DRAFT

ENVIRONMENT AGENCY

SPECIFICATION OF MCERTS PERFORMANCE STANDARDS AND CONFORMITY TESTING PROCEDURES

TURBIDIMETERS

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1. PURPOSE

The Environment Agency has established its Monitoring Certification Scheme: MCERTS to provide a framework within which quality environmental measurements can be made. MCERTS provides for the product certification of monitoring systems, (e.g. instruments, meters, analysers and equipment), the competency certification of personnel and the accreditation of laboratories under the requirements of European and international standards. A MCERTS register is being established. This includes details of monitoring systems, personnel and laboratories which have been certified as conforming with the MCERTS standards on the basis of conformity testing and assessment procedures. The Environment Agency intends to extend the Scheme further to include continuous water monitoring systems.

2. SCOPE

This document describes the performance standards and conformity tests that will be used to assess a turbidimeter for MCERTS certification. These performance standards apply to turbidimeters intended to be permanently sited and used for process and environmental monitoring or control applications which are regulated by the Environment Agency.

Typical ranges for turbidity measurements in these applications are given in Table 2.1 below. It is recognised that the actual ranges required for a specific regulatory application will be determined by the specific needs of the process. Therefore the following ranges are an indication of the overall ranges that may be encountered.

Table 2.1 Overall ranges for turbidity measurement

Application	**Range (FTU)**
Treated effluent monitoring	0 – 50
Process monitoring, including untreated discharges	0 – 2000
Water monitoring	0 – 5 to 0 – 500

Conformity testing comprises:

- a series of laboratory tests, to ensure that the turbidimeter meets the performance characteristics specified in this standard;
- field trails over a three-month period, to ensure that the turbidimeter is robust and continues to work and meet the performance characteristics in real applications.

During the laboratory tests, the turbidimeter will be assessed against the requirements for:

- range;
- documentation;
- maximum permissible error;
- repeatability error;
- drift;
- response time;
- analogue output signal impedance;
- power supply;
- loss of supply;
- instrument enclosure;

- sample flow-rate and pressure limitations;
- sample temperature;
- ambient temperature;
- relative humidity;
- incident light;
- entrained air.

During the field test the capability of an instrument to produce reliable measurements under field conditions and the maintenance activities required to ensure satisfactory measurement data will be assessed, by testing and reporting on:

- field test error;
- field response time;
- scheduled maintenance activities;
- unscheduled maintenance activities;
- up-time;
- reliability.

Throughout this document the terms 'MCERTS certificate' and 'certificate' refer to the MCERTS product conformity certificate and schedule of supporting information. Where all sub-clauses under a heading must be complied with, this is denoted by using a roman numbered list (i, ii, iii…). Where sub-clauses are alternatives, this is denoted by a lettered list (a, b, c…).

3. DEFINITIONS

3.1 Ancillary equipment

Any additional equipment which may be required for operation of the instrument on site but which does not normally form part of the instrument package. Examples include sampling systems, external data loggers or telemetry equipment, power conditioning devices, lightening protection, external pumps or compressors required for automatic cleaning systems.

3.2 Availability

Prediction of the proportion of total time, expressed as a percentage, for which an instrument is operational, i.e. available for measurement, over a period during which all maintenance activities are carried out at least once, excluding breakdowns.

3.3 Certification Body

The Certification Body manages the process of MCERTS testing and certification.

3.4 Certification Committee

The Certification Body's panel of experts who advise on the testing and certification of an individual instrument or series of instruments.

3.5 Determinand

The property that is required to be measured.

3.6 Dip sensor unit

Sensor unit designed to be located directly in a channel or tank and in contact with the process fluid.

3.7 Error

Difference between the value of the determinand obtained from the instrument and the value of the reference solution, after allowing for any errors in the test equipment.

3.8 Field reference solutions

Reference solutions based on the test fluid and made to specific turbidity values.

3.9 Field response time

The response time as measured under field conditions.

3.10 Field test error

Difference between the reference method value and the instrument measured value, as determined under field conditions, less the uncertainty of the reference method.

3.11 Flow cell

Sensor housing designed to be mounted directly in series with a process line or sample line.

3.12 Formazine turbidity units

One formazine turbidity unit (FTU) equals 1/400th of the Stock Turbidity of the suspension prepared by the method as set out in 'Methods for the Examination of Waters and Associated Materials - Colour and Turbidity of Waters 1981.

Informative note: Other systems of units are in common use for turbidity measurement. The nephelometric turbidity unit (NTU) is the turbidity of the sample measured by a detector at 90° from the source light. BS EN ISO 7027:2000 Water Quality – Determination of turbidity, uses formazine nephelometric units (FNU) and formazine attenuation units (FAU). There is no direct relationship between any of these units.

3.13 Highest range

The manufacturer's stated range with the highest upper range limit.

3.14 Indicating device

Visual display incorporated into the instrument showing the measured value of the determinand.

3.15 Influence quantity

Any quantity, generally external to the instrument, which may affect the performance of the instrument.

3.16 Insertion sensor unit

Sensor unit designed to be inserted directly into a process pipe.

3.17 Instrument

The device submitted for certification.

3.18 Interferent

Property of the test fluid, other than the determinand, which influences the measurement.

3.19 Limit conditions of operation

The entire range of values for any environmental, fluid or electrical parameter (beyond the rated range of use) within which the instrument is designed to function without resulting in damage or degradation of performance when it is afterwards operated within the rated ranges of use.

3.20 Lower range limit

The minimum value of the range, as stated by the manufacturer.

3.21 Lowest range

The manufacturer's stated range with the lowest upper range limit.

3.22 Maximum permissible error

The extreme values tolerated on the error when the instrument is operated within its rated range of use.

3.23 Range

The domain between the minimum and maximum values of the determinand which the instrument will measure within the maximum permissible error, as stated by the manufacturer. An instrument may have more than one range.

3.24 Rated range of use

The minimum to maximum values of any environmental, fluid or electrical parameter within which the instrument is designed to operate without adjustment, with errors within the maximum permissible error. The rated range of use will be a sub-set of the limit conditions of operation.

3.25 Reference conditions

Where all influence quantities are within their individual reference values, including tolerances.

3.26 Reference method

Method to be used to obtain the value of turbidity of the test fluid to a stated uncertainty, against which the readings from the instrument under test can be compared.

3.27 Reference solution

Solution with a known turbidity prepared by the method as set out in BS EN ISO 7027: 2000 Water quality – determination of turbidity, to a known and demonstrable level of uncertainty.

3.28 Reference value

Fixed value of an influence quantity within the limit conditions of operation which defines the reference condition for that quantity.

3.29 Repeatability error

A measure of the range of errors obtained by carrying out the same measurement on the same sample by the same operator, under the same conditions and over a short space of time. The repeatability error is calculated as the standard deviation of errors obtained from a series of successive measurements under reference conditions.

3.30 Response chart

Graph of readings derived from the instrument under test during the field test and independent measurements of the determinand value plotted against time.

3.31 Response time

The response time is the time interval between the instant when a sensor 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 the 90% and the 110% of the difference between the initial and final value of the abrupt change.

3.32 Secondary standard

Material having a fixed value for turbidity based on a substance other than formazine. Such standards are often specific to an individual instrument and are provided by manufacturers for calibration purposes.

3.33 Sensor

Transducer consisting of one or more components from which is derived an electrical output related to the turbidity of the sample.

3.34 Site occupier

Organisation responsible for the activity on the site where the field test is to take place.

