

MCERTS: Performance standards and test procedures for event duration monitors

External guidance LIT 60384

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The Environment Agency set up the Monitoring Certification Scheme (MCERTS) to provide guidance on the standards you must meet to monitor emissions that affect the environment. We based the scheme on international standards and provides for the product certification of instruments, the competency certification of personnel and the accreditation of laboratories.

This performance standard is for:

- manufacturers of event duration monitors (EDMs) who need to know what standards to meet to be able to use their equipment for regulatory purposes in England and Wales
- test organisations who carry out testing of the equipment on behalf of manufacturers to see if it meets the required standard

We designed MCERTS to support the measurement requirements specified in environmental permits by ensuring that instruments used to derive monitoring data are fit for purpose.

MCERTS for EDMs

EDMs (in combination with other equipment) detect and record the occurrence and duration of discharges from a wastewater system to storm storage and to the environment (an 'event'). At some discharge points permit conditions will require the EDM to be of sufficient quality and be correctly installed according to MCERTS standards.

This document provides a formal scheme for the product certification of EDMs conforming to these standards. It describes the performance standards and test procedures to assess the quality of EDMs. We will publish a separate MCERTS standard describing the requirements and assessment process for installation and operation of EDMs.

We based the MCERTS performance standards for EDMs described in this document on relevant sections from several international standards and take into account other relevant national standards.

This standard covers EDMs based on both water level measurement and level switches. It also covers a range of installation possibilities, such as EDMs mounted above the water surface (non-contact) or within the water flow (contact). EDMs may provide a measurement of the water level at the discharge location, a simple status output indicating discharge or no discharge, or both.

Certification body

We have appointed CSA Group Testing UK as the certification body to operate MCERTS on our behalf.

If you have any questions about the certification process, or would like more information on how to make an application, please contact [CSA Group Testing UK](#).

More information about MCERTS is available in the [Monitoring emissions to air, land and water](#) collection on GOV.UK.

If you have any general questions about MCERTS, please [contact the Environment Agency](#).

1. Summary

In this section we introduce the scheme.

1.1 Background

1.1.1 A permit may require operators of regulated processes to use MCERTS certified equipment, unless otherwise agreed in writing.

1.1.2 It is the responsibility of the user to ensure that the selection, installation, and operation of an EDM are appropriate to the application.

1.1.3 This document describes the performance standards, test procedures and general requirements for the testing of EDMs for compliance with MCERTS performance standards.

1.1.4 Specific site conditions can affect the performance of an installed EDM. We will publish a separate MCERTS standard on the minimum requirements for the installation and use of event duration monitors.

1.1.5 EDMs certified against this standard shall be tested and certified against their ability to indicate when water in a tank or channel reaches or exceeds a set level (the overflow level), their ability to measure the water level, or both.

1.1.6 The determinands covered are:

- discharge status (discharging or not discharging)
- water level

1.1.7 The requirements in this document should allow the certification of any technical solution that meets the requirements.

1.1.8 The standard applies to EDMs used for recording the occurrence and duration of discharges from overflow points prior to wastewater entering a treatment process. It includes EDMs intended to operate in or with:

- side weirs, double-side weirs and bell mouth weirs
- tanks and wet wells
- other locations suitable for event duration monitoring

The certification body will categorise EDMs submitted for certification under this standard into the following types:

- **Type A** – an EDM which incorporates a water level sensor that provides a direct, or inferred, measurement of the water level up to and beyond the overflow level

- **Type B** – an EDM which comprises a sensor that provides a switched status output to an external system that indicates when the water reaches the overflow level
- **Hybrid** – an EDM which uses a primary (contact) device to indicate when the water approaches the overflow level to trigger a non-contact sensor to take continuous readings

1.1.9 A video-based system in which a camera captures images of the overflow point at regular intervals and uses image analysis software to detect the water level, may be a Type A or Type B device depending on the information it provides.

1.1.10 For a Type A EDM the manufacturer and certification body shall agree the certification range, see section 2. The certification range shall define the range of water depths over which the EDM shall provide a measurement within the requirements of this standard.

1.1.11 Hybrid sensors will require a test regime that combines elements of Type A and Type B EDMs. The supplier and the certification body shall agree this on a case by case basis, depending on the operating principles of the 2 components.

1.1.12 Testing and certification of a video system should include both the camera and the software as the performance will be influenced by both. For example, the ability of the system to discriminate the water level will be a factor of both the camera resolution and the software's ability to identify small changes in water level in the image. Testing shall be carried out with the software installed on a system that meets the minimum specification required by the supplier.

