is subjected to different environmental conditions which could possibly affect its performance

NOTE Ruggedness also describes the behaviour of the equipment in the hands of different operators who will inevitably introduce small variations in operations such as calibration and maintenance which may or may not have a significant influence on performance.

3.36
selectivity
extent to which the on-line sensor/analysing equipment can determine a particular determinand in a complex mixture without interference from the other components in the mixture

NOTE On-line sensor/analysing equipment which is perfectly selective for a determinand is said to be specific.

3.37
short-term drift
slope of the regression line derived from a series of measurements carried out on the same calibration solution during laboratory testing, and expressed as a percentage of the measurement range over a 24 h period

3.38
signal
conveyor of information about one or more determinands

NOTE An input signal is a signal applied to the on-line sensor/analysing equipment. An output signal is a signal delivered by the equipment.

3.39
stated range
range covered by the on-line sensor/analysing equipment as stated by the manufacturer/supplier

3.40
test procedure
series of measurements performed to determine the value of a performance characteristic

3.41
test bench
test facilities which are necessary to test on-line sensor/analysing equipment or a complete measurement chain

3.42
up-time
⟨measurement chain⟩ percentage of a full measurement period during which the measurement chain is actually measuring during field testing

cf. **availability** (3.4)

3.43
working range
range between the lowest and highest determinand value for which tests to determine precision and bias have been carried out

4 Determining on-line sensor/analysing equipment performance characteristics — An overview

Determination of the performance characteristics of on-line sensors/analysing equipment has, for practical reasons, to be divided into two parts: a laboratory test under controlled conditions and a field test under real-life conditions. However, the route followed in each of the tests, and the information/materials needed, can be described with the same diagram as shown in Figure 1.

The manufacturer/supplier who provides the on-line sensor/analysing equipment will also provide relevant information concerning operation of the equipment as indicated in Annex A. Based on the equipment properties and the different needs of measurement chains as given in Annex B, the appropriate test bench facilities shall be constructed (recommendations for this are given in Annex C).

After construction of the test bench facilities, a preliminary determination of the sensor/analysing equipment response time shall be carried out, providing information necessary for the timing of measurements. The performance characteristics shall be determined in accordance with the test procedures given in Clauses 5 and 6. The test schedule shall take into account the automatic and/or manual maintenance of the sensor/analysing equipment (see Annex D for an example). Finally, a test report shall be written (see Annex E for examples).

Use of the guidelines outlined in ISO/TR 13530 will ensure that the precision of the results of the laboratory tests is sufficiently high. During testing, use only reagents of recognized analytical grade.