3.35 Span

The absolute value of the difference between the lower and upper range limits, as stated by the manufacturer. A span will be associated with each range.

3.36 Supplier

Organisation submitting the instrument for certification. This may be the instrument manufacturer or an agent.

3.37 Test fluid

Process fluid on or in which the instrument is operated during the field test.

3.38 Test house

Organisation responsible for carrying out all or part of the testing required for MCERTS certification of an instrument.

3.39 Transmitter

Device which takes the signal from the sensor and converts it into a visual or electrical output proportional to turbidity. The transmitter may include a user interface with the instrument.

3.40 Turbidimeter

Device for measuring turbidity.

3.41 Turbidity

The optical property of particles suspended in a fluid that causes light to be scattered and absorbed rather than transmitted through the fluid without change. For the purpose of this specification all measurements of turbidity shall be expressed in formazine turbidity units (FTU).

3.42 Up-time

Measurement of the proportion of time during the field test, expressed as a percentage, for which the instrument is measuring.

3.43 Upper range limit

The maximum value of range, as stated by the manufacturer.

4. THE MCERTS PERFORMANCE STANDARD

4.1 Operational requirements

4.1.1 Range

The manufacturer shall state the range(s) for which certification is sought.

Note: Where different sensors or sensor configurations can be used to increase the overall range, the manufacturer shall identify the applicable range for each version.

4.1.2 Documentation

The manufacturer shall state the storage life and requirements of all the scheduled spares and reagents. Any special equipment required for the storage of these spares and reagents shall be identified by and be available from the manufacturer, their agent or other identified source.

4.1.3 Maximum permissible error

i) The maximum permissible error shall apply to all instrument outputs, including the indicating device.

ii) In the laboratory tests, for each range, the maximum permissible error shall be ±2% of span or ±0.2 FTU, whichever is the greater.

4.1.4 Field test error

The field test error shall not exceed ±4% of span or ±0.4 FTU, whichever is the greater, in more than 10% of the paired readings taken.

4.1.5 Repeatability error

The repeatability error shall be no greater than half the maximum permissible error.

4.1.6 Drift

The manufacturer shall state the time period over which the instrument shall make measurements within the maximum permissible error when operated continuously under reference conditions and without adjustment.

4.1.7 Response time

i) The manufacturer shall state the response time of the instrument under reference conditions, for a step change from 20% span to 80% span or from 80% span to 20% span, whichever is the longer.

ii) The field response time shall not exceed twice the manufacturer's claimed response time in more than 50% of the tests undertaken.

4.2 Electrical requirements

4.2.1 Analogue output signal impedance

Reference value: 100Ω. Tolerance on reference value: ±1Ω.

The manufacturer shall state the rated range of use for the signal load impedance on the analogue output.

4.2.2 Power supply

For a.c. powered instruments: Reference values 230V or 110V. Tolerance on reference values: ±10%.

For d.c. powered instruments: The manufacturer shall state the reference value and tolerance.

In all cases, the manufacturer shall state the rated range(s) of use for the power supply.

4.2.3 Loss of supply

i) All pre-set data, including calibration and alarm set points and adjustments, shall be retained for a minimum period of 30 days after disconnection of the power supply.

ii) Instruments operating from an external power supply shall have the facility to incorporate an alarm indicating loss of supply.

iii) Instruments operating from a battery shall incorporate a method of indicating when the power supply voltage is below its normal operating limits.

4.3 Environmental requirements

The rated ranges of use of the influence quantities below have been divided into the following three usage groups (see IEC 60746-1 Expression of performance of electrochemical analysers - Part 1: General.)

I. For indoor use under conditions which are normally found in laboratories and factories and where apparatus will be handled carefully.

II. For use in environments having protection from the full extremes of environment and under conditions of handling between those of groups I and III.

III. For outdoor use and in areas where the apparatus may be subjected to rough handling.

The manufacturer shall state the usage class(es) for the instrument.

Note: Different usage classes may apply to individual components of the instrument.

4.3.1 Instrument enclosure

i) All mechanical and electrical equipment and connections shall be protected against the ingress of dust and water and shall meet or exceed the requirements of one of the following rated ranges of use.

Usage group	Protection
I	EN 60529 IP54
II and III	EN 60529 IP65

ii) For instruments specified to EN 60529 IP65, the degree of protection for all electrical equipment and connections shall not be degraded below IP65 during normal calibration and routine maintenance procedures. It shall only be necessary to open the electrical equipment protective enclosure when carrying out long-term maintenance or when clearing electrical faults.

iii) The degree of protection provided for a dip sensor unit shall conform to the requirements of EN 60529 IP65/IP68 at a depth to be stated by the manufacturer.

Any electrical equipment or termination section provided with a dip sensor unit as part of the sensor unit, but not intended to be immersed, shall conform to the requirements of EN 60529 IP65 and be clearly marked with a warning that this equipment is not to be immersed.

iv) The minimum degree of protection provided for a flow cell mounted sensor unit or an insertion sensor unit, including any electrical equipment or termination section provided as part of the sensor unit, shall conform to the requirements of EN 60529 IP65.

4.3.2 Sample flow-rate and pressure limitations

For all sensor units, the manufacturer shall state the following information:

i) the sample flow-rate reference value;

ii) the sample flow-rate rated range of use;

iii) the sample flow-rate limit conditions of operation.

In addition, for flow cell and insertion sensor units the manufacturer shall state the following information:

i) the sample pressure reference value;

ii) the sample pressure rated range of use;

iii) the sample pressure limit conditions of operation.

4.3.3 Sample temperature

Reference value: 20°C. Tolerance on reference value: ±2°C.

The sensor unit shall have a minimum rated range of use of ±15°C about any mean sample temperature within the limit conditions of operation of 0°C to +50°C.

4.3.4 Ambient temperature

Reference value: 25°C. Tolerance on reference value: ± 2°C.

The minimum rated range of use for the sensor unit and secondary electronics are shown in the following table.

Usage class	Rated range of use
I	+5°C to +40°C
II	-10°C to +55°C
III	-25°C to +70°C

4.3.5 Relative humidity

Reference range at 25°C: 45% to 75% humidity.

The instrument shall have a rated range of use of 5% to 95% relative humidity including condensation.

4.3.6 Incident light

Reference value: existing local incident light intensity.

The turbidity sensor unit shall operate over the full range of incident light intensities from darkness to bright sunlight and shall have a minimum rated range of use of 1 lx to 5 x 10^4 lx.

4.3.7 Entrained air

Reference value: Below minimum detectable value.

The design of the instrument shall be such that air bubbles entrained in the sample flow do not become trapped around the sensor in such a way as to cause errors in excess of the maximum permissible error.

The minimum rated range of use shall be 0 to 10% of air by volume.

4.4 Maintenance requirements

A turbidimeter shall be suitable for its intended use taking account of the practical working conditions, and shall not require unreasonable demands of the user in order to maintain its measurement performance within the requirements of this standard.

Note: The maintenance requirements will be dependent on the precise application of the instrument and will be assessed in the field test as availability, up-time, scheduled manual maintenance and reliability.

4.4.1 Availability

For applications not requiring frequent maintenance, the availability should be at least 98% when the instrument is operated within its rated ranges of use.

For applications where frequent automatic or manual maintenance is required due to high concentrations of minerals or biogrowth potential, the availability should be at least 96%, when the instrument is operated within its rated ranges of use.