1.2 Performance tests

1.2.1 Performance tests for certification of an EDM against the MCERTS requirements should be carried out in line with the procedures defined in this document.

1.2.2 Variations to the performance tests described in this standard may be acceptable if they demonstrate to the satisfaction of the certification body the EDM's performance against the requirements. Any such variations shall be agreed with the certification body.

1.2.3 The results of previous performance tests may be acceptable to the certification body if equivalent to MCERTS and carried out independently. The certification body may also consider manufacturers' own test data. This applies to both laboratory and field tests.

2. MCERTS certification

Here we explain how to obtain MCERTS certification.

2.1 Certification body and committee

We have appointed CSA Group Testing UK as the certification body to operate MCERTS on our behalf.

The role of the certification body is to assess and certify compliance with the MCERTS standard for defined applications and or conditions.

The MCERTS scheme requires the certification body to consider the relevance of the procedures defined in the MCERTS standard to the specific product being certified. The technology or defined application of a specific product may make some of the documented tests inappropriate. The certification body shall exercise its technical judgement when considering these matters.

The certification body appoints an independent, competent person or group of persons, who in this MCERTS standard are referred to as the 'certification committee'.

Any decision based on technical judgement of the standard shall be taken by the certification committee on behalf of the certification body. The decision of the MCERTS certification committee on technical questions and matters of data is final.

When the certification committee exercises its technical judgement, the rationale supporting any such decision shall be appropriately documented.

On request the certification body shall provide the MCERTS scheme owner with the rationale for any decision based on technical judgement, within the relevant confidentiality constraints.

Any certificate issued by the certification body shall identify any variations from this MCERTS standard.

2.2 Certification process

2.2.1 Product certification comprises 3 phases. These are:

- **laboratory testing** – used to determine performance characteristics, where such testing requires a highly controlled environment
- **field testing** – carried out on processes representative of the intended industrial sectors and applications
- **surveillance – initial and continuing** – which comprises an audit of the manufacturing process to confirm that the manufacturer has provisions to

ensure manufacturing reproducibility, and to control any design changes to ensure that they do not degrade performance below the MCERTS standards

Manufacturers seeking certification should contact the certification body who will advise on any specific requirements for the EDM under consideration.

2.2.2 Where an EDM can be supplied with a number of options, or is available in different sizes, or where more than one sensor or sensor configuration can be used to cover different ranges, one EDM should undergo the full conformity tests.

In selecting the options to be tested, consideration should be given to the selections for that EDM type likely to be used for each of the identified applications.

2.2.3 For additional sensors, sensor configurations or other options, it may be possible to extend certification by carrying out a subset of the full test programme or selected additional tests on an alternative EDM where the options are likely to have a significant effect on the performance of the EDM.

Similarly, where different transmitters having different facilities may be used with a single sensor, one complete EDM 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.

2.2.4 If the use of alternative equipment, for example a non-certified sensor, would invalidate the performance of a certified product, the certificate and the manufacturer's operating instructions shall include an appropriate reminder to the user

2.3 Certification range

2.3.1 A Type A EDM will be certified over the measurement range for which it is tested. If a manufacturer wishes to demonstrate performance over one or more supplementary ranges some additional testing will be required over those ranges. This additional testing shall at least include evaluations of the mean error and repeatability.

2.3.2 The manufacturer and the certification body shall agree the extent of the environmental testing.

2.4 Testing

This MCERTS standard sets out some essential requirements (see section 4) written in general terms which must be met before products can be certified as meeting MCERTS.

The ability of an EDM to meet the requirements of this standard will be assessed by inspection, laboratory tests and a field test

2.4.1 Laboratory tests

Laboratory test procedures are described in section 6.

Manufacturers may commission testing from any organisation that meets the requirements for testing organisations (see section 5). Manufacturers' own test data may also be considered. This applies to both laboratory and field tests.

Certain tests may present practical difficulties for certain EDMs. In such cases, manufacturers should discuss these matters with the certification body to determine the most appropriate course of action.

2.4.2 Field test

Field test procedures are described in section 7.

The field test requirements take into account 2 scenarios:

- established products that have a track record of use in a variety of applications
- products that are new onto the market and as such do not have data to demonstrate use in a real environment

Emphasis will be placed upon the manufacturer setting out a case justifying, with appropriate evidence, why the product will meet the field test requirements.