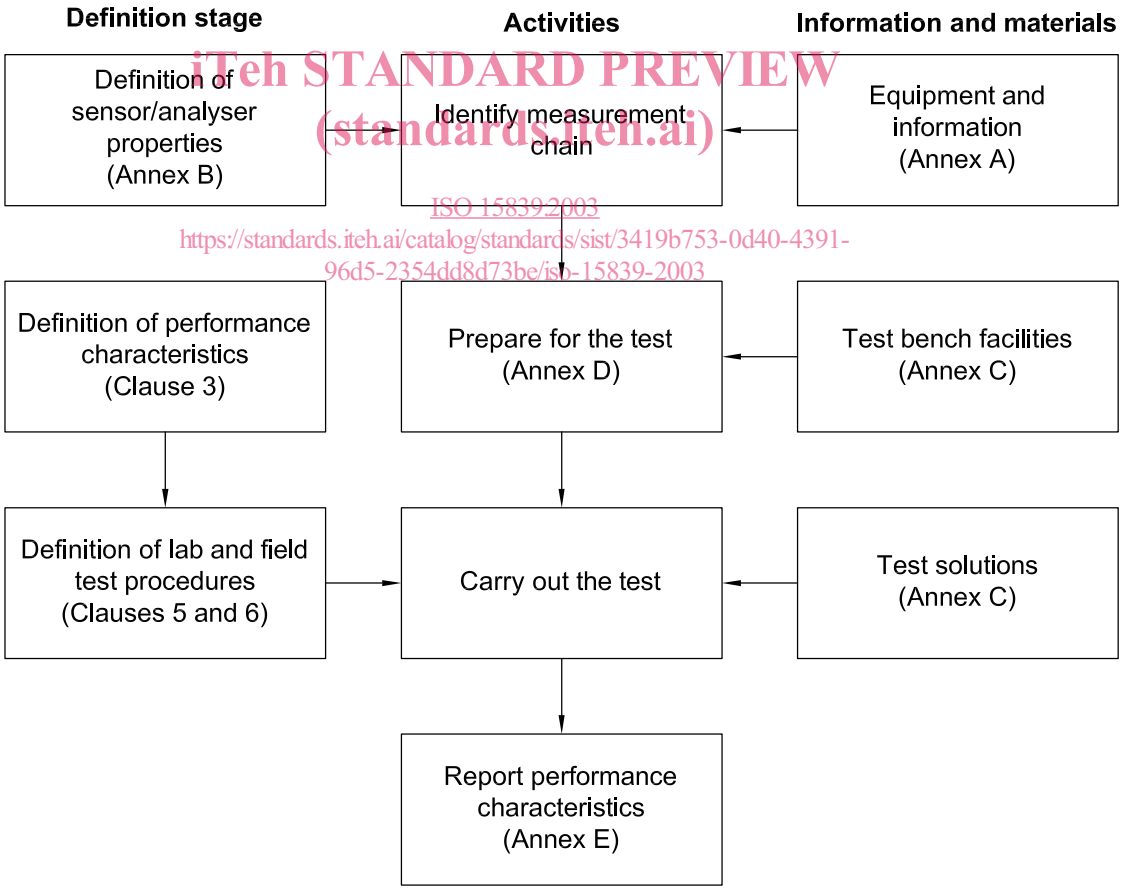

Figure 1 — Overview of test

5 Determination of performance characteristics in the laboratory

5.1 Preparation for the test

5.1.1 Equipment

The test bench facilities (see Annex C) may be different for different on-line sensors/analysing equipment. However, the following conditions shall be fulfilled for all on-line sensors/analysing equipment:

— The test bench facilities shall match the requirements specified for the sensor/analysing equipment by the manufacturer/supplier.

— The facilities shall include the ability to record (manually or automatically) readings of the sensor/analysing equipment in analog or digital form.

— Where appropriate, it shall be possible to change the calibration solution determinand value measured by the sensor/analysing equipment within less than 10 % of the response time declared by the manufacturer/supplier. (Typical examples where this is not appropriate are the determination of turbidity and electrical conductivity.)

— The facilities shall include laboratory instruments for analysis of the required determinand(s). The methods used and their precision shall be reported (see Annex E).

After receipt of the on-line sensor/analysing equipment to be tested, set up the sensor/analysing equipment together with the appropriate test bench facilities. Report the details of the test set-up (see Annex E). Use and maintain the sensor/analysing equipment in accordance with the instructions given by the manufacturer/supplier. Before testing is started, prepare a test schedule taking the measurement and maintenance periods into account (see Annex D).

5.1.2 Determination of details of measurement procedure

The working range used shall be within the declared working range. Carry out a preliminary determination of the sensor/analysing equipment response time by changing from one calibration solution to another, thus inducing an abrupt change. The calibration solutions used for this shall have determinand values of approximately 20 % and 80 %, respectively, of the working range. (A typical example where this is not appropriate is the determination of dissolved oxygen).

Expose the sensor/analysing equipment to the first calibration solution for a period equal to at least five times the response time declared by the manufacturer/supplier before changing to the second calibration solution. After the changeover, expose the sensor/analysing equipment to the second solution for the same length of time. During these two periods and the changeover, record the readings of the sensor/analysing equipment. The frequency at which readings are taken shall be at least 20 readings for each period corresponding to the response time as declared by the manufacturer/supplier.

From the record of the readings, determine the preliminary response time as described in 5.2.1. The time interval between readings in the subsequent laboratory test shall be approximately 10 % of the preliminary response time. A measurement shall consist of the mean of ten consecutive readings of the sensor/analysing equipment output signal after the signal has become stable, e.g. after a period equal to three times the preliminary response time.

To be sure that the calibration solutions have remained stable during the test, analyse samples of the calibration solutions before and after each test. No significant difference shall be found.

5.1.3 Monitoring the test

Although sensor/analysing equipment malfunction may be indicated automatically by the equipment's own diagnostic system, monitor the general performance of the sensor/analysing equipment during the test using a response chart (Figure 2). At least once a day during the test, carry out a measurement on one of the calibration solutions (the same strength solution each time).