4.4.2 Up-time

The up-time, as assessed in the field test, shall not be less than 96% for clean water applications and 94% for applications where frequent automatic or manual maintenance is required due to high concentrations of minerals or biogrowth potential, when the instrument is operated within its rated ranges of use.

4.4.3 Scheduled manual maintenance

Manual maintenance should not be required more often than once a month when the instrument is operated within its rated ranges of use.

4.4.4 Reliability

The instrument shall not require more than three repairs during the field test.

5. GENERAL PROCEDURES FOR TESTING

5.1 Conformity testing process

Conformity testing of a turbidimeter is a two stage process comprising a series of laboratory tests against the performance criteria and a field test. The turbidimeter shall pass both stages in order to achieve certification.

Where more than one sensor or sensor configuration can be used to cover different ranges, one complete instrument shall undergo the full conformity tests. For additional sensors or sensor configurations, it may be possible to extend certification by carrying out a subset of the full test programme. Similarly, where different transmitters having different facilities may be used with a single sensor, one complete instrument shall undergo the full conformity tests. For additional transmitters, it may be possible to extend certification by carrying out a subset of the full test programme. This shall be agreed between the Certification Body and the supplier.

5.1.1 Role of the Certification Body

The Certification Body manages the overall process of testing and certification. The Certification body receives applications from suppliers for certification, agrees the test programme with the Certification Committee and in consultation with the applicant commissions an appropriate test-house to perform the tests.

5.1.2 Role of the Test House

The test house shall:

i) confirm its capability to carry out the test programme on the instrument;

ii) carry out the test programme to the standards required by the Certification Body, as contained in this document;

iii) collect and analyse all data in accordance with the procedures contained in this document;

iv) keep the Certification Body and supplier informed of progress throughout the test programme;

v) liase with the site occupier during the field test;

vi) communicate with the supplier promptly whenever there are any issues to resolve, or when the test house needs information or support in order to continue with the test-programme;

vii) handle and manage the instrument in a careful and appropriate manner, to ensure its integrity;

viii) maintain security and confidentiality of data;

ix) deliver copies of the completed test reports to the supplier and the Certification Body.

Note: Different test houses may be used for different stages of the test programme, e.g. for the laboratory and field tests.

5.1.3 Supplier

A supplier shall submit a complete instrument for testing. This shall comprise all the necessary components for operation, including any reagents, calibration standards, ancillary equipment, software, communications equipment and consumables.

The supplier shall also:

i) provide a complete set of documentation for the instrument, including any pertinent safety procedures and COSHH assessments for chemicals;

ii) provide declarations of the conformity to all relevant EC Directives;

iii) recommend values for all instrument set-up parameters (e.g. auto-cleaning timing), maintenance schedules and calibration intervals suitable for the field test;

iv) train the test-house staff in the correct operation of the instrument;

v) perform any maintenance and modifications as required;

vi) promptly provide any necessary additional information.

5.2 Uncertainty and traceability of measurements

5.2.1 The test house shall know and understand the traceability and uncertainty of all measurements used during the test procedures.

5.2.2 Any equipment used to test the instrument shall not appreciably (or only calculably) affect the values to be measured.

5.2.3 The errors associated with any test equipment should be no greater than $1/10^{th}$ of the maximum permissible error for the instrument.

5.2.4 When the error of the test equipment is greater than $1/10^{th}$ of the maximum permissible error for the instrument, the error of the test equipment shall be subtracted from the apparent error of the instrument under test, i.e. if the error of the test equipment is $\pm e_t$ and the apparent error of the instrument under test is $\pm e_a$, then:

$$\text{reported error} = \pm (e_a - e_t).$$

Where this correction is made, the test report shall state the value of the test equipment error, e_t, which has been applied.

5.2.5 Test equipment shall include all of the necessary reference solutions.

5.2.6 The test-house shall express all measurements with an uncertainty to a 95% confidence level.

5.2.7 The traceability of all values shall meet the requirements of BS EN ISO/IEC 17025, and all other applicable national or international standards of the appropriate quantities.

5.3 Termination

Any of the parties involved may request the termination of the test programme before its normal conclusion. The test house shall compile a report for submission to the Certification Body detailing the reasons for the termination of the test. The Certification Body shall decide on an appropriate course of action depending on the reasons for termination and the proportion of the test programme completed. Reasons for termination are as follows:

At the request of:

The supplier:	The instrument is expected to fail to meet the criteria for the award of an MCERTS certificate;
	The instrument is being discontinued or superseded by a new model;
	The supplier wishes to make substantial modifications to the instrument.
The test house:	Continued operation of the instrument poses an unacceptable safety risk to personnel or the integrity of the process or plant during the field test;
	If during the field test, changes to the test site conditions or process make the test unrepresentative;
	The supplier does not provide an adequate level of support when requested;
	Repeated failure of the instrument;
	Cause for suspicion that the instrument has been tampered with or that the test results are not representative of the true capability of the instrument.
The site occupier (field test):	Continued operation of the instrument poses an unacceptable safety risk to personnel;
	Continued operation of the instrument poses an unacceptable risk to the integrity of the process or plant.
The Certification Body:	Where matters are referred to the Certification Body for consideration by the supplier, test house or site occupier and where suitable reasons are given;

Testing is not being carried out in a rigorous manner or in accordance with this protocol.

6. LABORATORY PROCEDURES

6.1 General procedures for laboratory tests

6.1.1 Conformity tests shall be performed with the instrument ready for use after being installed and commissioned, including any warm-up time and adjustments, according to the manufacturer's instructions.

6.1.2 The instrument may be maintained, cleaned or recalibrated in line with manufacturer's instructions prior to any test, but adjustments shall not be carried out during the course of the test.

6.1.3 Any self cleaning mechanisms or other automatic maintenance functions shall be disabled during any test unless these are part of the normal measurement cycle or the test procedure states otherwise.

6.1.4 The analogue output, if present, shall be set to represent the range.

6.1.5 For dip sensors: during all tests which use more than one reference solution, the following sensor unit treatment shall be followed, unless stated otherwise in the particular test procedure.

The sensor unit shall be rinsed with demineralised water, then rinsed with the new solution and finally immersed in the beaker filled with fresh reference solution. The beaker shall be refilled each time it is used. In every case, measurements shall be made in continuously stirred solutions.

6.2 Operational conformity tests

6.2.1 Range

The manufacturer's documentation shall be examined to determine the instrument's range(s).

6.2.2 Documentation

The manufacturer's documentation shall be examined for a statement covering the storage life and requirements for spares and reagents.

6.2.3 Maximum permissible error

Test conditions: All influence quantities to be at their reference values, including tolerances.

This test shall be applied to each of the available outputs, e.g. local display, analogue output signal and/or digital output signal, and shall be repeated for each available range.

Expose the sensor unit, in turn, to five reference solutions with values distributed as follows:

1) Lower range limit + (5%±2.5%)span

2) Lower range limit + (25%±5%)span

3) Lower range limit + (50% ±5%)span

4) Lower range limit + (75%±5%)span

5) Lower range limit + (97.5%±2.5%)span

For each reference solution allow sufficient time for the reading to stabilise and record the readings from each output. Determine the error at each point.

Repeat the series of test points three times. Calculate the mean error for each output with each reference solution.

The instrument shall pass the test if the mean error for each output is no greater than the maximum permissible error at each test point.

6.2.4 Repeatability error

Test conditions: All influence quantities to be at their reference values, including tolerances. The instrument shall be set to its highest range.