2.5 Auditing and surveillance

2.5.1 The certification body shall conduct an audit of the manufacturing process to confirm that the manufacturer has provisions to ensure manufacturing reproducibility and to control any design changes that may affect product performance.

2.5.2 Subsequent surveillance audits are normally conducted annually until sufficient evidence of a well-proven, robust system has been collected. Once this has been established the certification body may extend the interval between audits or require submission of specific audit data for review off site.

2.6 Modifications to certified EDMs

2.6.1 Any spares or replacement parts for certified EDMs must meet the same performance standards as the original parts. Operators and equipment suppliers may need to provide evidence that the replacement parts meet the required performance standards of the original equipment as specified by the manufacturer.

2.6.2 Modifications to certified EDMs are allowable so long as manufacturers can demonstrate that these design changes do not degrade the performance of the EDM below the MCERTS performance standards.

2.6.3 Modifications and design changes include changes to all components of the level measurement system, including software and firmware.

2.6.4 Manufacturers must keep detailed records and drawings of all design changes to EDMs, and have provisions for design verification, inspection and testing to ensure that the EDMs still meet the required performance standards. The certification body will conduct audits of the design changes to EDMs to meet the requirements of product certification. Manufacturers must notify the certification body of any modifications to equipment that may have a significant effect on EDM performance.

2.6.5 Design modifications or extensions to the range of application of an EDM may require renewed testing. The extent of this renewed testing will depend upon the nature of the modifications to the EDM.

2.6.6 If there is evidence that a modification has only limited effects on the performance of the EDM, then it would not be necessary to retest an EDM completely. This will only require a supplementary test against the applicable sections of this MCERTS performance standard.

2.6.7 In the case of modifications to software – particularly in measuring instruments – manufacturers must present documentation to the certification body indicating the nature of the modification as well as resultant effects on operation and functionality. The certification body will then decide if further testing is required.

2.7 Certificate validity

2.7.1 MCERTS certificates are valid for 5 years. After this time, the certification is reviewed, and any necessary retesting identified to maintain the certification. The certification body will carry out an assessment for recertification against the MCERTS standards current at the time of recertification.

3. General requirements

This section describes general requirements for the identification, design and operation of the EDM, and information required in manufacturers' documentation.

3.1 General requirements for EDMs

The following requirements will be assessed by inspection or manufacturer's statement for all EDMs.

3.1.1 All MCERTS certified EDMs shall have a unique designation that unambiguously identifies the EDM as a certified model.

To enable identification of an MCERTS certified EDM, reference may also need to be made to versions of any software and firmware installed in the EDM.

3.1.2 The EDM shall have a means of protection against inadvertent or unauthorised access to control, set point and calibration functions.

3.1.3 It shall be possible for an authorised person to obtain the water level or discharge status on site. That can be achieved with an integral display, or connection to one or more external devices such as a digital voltmeter (DVM), laptop, tablet or smartphone. Connection and communication to an external device shall not interrupt the operation of the EDM. Any software or application required for this shall be available free of charge from the manufacturer.

3.1.4 An EDM shall have a means of communicating fault conditions to a remote system.

3.1.5 An EDM operating from an external power supply shall have the facility to incorporate an alarm indicating loss of supply.

3.1.6 An EDM operating from a battery shall incorporate a method of indicating when the power available is insufficient to maintain the measurement within the performance requirements of this standard.

3.1.7 An EDMs design shall minimise the impact on its operation from fouling by gross solids, fats, rags and other materials that are likely to be present in unscreened and untreated wastewater.

3.1.8 An EDM may use automatic routines for cleaning, maintenance or recalibration to maintain performance within the required limits between manual interventions

3.1.9 All parts of an EDM shall be at least IP65 compliant, as defined in BS EN 60529, to ensure that they are sufficiently waterproof to allow protection from spray and rain.

3.1.10 All electrical parts of an EDM that are submerged, or likely to be submerged, shall be IP68 compliant to an appropriate depth and duration as defined in BS EN 60529.

3.1.11 A Type A EDM shall provide one or both of:

- an analogue or digital output signal of liquid level
- a programmable alarm output

3.1.12 For a Type A EDM with an indicating device, the indicating device output shall be scaled in metric units and shall display the units of measurement.

3.1.13 The resolution of a Type A EDM shall be as shown in Table 1.

Table 1 - Resolution requirements for Type A EDMs

Certification range	Resolution
≤ 1.0 m	≤ 1 mm
1.0 to 5.0 m	≤ 2.0 mm
≥ 5.0 m	≤ 2.5 mm

3.1.14 For a Type A EDM with an alarm, it shall be possible to set the level at which the alarm changes status with a resolution of 1 mm or better.