Determine the error for each output with reference solutions having turbidity values at test points 1, 3 and 5 as defined under 6.2.3. Repeat each test point N times (where $N \geq 6$) and calculate the repeatability error for each output as the standard deviation of the errors at each point.

The instrument shall pass the test if the repeatability error for each output is no greater than half the maximum permissible error at each test point.

6.2.5 Drift

Test conditions: Automatic cleaning functions shall be enabled at a frequency agreed with the supplier. The instrument shall be set to its lowest range. The test may be carried out using any one output.

Determine the mean error from three measurements on a reference solution having a turbidity value at test point 2 as defined under 6.2.3 with all influence quantities at their reference values, including tolerances. Repeat after a period of 24 hours, with a further 6 determinations carried out at approximately equal intervals of time over a period of the manufacturer's stated recalibration interval.

Between measurements, the sensor shall be kept exposed to the solution with all influence quantities maintained within their rated ranges of use.

Note: Due to the unstable nature of formazine reference solutions, fresh solutions should be made up for each measurement. Alternatively, if a secondary standard is available, that may be used for this test.

The instrument shall pass the test if the mean error at each determination is no greater than the maximum permissible error.

6.2.6 Response time (laboratory)

Test conditions: All influence quantities to be at their reference values, including tolerances. The instrument shall be set to its highest range.

Provide means to apply a step change in the determinand to be applied to the sensor. For flow cell mounted sensors, this may be achieved using a three way diverter valve on the inlet to the cell. For dip sensors, two continuously stirred reference solutions contained in beakers may be used. When transferring the sensor unit from one beaker to the other, shake off the test solution from the sensor unit but do not wipe or rinse.

Provide the instrument with a reference solution having a value of [lower range limit + (20%±2%)span] until a constant output reading is obtained. Apply a step change by switching to a reference solution having a value of [lower range limit + (80%±2%)span]. Record an event marker at the instant of switching.

Continue to supply this reference solution until a constant reading between 90% and 110% of the value of the second reference solution is obtained. Apply a decreasing step change by reverting to the lower value reference solution, recording a second event marker at the instant of switching. Continue to supply the lower reference solution until a constant reading between 90% and 110% of the value of the lower reference solution is obtained.

Repeat the procedure 6 times and report the mean response times for an increasing and a decreasing step change.

The test shall be repeated for each electrical output.

Note: Should the instrument reading fail to maintain a value within the 90% to 110% band for the increasing or decreasing changes, report the value which it does reach. In such cases, it will not be possible to calculate the response time.

The instrument shall pass the test if the highest of the mean response times is less than or equal to the manufacturer's stated value.

6.3 Electrical conformity tests

6.3.1 Analogue output signal impedance

Test conditions: All other influence quantities to be at their reference values, including tolerances. The instrument shall be set to its highest range.

The manufacturer's documentation shall be examined to determine the rated range of use for the analogue output signal load impedance.

Connect the analogue output from the instrument to a variable resistance load. Expose the sensor unit to a reference solution having a turbidity value at test point 5 as defined under 6.2.3. Alternatively, using an appropriate simulator, apply an electronic signal representing [lower range limit + (95%±0.5%)span] to the secondary electronics.

Adjust the value of the load resistance in turn, to the upper limit and then the lower limit of the rated range of use. In each case, allow sufficient time for the reading to stabilise, record the value of the output signal and determine the error. Repeat three times and calculate the mean error under each load.

The instrument shall pass the test if neither mean error is greater than the maximum permissible error.

6.3.2 Power supply

Test conditions: All other influence quantities to be at their reference values, including tolerances. The instrument shall be set to its highest range.

The manufacturer's documentation shall be examined to determine the power supply rated range(s) of use.

Expose the sensor to a reference solution having a turbidity value at test point 3 as defined under 6.2.3. Adjust the power supply voltage, in turn, to the upper and then lower limit of the rated range of use. In each case, record the value of all outputs and calculate the errors. Repeat the test with the sensor exposed to reference solutions with turbidity values at test points 1 and 5 as defined under 6.2.3.

Repeat each measurement three times and calculate the mean error for each output, at each supply voltage and test point.

The test shall be repeated for each available power supply range.

The instrument shall pass the test if no mean error is greater than the maximum permissible error.

6.3.3 Loss of supply

i) Record the values of all pre-set data, calibration data and alarm set points. Disconnect the instrument from the power supply. After a period of 30 days reconnect the power supply and report any changes in the values of the pre-set data, calibration data or alarm set points.

   The instrument shall pass the test if all data has been correctly retained.

ii) This test is only applicable to instruments operating from an external power supply.

   The instrument shall be examined to determine whether it has the facility to incorporate a loss of supply alarm.

iii) This test is only applicable to instruments operating from a battery.

The instrument shall be examined to determine whether it has a method of indicating when the power supply voltage is below its normal operating limits.

6.4 Environmental conformity tests

6.4.1 Instrument enclosure

i) The tests detailed in EN 60529 Degrees of protection provided by enclosures (IP code), appropriate to the usage class(es) of the instrument shall be carried out.

ii) This test is only applicable to instruments specified to EN 60529 IP65.

The tests detailed in EN 60529 Degrees of protection provided by enclosures (IP code), for IP65 shall be carried out. Any covers which have to be opened or removed to enable calibration or maintenance to be carried out shall be opened/removed during this test.

iii) This test is only applicable to dip sensors.

The manufacturer's documentation shall be examined to determine the submersion depth for the sensor.

The tests detailed in EN 60529 Degrees of protection provided by enclosures (IP code), for IP65/IP68 shall be carried out. For the IP68 test, the depth shall be the maximum stated by the manufacturer and the duration a minimum of 30 days.

Any electrical equipment or termination section provided with a dip sensor, but not intended to be immersed, shall be examined for appropriate warnings. The tests detailed in EN 60529 Degrees of protection provided by enclosures (IP code), for IP65 shall be carried out on such parts.

iv) This test is only applicable to flow cell and insertion sensors.

The tests detailed in EN 60529 Degrees of protection provided by enclosures (IP code), for IP65 shall be carried out.

6.4.2 Sample flow-rate and pressure limitations

Sample flow rate

This test is applicable to all sensors.

Test conditions: All other influence quantities to be at their reference values, including tolerances. The instrument shall be set to its highest range. The test may be carried out using any one output.

Expose the sensor unit to a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Adjust the sample flow-rate, in turn, to the upper limit and the lower limit of

the rated range of use. In each case allow sufficient time for the reading to stabilise and record the indicated value. Determine the error at each flow-rate.

Repeat three times and calculate the mean error at each sample flow-rate.

The instrument shall pass the test if neither mean error is greater than the maximum permissible error.

Sample pressure

This test is only applicable to flow cell mounted and insertion sensors.

Test conditions: All other influence quantities to be at their reference values, including tolerances. The instrument shall be set to its highest range. The test may be carried out using any one output.

Expose the sensor unit to a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Adjust the sample pressure, in turn, to the upper limit and the lower limit of the rated range of use. In each case hold the pressure constant for a minimum period of 5 minutes to allow the instrument to stabilise and then record the indicated turbidity value. Determine the error at each sample pressure.

Repeat three times and calculate the mean error at each sample pressure.

The instrument shall pass the test if neither mean error is greater than the maximum permissible error.

6.4.3 Sample temperature

Test conditions: All other influence quantities to be at their reference values, including tolerances. The instrument shall be set to its highest range. The test may be carried out using any one output. For dip sensors, carry out the test in such a way as to ensure that the depth of immersion of the sensor unit is representative of the way in which the sensor unit is intended to be used.