3.1.15 A Type B EDM shall:

- report the discharge status as discharging as the water level rises to, and remains above, the overflow level
- report the discharge status as not discharging when the water level falls, and remains below, the overflow level

3.1.16 For a Type B EDM it shall be possible to set the level at which the discharge status changes with a resolution of 2 mm or better.

3.1.17 Any additional equipment required for the EDM to operate continuously on site within the requirements of this standard shall be available from the manufacturer. This shall include (but not be limited to) sunshades, batteries and brackets or other means to secure the device.

3.2 Manufacturers’ published documentation

The manufacturer shall incorporate the following guidance or statements into the manufacturer’s published literature.

3.2.1 The manufacturer shall provide operating instructions which cover the full functionality of the EDM.

3.2.2 The manufacturer shall give guidance on the time period over which the EDM shall operate continuously without requiring manual adjustment or intervention. This should include any relevant application specific information. The guidance shall include advice on how to clean the EDM so that the user can use a suitable regime for an individual application.

3.2.3 The manufacturer shall state any limitations about the material into or onto which the EDM sensor can be installed.

3.2.4 The manufacturer shall state any limitations on the location dimensions or shape into or onto which the EDM sensor can be installed.

3.2.5 The manufacturer shall state any specific requirements relating to the location or shielding of components necessary to maintain performance within the requirements of this standard under varying environmental conditions, for example, the use of sunshades for air firing ultrasonic level sensors.

3.2.6 For a Type A EDM with a non-contact sensor, the manufacturer shall state the minimum separation distance and the maximum separation distance from the sensor face to the water surface.

3.2.7 For a Type A EDM with a sensor designed to be installed below the water surface, the manufacturer shall state the minimum measurable water depth.

3.2.8 Where appropriate, the manufacturer shall state the rated operating conditions for fluid pressure.

3.2.9 The manufacturer shall state the rated operating conditions for the power supply or switching circuitry.

3.2.10 The manufacturer shall state the rated operating conditions for the signal load impedance on the analogue output, if present.

3.2.11 The manufacturer shall state the measurement resolution of the EDM.

4. Performance requirements

This section describes the characteristics of EDMs that need to be tested.

4.1 Performance characteristics

4.1.1 Performance characteristics of the EDM under test are determined using the test methods described in section 6. They have been defined in such a way that they can be calculated from test data in line with the principles contained within the [ISO Guide to the expression of uncertainty in measurement \(GUM\)](#).

4.1.2 Specific characteristics are expressed as error (x), change in error (X), standard deviation (u) or expanded uncertainty (U). Unless agreed otherwise the unit of measurement shall be mm.

4.1.3 The characteristics obtained from the test results shall be compared to the requirements described in the following sections to determine whether the instrument can be certified against this standard.

4.2 Performance requirements for EDMs

4.2.1 In order to achieve certification an instrument must comply with the performance requirements shown in Table 2. Table 2 shows the maximum value of each performance characteristic for an EDM. The values for individual and combined performance characteristics are expressed in mm.

Not all characteristics will apply to every EDM.

Table 2 - Performance requirements for EDMs

Performance characteristic	Symbol	Test	Requirement mm
Mean error	\bar{x}	6.3.5	2.5
Repeatability	u_R	6.3.5	2.5
Supply voltage	X_V	6.3.6, 6.3.7, 6.3.8	1.0
Output impedance	X_O	6.3.9	1.0
Water temperature	X_{FT}	6.3.10	1.0
Ambient air temperature	X_T	6.3.11	1.0
Relative humidity	X_{RH}	6.3.11	1.0
Direct solar radiation	X_{SV}	6.3.12	1.0
Combined performance	U_C	6.4	5.0
Maximum response time	No symbol	6.3.13	30 seconds

4.3 Data retention, logging and timing

4.3.1 EDMs shall retain all user configurable data, including calibration and alarm set points and adjustments, for a minimum period of 30 days after disconnection of the power supply. (Test 6.3.4.)

4.3.2 Where an EDM incorporates an integrated data logger, this shall meet the following requirements:

- a) The logger be capable of storing at least 60 days of time and date stamped data.
- b) A battery powered logger shall retain recorded data for a minimum period of 30 days after disconnection of the power supply and while batteries are being changed. (Test 6.3.4.)
- c) The logger shall be able to record and store the discharge status (discharge or no discharge) with a 2-minute temporal resolution. (Test 6.3.14.)
- d) The error of the interval timing shall be no greater than ± 10 seconds in 24 hours. (Test 6.3.14.)