Expose the sensor unit to a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Adjust the temperature of the reference solution, in turn, to the upper limit and then the lower limit of the sample temperature rated range of use. In each case allow sufficient time, after each adjustment of the sample temperature, for the parts of the sensor unit in contact with the sample, to reach a state of thermal equilibrium with the sample. Record the indicated turbidity values and determine the errors.

Repeat three times and calculate the mean error at each sample temperature.

The instrument shall pass the test if neither mean error is greater than the maximum permissible error.

6.4.4 Ambient temperature

Test conditions: All other influence quantities to be at their reference values, including tolerances. The instrument shall be set to its highest range.

If the sensor unit and the secondary electronics have the same ambient temperature rated range of use, then the instrument may be tested as a single unit. Otherwise, the components shall be tested separately at temperatures in accordance with their individual usage classes. The test report shall identify where a single test or individual tests has been carried out.

Informative note: EN 60068-2-1 Basic environmental testing procedures - Part 2: Tests - Test A: Cold, and EN 60068-2-2 Basic environmental testing procedures - Part 2: Tests - Test B: Dry Heat incorporate test procedures for non-heat-dissipating and heat-dissipating specimens. A specimen is considered heat-dissipating only if the hottest point on its surface, measured in free air conditions, is more than 5°C above the ambient temperature. The appropriate procedure for the individual instrument shall be followed and identified in the test report.

Introduce the specimen into the test chamber at the laboratory temperature.

Following the procedures in EN 60068-2-1 Basic environmental testing procedures - Part 2: Tests - Test A: Cold, for a gradual change in temperature, lower the temperature to the lower limit of the ambient temperature rated range of use.

The specimen shall be switched on and exposed to the low temperature conditions for a duration of 2 hours.

During the exposure period, any self-cleaning or auto-calibration routines shall be operated at least once.

Provide the sensor with a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Record the value of each output and determine the errors. Take two further sets of readings no less than 5 minutes apart and determine the mean error for each output.

After the recovery period, provide the sensor with a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Record the value of each output and determine the errors. Take two further sets of readings no less than 5 minutes apart and determine the mean error for each output.

Following the procedures in EN 60068-2-2 Basic environmental testing procedures - Part 2: Tests - Test B: Dry Heat, for a gradual change in temperature, raise the temperature to the upper limit of the ambient temperature rated range of use.

The specimen shall be switched on and exposed to the high temperature conditions for a duration of 2 hours.

During the exposure period, any self-cleaning or auto-calibration routines shall be operated at least once.

Provide the sensor with a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Record the value of each output and determine the errors. Take two further sets of readings no less than 5 minutes apart and determine the mean error for each output.

After the recovery period, provide the sensor with a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Record the value of each output and determine the errors. Take two further sets of readings no less than 5 minutes apart and determine the mean error for each output.

The instrument shall pass the test if no mean error is greater than the maximum permissible error.

6.4.5 Relative humidity

Test conditions: All other influence quantities to be at their reference values, including tolerances. The instrument shall be set to its highest range.

The instrument shall be tested in accordance with IEC 68-2-3 Basic environmental testing procedures - Part 2: Tests - Test CA: Damp Heat, steady state.

Introduce the instrument into the test chamber after pre-heating it to the chamber temperature.

The test severity shall be 4 days.

During the test, the instrument shall be in its operational state and, any self-cleaning or auto-calibration routines shall be operated at least once.

At the end of this period, provide the sensor with a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Record the value of each output and determine the errors. Take two further sets of readings no less than 5 minutes apart and determine the mean error for each output.

After the recovery period, provide the sensor with a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Record the value of each output and determine the errors. Take two further sets of readings no less than 5 minutes apart and determine the mean error for each output.

The instrument shall pass the test if no mean error is greater than the maximum permissible error.

6.4.6 Incident light

Test conditions: All other influence quantities to be at their reference values, including tolerances. The instrument shall be set to its lowest range. The test may be carried out using any one output. The sensor shall be in the most unfavourable operating mode. For example, in the case of a flow cell mounted sensor which has to be removed from the flow cell for the purpose of calibration, conduct the test with the sensor immersed in a container of reference solution such that the test replicates the conditions which occur during the calibration procedure.

Expose the sensor to a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Adjust the illumination intensity, in turn, to the upper limit and then the lower limit of the

rated range of use and record the indicated value in each case. Determine the error under each test condition.

Repeat three times and calculate the mean error for each illumination intensity.

The instrument shall pass the test if neither mean error is greater than the maximum permissible error.

6.4.7 Entrained air

Test conditions: All other influence quantities to be at their reference values, including tolerances. The instrument shall be set to its lowest range. The test may be carried out using any one output.

Expose the sensor unit to a reference solution having a turbidity value at test point 3 as defined in 6.2.3. Adjust the sample flow-rate to the reference value and record the indicated value. Inject air through a diffuser, with a pore size of 10μm to 20μm, into the flowing sample at a rate of 8% ±2%v/v of the sample flow-rate. After a period of 15 minutes turn off the flow of air then, after a further period of 5 minutes, record the indicated value. Determine the error.

Repeat three times and calculate the mean error.

The instrument shall pass the test if the mean error is no greater than the maximum permissible error.

6.5 Reporting of results

6.5.1 Equipment tested

The report shall include, as a minimum, the following details of the instrument under test:

1. manufacturer's name;
2. manufacturer's address;
3. the supplier's name and address where the instrument was submitted for testing by someone other than the manufacturer;
4. model name and number;
5. serial number(s) of the instrument tested;
6. software version number;
7. details of any ancillary equipment provided with the instrument;
8. details and source of reagents and consumables used during the tests.

6.5.2 Test programme

The report shall identify:

1. the tests required and those carried out;
2. any deviations from the stated test procedure;
3. the name of the test house which carried out the testing and location of the laboratory;
4. the period over which the testing took place;
5. the name of the sponsor of the test programme.

6.5.3 Test results

The test report shall state, for each test carried out:

i) where there is a numeric result(s), the value(s) after adjustment for testing error and the reference conditions during the test;

ii) where there is a specific requirement(s), the nature of the requirement(s) and whether the instrument met the requirement(s).

All the data obtained for each test carried out shall be included as an appendix to the test report. This data shall be represented in tabular or graphical form as appropriate.

6.5.4 Comments

The test report shall record any unexplained or unexpected results from the instrument and any requirements for manual intervention that are not adequately documented in the defined test results.

7. FIELD TEST PROCEDURE

7.1 Introduction

7.1.1 The field test may be carried out either on an instrument specifically installed for the test, or on an instrument already installed and in operation. In either case, the site shall meet the criteria described in Section 7.5.1 and the procedures contained within this protocol shall be followed.

7.1.2 It is recognised that no two applications will be identical and that site and ambient conditions will be subject to variability. This protocol defines the broad conditions under which tests should be carried out, the approach to be taken and the data that should be reported in order to give some comparability between reports.

7.1.3 It is also recognised that matters such as how straightforward an instrument is to use can be subjective. However, such considerations are important to MCERTS because an instrument which is overly complicated or difficult to use can provide more scope for operator error, and hence poor measurement, than one which is straightforward to use. It is thus important that each field test is approached in a systematic manner and without preconceptions.

7.2 Structure of field test

The field test is a procedure with 4 clear stages. Previous stages shall be completed before proceeding to the next stage.

These stages are:

1. Site selection and approval
2. Installation and initial checks
3. Main test period
4. Decommissioning and reporting.

The requirements for each stage are dealt with in Sections 7.5 to 7.10 inclusive.

7.3 Ambient condition monitoring

Ambient conditions at the test site shall be monitored for the duration of the field test. For all tests, the test house shall maintain daily records of:

- Ambient temperature – maxima and minima;
- Ambient pressure – maxima and minima;

- Relative humidity – maxima and minima;
- General weather conditions.

The Certification Body may also request the monitoring of further parameters where they are thought to have an influence on the performance of the instrument under test.

It shall be identified and reported when the ambient conditions fall outside the rated range of use for the instrument.

The final report shall identify the maximum, minimum and mean values for each ambient condition parameter over the test period.

7.4 Test fluid monitoring

The test fluid shall be monitored for the duration of the test.

The turbidity shall be monitored independently of the instrument, to a known and stated uncertainty, in order to determine general trends. A response chart should be plotted showing the monitored turbidity against the values derived from the instrument over time.

Other parameters which shall be monitored are:

- fluid temperature;
- fluid pressure;
- fluid flow-rate past sensor (for dip and insertion sensors);
- fluid flow-rate to inlet of flow-cell sensors;
- suspended solids content;
- presence of colloidal particles;
- presence and quantity of entrained gases;
- presence and nature of fouling matter (including the presence and quantity of manganese iron, grease and fat);
- presence and quantity of known and suspected interferents;
- colour;
- biogrowth potential (by observation of the instrument or measurement of BOD and nutrients – nitrate and phosphate - in the test fluid).

The Certification Body may also request the monitoring of further parameters in the test fluid where they are thought to have an influence on the performance of the instrument under test.

It shall be identified and reported when the fluid conditions fall outside the rated range of use for the instrument.

The final report shall identify the maximum, minimum and mean values for each test fluid parameter over the test period. The measurement uncertainty for each parameter shall also be reported.

7.5 Site selection and approval

7.5.1 Criteria for test site

The test site shall be agreed between the test house and the supplier, and, before tests commence, shall be approved by the Certification Body (see below). There shall be full agreement between the site occupier and the test house for the testing to be carried out at the site.

Note: The site occupier must be made aware that details of the site, process and test fluid which are pertinent to the field test shall be made available where necessary in the final test report.

The site shall conform to the following criteria:

- The test site shall be representative of the identified application.
- The range of values or concentrations and the pattern of variability of the determinand at the test site shall be typical for that application.
- The site shall be operating normally and continuously for the duration of the test.
- There shall be no planned disruption to the site or process during the period of the field test which may impact on the operation of the instrument.
- There shall be no potential sources of damage or interference to the instrument which would make the site atypical of most locations where instruments are to be installed.
- Arrangements shall be made for safe access to the test site and the instrument. These arrangements shall facilitate the smooth running of the tests whilst taking due regard of site safety and security.
- Facilities shall be made available at the test site as required for the operation of the instrument or reference method during the testing. *Note: Some of these facilities may be installed on a temporary basis for the purpose of the field test.*

7.5.2 Site report

A site report shall be compiled by the test house which includes the following details:

- name of site occupier;

- address of test site;
- nature of activity on the test site;
- signed formal agreement of site occupier (see Appendix B);
- specific application of the instrument;
- nature of the test fluid;
- specific test site location details where the instrument is to be installed (distance between components, whether in the open air or under cover etc);
- expected range of determinand values or concentrations (where available this information shall be supported by historical records);
- expected content of known interferents and fouling materials;
- facilities to be used for monitoring ambient conditions;
- facilities to be used for monitoring the instrument.

The report shall also include details of:

- the instrument supplier, manufacturer and model;
- the status of the instrument (whether production model, pre-production prototype etc.)
- options on the specific instrument undergoing test (e.g. size, format, housings, auto-cleaning facilities etc.);
- where relevant, the date of installation and installer;
- ancillary equipment to be installed or supplied;
- reference method to be used;
- background parameters to be monitored;
- proposed timetable for the field test, including reporting dates.

7.5.3 Site approval

The site report shall be submitted to the Certification Body for consideration. The Certification Body shall either:

- approve the site report in which case the test progresses to Stage 2;
- approve the site report subject to identified changes which, when made, allow the test to progress to Stage 2; or

- request that an alternative site be found, in which case Stage 1 shall be repeated.

7.6 Installation and initial checks

7.6.1 Installation

Once the site report has been approved by the Certification Body, the instrument and ancillary equipment shall be installed at the test site and commissioned in accordance with the supplier's recommendations. This may include an initial calibration, where relevant. For existing installations, the instrument and ancillary equipment shall be serviced and checked by the supplier before the field test commences. Any worn or damaged parts and consumables shall be replaced by the supplier.

All additional equipment required for monitoring the ambient conditions and the test fluid shall be installed.

The values of all user set parameters shall be recorded by the test house.

7.6.2 Verification period

There shall be a two week verification period to verify that the instrument, ancillary equipment and background data collection are operating correctly. During this time the following checks shall be undertaken:

- the supplier shall formally approve the installation;
- the test house shall verify the correct operation of any data recording system;
- the test house or supplier shall verify the correct operation of any ancillary equipment;
- the test house shall validate any sampling system by comparing the value of the turbidity from a sample taken at the point of extraction by the sampling system, with that obtained from a second sample taken at the point of delivery to the instrument;
- the correct operation of the instrument shall be verified by collecting a minimum of ten paired reference measurements and determining the field test error for each. Each pair shall comprise a reading from the instrument under test and a reading obtained from the reference method taken in a way that ensures comparability between the two readings, i.e. any sample shall be taken from the fluid just before it enters the measuring cell or reaches the sensor. Delays in analysis time shall also be taken into account. A maximum of 4 pairs may be taken per day, spread throughout the day and at different times on each day;
- a minimum of two measurements of the field response time shall be made following the procedures in 7.8.4;
- the test house or supplier shall observe the correct operation of any auto-cleaning or auto-calibration routines;

- the data from the instrument under test shall be characterised against the method used for the independent monitoring of the turbidity to establish the trends and the standard deviation between the two sets of measurements. This data will be used to interpret the response chart and determine when maintenance is required on the instrument under test.

7.6.3 Changes

Any changes made either at the request of the supplier or in light of data collected during this verification period shall be recorded.

7.6.4 Reporting

The test house shall compile a report containing the following information:

- details of the instrument installed;
  - instrument type
  - manufacturer's name and address
  - supplier's name and address
  - date of installation
  - installer
  - model number(s)
  - serial number(s)
  - operating method
  - measurement range
  - power supply
  - output(s) used during test
  - ancillary equipment
  - options tested
- details of the test site preparation and services required,
- hardware specification of computer on which any software required for the operation of the instrument was installed;
- any problems or difficulties encountered;
- time taken in man-hours to perform any initial calibration routine;

- any problems or difficulties with the initial calibration, including number to attempts to obtain a successful calibration;
- supplier's approval of the installation;
- results from the determinations of field test error and field response time.

7.7 Main test period - general operation

7.7.1 The test house shall inform the Certification Body when the main test period has started.

7.7.2 The main test period shall last 12 weeks.

7.7.3 During the main test period, the instrument shall be operated continuously on the test fluid, except as for such periods when maintenance and calibration procedures are undertaken or as required to carry out performance tests (see 7.8).

7.7.4 The measurements made by the instrument shall be logged over time at a frequency appropriate to the application, subject to a minimum frequency of one reading every 15 minutes.