4.4 Fluid requirements

4.4.1 The minimum rated operating conditions for water temperature shall be $+1^{\circ}\text{C}$ to $+30^{\circ}\text{C}$. (Test 6.3.10.)

4.5 Environmental requirements

4.5.1 The minimum rated operating conditions for ambient air temperature shall be -10°C to $+35^{\circ}\text{C}$. (Test 6.3.11.)

4.6 Field test performance requirements

See section 7 for a description of the test procedure.

4.6.1 During the field test the error of the EDM shall be less than or equal to the value of the combined performance requirement, as given in Table 2, for at least 90% of the overflow events recorded.

4.6.2 During the field test the EDM shall have an up-time greater than 95%.

5. Provisions for test organisations

This section describes the requirements for test organisations and test houses.

5.1 General requirements for test houses

5.1.1 For the testing of EDMs under MCERTS, test organisations shall demonstrate to the satisfaction of the certification body that their test house complies with the relevant requirements of BS ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories.

5.2 General requirements for testing

5.2.1 The errors associated with any test equipment or reference measurements should be no more than one fifth of the mean error requirement against which the instrument is being tested. Example reference methods for EDM tests are given in 5.5 and 5.6. Simulated inputs may be used if agreed by the certification body.

5.2.2 EDMs may be tested using a direct input of level or pressure generated by means other than a water surface, for example a plate or pressure calibrator unless specified by the test procedure.

5.2.3 The EDM 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.

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

5.2.5 The outputs from the EDM shall be allowed to stabilise after any change in an influence quantity or water level.

5.2.6 With the prior agreement of the certification committee, fewer measurements than required by the individual test may be made, if this can be justified, for example, where a pattern of low variability is supported by statistical analysis. This shall be shown in the test report.

5.3 Test conditions

5.3.1 Table 3 gives the reference conditions for possible influence quantities. Tests shall be carried out with all influence quantities at their reference values, including tolerances, unless where specifically varied in any one test.

Table 3 - Reference conditions

Influence quantity	Reference value	Tolerance
Ambient air temperature (note 1)	20°C	±5°C
Ambient humidity at 20°C (note 2)	<60% RH (relative humidity)	Not applicable
Incident light	Existing local light level	Not applicable
Fluid pressure (closed pipes)	≥ maximum head loss across meter + 0.5 bar	Not applicable
Supply voltage (a.c.)	230 or 110V	±6%
Supply voltage (d.c.)	Manufacturer to state this	±2%
Output impedance	Manufacturer's stated maximum	+0, -5Ω
Sensor location for non-contact level sensors	Mean of maximum and minimum limits stated by manufacturer	±10%
Test fluid	Water	Not applicable
Test water temperature	20°C	±5°C
Test water conductivity	50 < conductivity < 5000mS/cm	Not applicable
Water quality	Public potable water supply or equivalent. The water should be free of debris and entrained gas, unless specifically required for the functioning of the instrument	Not applicable
Water surface	In line with manufacturer's recommendations.	Not applicable

Notes to Table 3:

1. During any one test, the ambient air temperature shall not vary by more than 5°C.
2. During any one test, the relative humidity (RH) shall not vary by more than 10%.

5.3.2 For Type A EDMs, the test points given in Table 4 shall be used as required by each individual test.

Table 4 - Test point values for Type A EDMs

Test point	Limits of water level
1	(5% ± 2.5%) of the certification range
2	(25% ± 5%) of the certification range
3	(50% ± 5%) of the certification range
4	(75% ± 5%) of the certification range
5	(95% ± 5%) of the certification range

5.4 Reporting

5.4.1 The test house should produce a clear report using a model test report provided by the certification body.

5.5 Laboratory reference methods

5.5.1 Laboratory determinations for level sensor EDMs may be based on fixed targets, with the distance from the sensor being established by a traceably calibrated length measurement device.

5.5.2 There are various methods for establishing the position of a fluid surface relative to a datum which would be acceptable to MCERTS, provided that they have been calibrated in such a way as to be traceable to National standards and provide a resolution and uncertainty commensurate with the requirements of the test being undertaken. These include pressure transducers, float and shaft encoders, mechanical gauges (such as hook gauges) and solid state devices (such as radar gauges).