7.7.5 Any scheduled maintenance shall be carried out in accordance with the supplier's recommended procedures by the test house (see 7.9.1).

7.7.6 During the main test period the supplier will not have access to the instrument unless invited by the test house in order to carry out specific maintenance or repairs.

7.7.7 Test site conditions shall be monitored and recorded including:

- ambient conditions (see 7.3);
- test fluid conditions (see 7.4);
- unexpected events or activity on site which may impact on the instrument under test or on the test fluid being monitored.

7.7.8 At the end of the first month, the test house shall provide the supplier and the Certification Body with a summary of the data obtained. This shall include summaries of:

- background data (ambient and fluid conditions);
- results from performance tests;
- any unscheduled maintenance carried out;
- any unexpected events or activity on site which may have impacted on the instrument under test or the test fluid being monitored;
- any difficulties or problems experienced with the instrument or maintenance procedures.

Testing will continue though the supplier may recommend changes to the maintenance schedule or minor modifications to the instrument or ancillary equipment. Any such changes or modifications shall be agreed with the test house and recorded. Major modifications, e.g. replacement of major components, redesign of sampling system, should be referred to the Certification Body for consideration.

7.7.9 A draft test report (see 7.10.1) shall be compiled by the test house and submitted to the Certification Body no later than two weeks prior to the conclusion of the field test.

7.8 Performance tests

7.8.1 Timing of performance tests

Performance tests, i.e. field test error and field response time, shall only be carried out when the ambient and fluid conditions are within the rated ranges of use for the instrument.

The timing of performance tests shall be chosen such that:

- the turbidity is stable (i.e. does not change by more than ±5% whilst each pair of readings is being taken);
- they are carried out at a number of different times during the normal operating cycle(s) for the site whether these be diurnal, weekly or monthly;
- they are spread across as wide a range of turbidity values encountered on the test site as possible;
- they encompass as wide a range of the variations occurring in the test fluid as practicable;
- they are carried out at a number of different points during the maintenance cycle of the instrument.

7.8.2 Reference method

The reference method shall be to expose the sensor to reference solutions. Formazine may be used, made up in accordance with ISO7027:2000 under quality assured conditions to a stated uncertainty. ISO7027:2000 also includes data on a synthetic polymer which shows good correlation to the formazine standard. This may be preferred as the production of formazine requires the use of chemicals which are known to be carcinogenic. Proprietary secondary standards may be used for routine calibration activities in line with manufacturer's instructions but cannot be used to derive field test error values.

7.8.3 Field test error

During the main test period a number of paired readings shall be taken as described below. Each pair shall comprise a reading from the instrument under test and a reading from the reference method taken in a way that ensures comparability between the two readings, i.e.

any sample shall be taken from the fluid just before it enters the measuring cell or reaches the sensor. Delays in analysis time shall also be taken into account.

The frequency of paired readings shall be as follows:

- A minimum of twelve paired readings shall be taken in each 4 week period (i.e. weeks 1 to 4, weeks 5 to 8, weeks 9 to 12).
- No less than two paired readings and no more than five paired readings shall be taken each week.
- No more than two paired readings shall be taken on any one day.

For each pair, the field test error shall be the difference between the reference method value and the instrument measured value less the uncertainty of the reference method.

7.8.4 Field response time

The field response time test shall be carried out to the following schedule:

- twice a week during the first two weeks;
- once a week thereafter.

For the field response time test, the field reference solutions are based on the test fluid. A high concentration field reference solution shall be made by taking a sample of test fluid and increasing the turbidity to the maximum for the sensor as set up on site. A low concentration field reference solution shall be made by taking a sample of test fluid and decreasing the turbidity to the minimum for the sensor as set up on site.

The high concentration field reference solution should have a value or concentration of the determinand of [lower range limit + (80%±5%)span]. The low concentration field reference solution should have a value or concentration of the determinand of [lower range limit + (20%±5%)span].

Note: care should be taken to ensure that the method of altering the turbidity does not produce significant changes in the overall fluid matrix which will give rise to misleading results. The method of adjusting the turbidity should be reported.

Dip sensors

Dip or insertion type sensors shall be removed from the test fluid and immediately immersed into the low field reference solution. The reading shall be allowed to stabilise. The sensor shall be transferred to the high field reference solution. Record an event marker at the instant of transfer.

Wait until the reading remains in a band between 90% and 110% of the value of the second reference solution. Apply a decreasing step change by reverting to the lower value reference solution, recording a second event marker at the instant of transfer. Wait until the reading remains in a band between 90% and 110% of the value of the lower reference solution.

During removal from the test fluid and transfer between the field reference solutions care shall be taken not to disturb or remove any fouling. Stirring of the reference solutions should also not disturb any fouling material on the sensor.

Flow cell mounted sensors

For flow cell mounted sensors, provision shall be made to introduce the field reference solutions at the point of entry to the instrument.

The test fluid supply shall be shut off and the low field reference solution introduced without any purging of the pipes. The reading shall be allowed to stabilise at the low value. Apply a step change by switching to the high field reference solution, recording an event marker at the instant of switching.

Continue to supply this reference solution until the reading remains within a band between 90% and 110% of the value of the high field reference solution. Apply a decreasing step change by reverting to the low field reference solution, recording a second event marker at the instant of switching. Continue to supply the lower reference solution until the reading remains within a band between 90% and 110% of the value of the lower reference solution.

Note: Should the instrument reading fail to maintain a value within the 90% to 110% band for the increasing or decreasing changes, report the value which it does reach. In such cases, it will not be possible to calculate the field response time.

7.9 Maintenance

7.9.1 Scheduled maintenance

During the field test any scheduled maintenance shall be carried out according to the supplier's instructions. A record shall be kept of all maintenance activities.

Any changes to the frequency of the scheduled maintenance activities which become necessary as the test progresses, shall be agreed between the test house and the supplier, and recorded.

The following information shall be reported with regards to each scheduled maintenance activity:

- description of activity;
- time taken in man-hours;
- frequency;
- any changes made to the frequency and the reasons;
- any problems or difficulties experienced in following the supplier's recommendations for maintenance;
- any spare parts or consumables required.

7.9.2 Unscheduled maintenance

Unscheduled maintenance will be required under one of the following circumstances:

a) The instrument visibly ceases to function correctly.

b) The instrument activates a fault alarm as a result of self-diagnostic checks.

c) The response chart of the instrument derived readings and the independent background monitoring of the turbidity plotted over time, shows that the two series of data have diverged significantly, or where the variability between the two series of data has increased significantly, excluding points where ambient or fluid conditions are outside the instrument's rated range of use.

d) The results from two successive performance tests show a field test error in excess of three times the maximum permitted error.

e) The results from a field response time test show that the field response time is in excess of three times the supplier's claimed response time under reference conditions.

In the above circumstances, the supplier's instructions for fault diagnosis and repair shall be followed. Should this not rectify the problem, the supplier shall be contacted and invited to carry out specific maintenance or repair the instrument on site.

Note 1: Possible failures in the ancillary equipment should be investigated and rectified before ascribing failure to the instrument. Failures in ancillary equipment shall be recorded.

Note 2: Circumstances c), d) and e) may also be used to refine the frequency of scheduled maintenance activity. Any such changes shall be agreed between the test house and the supplier, and recorded.

If the nature of the fault is such that the instrument cannot be repaired on site, the supplier may remove it for repair. Prior to removal the supplier shall indicate to the test house any components that need to be replaced. The test house shall take steps to verify that only those components are replaced. Should the supplier find during repair that additional components also require replacement, the test house shall be notified.