5.5.3 Laboratory determinations for single-point, contact EDMs may also be based on fixed targets, with the distance from the sensor established by a traceably calibrated length measurement device.

5.6 Field reference methods

5.6.1 There are various techniques by which level measurements may be verified in-situ. The choice of technique will be largely influenced by site conditions. However, the errors associated with some of these techniques may be higher than the errors claimed for some of the sensor types under test.

Possible methods are:

- reference measurement – a second level sensor of known and demonstrable uncertainty also measuring the same liquid surface (note that single point sensors being tested must use a continuous level sensor as the reference measurement)
- fixed targets for level sensors, the height of which shall be measured using a traceably calibrated length measurement device

6. Laboratory test procedures

This section describes the laboratory test methods required to assess the instrument performance against the requirements listed in section 4.

6.1 Initial checks

6.1.1 The test house shall make sure that the EDM is set up, calibrated and adjusted in line with the manufacturer's instructions. The manufacturer may install and set up the EDM.

6.1.2 The test house shall verify by inspection or by a statement from the manufacturer that the general requirements listed in section 3.1 are fulfilled, as appropriate to the EDM under test. The means by which each requirement is fulfilled shall be reported.

6.1.3 The test house shall verify and report that measurements obtained from all available analogue and digital outputs and any local display are equivalent. (Readings will rarely be identical due to, for example, small errors between devices, different refresh rates or numbers of significant figures.)

6.1.4 If the EDM incorporates an integral data logger, the test house shall verify:

- a) that the logger has sufficient memory capacity to store 60 days of data
- b) that the logger can store data at 2-minute intervals

6.2 Manufacturer's published documentation

6.2.1 The test house shall verify and report that the manufacturer's published documentation includes the relevant statements required in section 3.2, as appropriate to the EDM under test.

6.3 Performance tests

The tests required for a specific EDM will depend on the operating principle of the EDM and its intended scope of application (meaning weir installation, wet well installation or other). The manufacturer and the certification body shall agree the test programme.

6.3.1 Calculation of error

For EDMs tested against this standard, errors are expressed as mm unless an alternative measurement unit is required and agreed by the certification body.

For any individual test point, the error, X_i , is the difference between the value given by the EDM and the conventional true value.

The mean error, \bar{x} , from a series of n measurements is the average of the individual errors, calculated in the normal way.

Equation 1:
$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

For a Type B EDM, the error is calculated as the difference between the point at which the output changes status and the conventional true set point.

6.3.2 Calculation of repeatability

Repeatability is expressed as the sample standard deviation of measurements taken at reference conditions.

Equation 2:
$$u_R = \sqrt{\frac{\sum_{i=1}^n (\bar{x} - x_i)^2}{n-1}}$$

As the repeatability test requires the test point to be approached from both higher and lower values, the calculation of repeatability here includes any effect due to hysteresis.

6.3.3 Calculation of performance characteristic

For some tests the performance requirement for the effect of an influence quantity, X_i , is expressed as the mean of the absolute change in error resulting from the influence quantity being varied between its minimum and maximum values, within the rated operating conditions of the EDM. This shall be expressed as mm. This is illustrated in Figures 1 and 2 and expressed in equation 3. This shall be applied to the following influence tests:

- supply voltage (6.3.6, 6.3.7, 6.3.8)
- output impedance (6.3.9)
- water temperature (6.3.10)
- solar radiation (6.3.12)

Equation 3:
$$X_i = \left(\frac{|\bar{X}_{high} - \bar{X}_{ref}| + |\bar{X}_{low} - \bar{X}_{ref}|}{2} \right)$$

Figure 1 - Effect of influence quantities

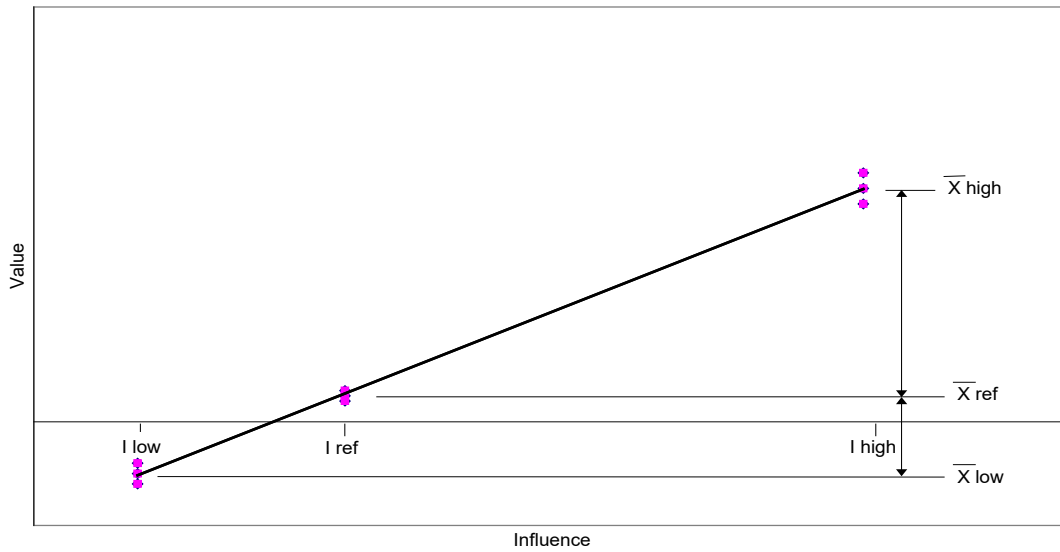


Figure 1 is a graph of influence quantity against measurement value. It shows a linear increase in the measurement reading as the influence quantity increases from a low value to a high value.

Figure 2 - Effect of influence quantities - U shaped response

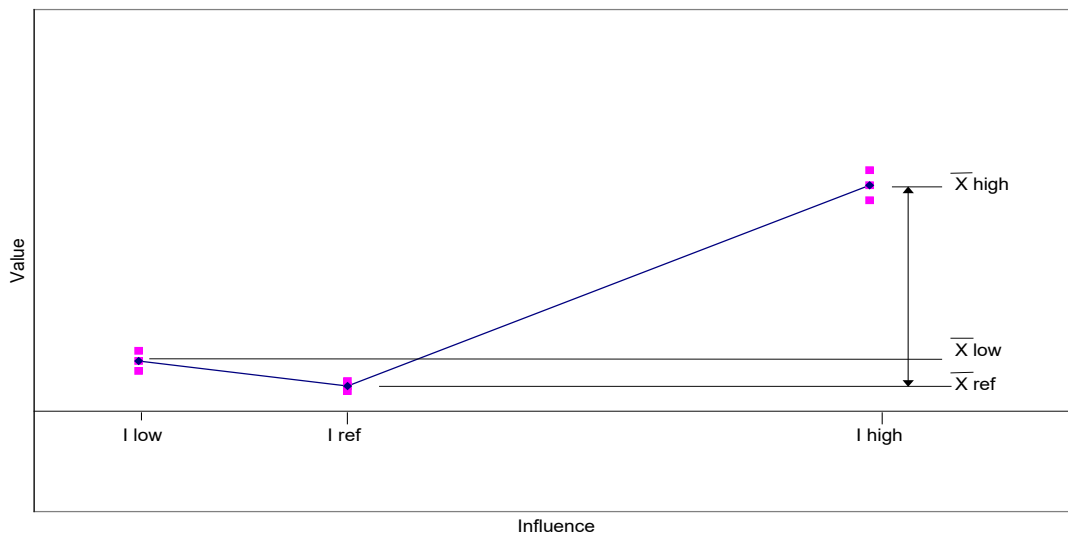


Figure 2 is a graph of influence quantity against measurement value. It shows a decrease in the measurement reading as the influence quantity increases from low value to reference value, then an increase in the measurement reading as the influence quantity increases from reference value to high value.

6.3.4 Loss of power test

Adjust at least 10 of the EDM's user configurable settings so that they are different from the factory default values. If there are fewer than 20 user configurable settings, at least half of those available should be set to non-default values. Where available, the changed settings should include an output scale

setting and an alarm setting. Record the values of all user configured settings, calibration data and alarm set points.

For EDMs that incorporate a local data logger, the EDM shall have been recording non-zero data for at least 30 days prior to the test. The data shall be downloaded immediately before the power is disconnected without clearing the logger.

Disconnect the equipment from the power supply. After a period of 30 days reconnect the power supply and report any changes in the values of the user configured settings, calibration data and alarm set points.

On reconnection the stored data shall be downloaded. Any differences in the stored data from before and after the power disconnection shall be reported.

For instruments where user-programmed data is stored in non-volatile memory, the test period may be reduced to 48 hours. Instruments with battery back-up will still be required to undergo the full 30-day test.