Following repair, any recommissioning or recalibration procedures recommended by the supplier shall be carried out. The test shall restart from the point of failure.

If the fault results in a catastrophic failure requiring the replacement of one or more major components (for example, the entire sensor or transmitter) of the instrument under test, the matter shall be referred to the Certification Body who shall consider whether:

- the test shall be allowed to continue from the point of failure with a replacement unit;
- the test shall be restarted; or
- the test shall be terminated.

The following shall be reported with regards to each unscheduled maintenance event:

- nature of the fault causing interruption of the test;
- actions required to remedy fault;
- time taken in man-hours to remedy the fault;
- any problems or difficulties experienced in following the supplier's recommendations for fault diagnosis and repair;
- requirement for supplier's attendance on site;
- any components replaced;
- total time while the instrument was not operational, i.e. time from point of failure to the instrument coming back on line.

If the total time while the instrument is not operational due to failure is more than two weeks, the Certification Body may require an extension of the test to ensure that sufficient operational data are collected.

7.9.3 Availability

Availability is a preliminary estimate of the up-time at the start of the field test. The availability of the instrument shall be calculated from:

$$Availability = 100 \times \left(1 - \frac{\sum (Time\ of\ scheduled\ stops)}{total\ period} \right)$$

$$= 100 \times \left(1 - \frac{\sum (frequency \times total\ period \times time\ of\ activity)}{total\ period} \right)$$

Where:

- scheduled stops shall include all manual and/or automatic maintenance procedures as stated by the supplier as necessary for the reliable operation of the instrument;
- the frequency for each activity carried out during the test period is based on the initial maintenance schedule recommended by the supplier to keep the instrument operating within the required error limits;
- the total period covers a period of time where all maintenance activities are carried out at least once; and
- the time taken for each activity shall be stated by the supplier.

7.9.4 Up-time

The measured time taken for automatic and manual maintenance of the instrument during the test period shall be calculated as up-time.

$$Up-time = 100 \times \left(1 - \frac{\sum \left(Measured\ time\ of\ scheduled\ and\ unscheduled\ stops\right)}{test\ period}\right)$$
$$= 100 \times \left(1 - \frac{\sum \left(frequency \times test\ period \times measured\ time\ of\ activity\right)}{test\ period}\right)$$

Where :

- the measured time of stops is a measurement of the time used for scheduled and unscheduled automatic or manual maintenance of the instrument during the test period. Failures of the instrument and the time taken to repair shall not be included in the calculation;
- the frequency for each activity is based on the final maintenance schedule required to keep the instrument operating within the required uncertainty limits; and
- the test period is the total operational time of the instrument, i.e. excludes time when the instrument has failed and is under repair.

Automatic activities which take the same length of time every time they are performed need only be measured once. Where the time taken for an activity can vary and for manual activities, the time taken shall be recorded for each occurrence.

Only the activities which occur during the field test period are included in the up-time calculation.

7.10 Decommissioning and reporting

7.10.1 Draft report

No later than two weeks prior to the conclusion of the field test, the test house shall submit a draft report to the Certification Body. This draft report shall contain the results from the main test period up to that point, including:

- name and address of test house;
- instrument details;
- results from performance tests
  - field test errors;
  - individual paired readings;
  - reference method and its associated uncertainty;
  - field response times;

Where appropriate, data should be presented in such a way as to show any patterns or correlation between field error or response time and factors such as ambient conditions, stage of maintenance cycle, test fluid quality etc.

- summary of ambient conditions;
- summary of test site conditions during test;
- summary of scheduled maintenance requirements, including changes made;
- details of unscheduled maintenance, including changes made;
- up-time to date;
- availability;
- details of any unusual or unexpected events relevant to the interpretation of the field test data;
- any errors or omissions in the manufacturer's documentation;
- observations on the instrument, including all maintenance and calibration activities;
- any problems or difficulties experienced in following the supplier's recommendations;
- observations on the design and robustness of the instrument which may influence long term performance.

The report shall include the report from the Verification period (see 7.6.4) as an Appendix.

The Certification Body shall review the draft report and, in light of its findings, may:

a) accept the draft report and allow the test to finish on schedule;

b) require additional testing to be carried out, the results of which shall be added to the draft report and the report resubmitted;

c) reject the draft report and require the field test to be repeated.

The Certification Committee may reject the report if there is evidence that the data is corrupt or unrepresentative of the true capability of the instrument or that the tests were not carried out in a rigorous manner and in accordance with the guidance set out in this protocol.

7.10.2 Decommissioning

Following final acceptance or rejection of the draft report and completion of any necessary tests, the test site shall be restored to its former state and to the satisfaction of the site occupier.

7.10.3 Final report

On completion of all tests, the test house shall finalise the report. This shall include all the information contained in the draft report with:

- additional data from the remainder of the test;
- final calculations of up-time;
- appendices for:
  - the original test site report;
  - details of test methods;
  - details of reference method and traceability;
  - field test diary, detailing all events.

The report shall include details of any modifications made by the supplier to the instrument, documentation or operating procedures as a result of the field test.

The final report shall be submitted to the Certification Body who will decide as to whether the instrument should be awarded an MCERTS certificate.

APPENDIX A REFERENCE STANDARDS

BS EN ISO 7027: 2000 Water quality – determination of turbidity

EN 60529 Degrees of protection provided by enclosures (IP code).

EN 60068-2-1 Basic environmental testing procedures - part 2: Tests-Test A: Cold.

EN 60068-2-2 Basic environmental testing procedures.-.Part 2: Tests-Test B: Dry heat.

IEC 68-2-3 Basic environmental testing procedures - Part 2: Tests - Test CA: Damp heat, steady state (HD 323.2.3 S2 = IEC 68-2-3:1969 +A1:1984).

IEC 60746-1 Expression of performance of electrochemical analysers - Part 1: General.

BS EN ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories

ISO/DIS 15839 Water Quality – On-line Sensors/Analysing Equipment for Water – Specifications and Performance Tests

Methods for the Examination of Waters and Associated Materials. Colour and Turbidity of Waters 1981. HMSO 1984. ISBN 0 11 751955 3.

APPENDIX B FORM FOR AGREEMENT OF SITE OCCUPIER

Name of site occupier:	
Address of site:	

I <*name of responsible person*>, on behalf of <*company name*>, agree to allow <*name of test house*> to carry out field testing of a <*name or type of instrument*> at the above site for the purposes of MCERTS certification.

In order to facilitate a successful test, I agree:

- To provide access to the test fluid at the test site location for the installation of the instrument to be tested;
- To provide access to the test fluid at the test site location for sampling or for the use of a reference method;
- To allow samples of test fluid to be removed from the test site for submission for laboratory analysis (subject to normal safety procedures). Such samples will only be taken and used for generation of background and reference measurements that are required by the field test;
- To inform <*name of test house*> of any relevant test site safety and security procedures;
- To provide safe access to the test site where the instrument will be installed;
- To provide those facilities as required by the instrument and agreed with <*name of test house*>;
- Not to move or interfere with the operation of the instrument, except where there is a risk to the safety of personnel or the integrity of the process or instrument by not doing so;
- To allow <*name of test house*> access to the test site where the instrument will be installed. *Note any access restrictions are detailed on a separate sheet which is attached*;
- To allow details of the test site, process and test fluid which are pertinent to the field test to be made available and, if necessary, published with the report.

Signed: _____ Date: _____

Name: _____

Position: _____