6.3.5 Mean error and repeatability test

Type A EDMs

A Type A EDM (see 1.1.9) may be tested with a real or simulated water level, for example using a plate or pressure calibrator, as appropriate to the operating principle of the sensor. If using a simulated input, this shall be capable of providing a continuously variable input, rather than a series of fixed points, to allow any alarm activation to be observed.

If the EDM incorporates an alarm function, this shall be programmed to alarm at 75% of the certification range (test point 4).

Provide the sensor with a reference input at each test point in turn in ascending order, see 5.5.1. At each test point, record the reading and calculate the error. Repeat the measurements in descending order. Repeat the sequence of ascending and descending points twice more to give 6 discrete readings at each test point and ensure that any hysteresis effects are captured.

Monitor the alarm status throughout the test. As test point 4 is approached in each rising or falling sequence, the level at which the alarm status changes shall be recorded. The rate of change as the set point is approached in either a rising or falling sequence shall not be more than 20 mm/minute for the 50 mm either side of the set point. With a rising level, test point 5 shall be held for 10 minutes. With a falling level, test point 3 shall be held for 10 minutes.

Calculate and report the mean error, \bar{x} , and repeatability, u_R , for each test point using the methods described in 6.3.1 and 6.3.2.

Calculate and report the mean levels at which the alarm status changes for rising and falling level sequences.

Verify that the alarm status remains high whilst the level is held at test point 5 and low whilst the level is held at test point 3.

Type B EDMs

For a Type B EDM (see 1.1.9), this test shall be carried out using a tank of water where the water depth can be varied. The tank shall include a horizontal weir type overflow that allows a proportion of water to spill over when the water level exceeds the overflow level. The tank shall be of sufficient dimensions to enable testing over the full certification range without the sensor fouling on the sides of the tank. The mechanism for changing the water level shall not introduce significant surface turbulence or waves.

Install the EDM in the tank and configure it to change status at the overflow level.

Set the water level between 50 and 60 mm below the overflow level. Gradually raise the water level at no more than 20 mm/minute until it reaches 20 to 25mm above the overflow level. Record the water level at which the EDM changes status.

Hold this level for 10 minutes and verify that the EDM output status remains stable.

Gradually lower the water level to between 50 and 60 mm below the overflow level. Record the water level at which the EDM changes status.

Hold this level for 10 minutes and verify that the EDM output status remains stable.

Repeat this procedure a further 5 times to obtain 6 discrete switching points for a rising level and 6 for a falling level.

Calculate and report the mean error, \bar{x} , and repeatability, u_R , for rising and falling switching points using the methods described in 6.3.1 and 6.3.2.

6.3.6 Supply voltage - mains powered instruments

Vary the supply voltage to the sensor using an isolating transformer, in steps of 10V from 230V (or 110V) to the upper and lower limits of the rated operating conditions.

Note – If a supply voltage change of $\pm 10V$ causes a measurable effect on the instrument output, then supply voltage stability will need to be considered during other tests.

Type A EDMs

For type A EDMs, provide the sensor with a reference input at test point 4 from Table 4 as appropriate to the instrument under test, see 5.5.1, and record the value of the analogue output signal. At each voltage, record the value of the analogue output signal. If the EDM has no analogue output, the relevant supply voltage tests shall still be carried out using the local display and any available digital output.

Calculate and report the performance characteristic effect due to supply voltage changes, X_v , using the method described in 6.3.3.

Type B EDMs

For type B EDMs follow the methodology described in 6.3.5 with the applied voltage to the sensor provided by an isolating transformer. Carry out one cycle of rising and falling water level at each voltage setting. At each voltage, record the level at which the EDM changes status for both rising and falling levels.

Calculate and report the performance characteristic effect due to supply voltage changes, X_v , using the method in 6.3.3.

6.3.7 Supply voltage - DC powered (including loop powered) instruments

Vary the supply voltage to the sensor using a variable DC power supply, in steps of 5V from the manufacturer's stated reference voltage to the upper and lower limits of the rated operating conditions.

Type A EDMs

Provide the sensor with a reference input at test point 4 from Table 4 as appropriate to the instrument under test, see 5.5.2, and record the value of the analogue output signal. At each voltage, record the value of the analogue output signal. If the EDM has no analogue output, the relevant supply voltage tests shall still be carried out using the local display and any available digital output.

If the range between the upper and lower limits is less than 20V, smaller steps shall be used such that readings are obtained at the upper and lower limits and at least 2 intermediate points spaced approximately evenly through the range.

Calculate and report the performance characteristic effect due to supply voltage changes, X_v , using the method in 6.3.6.

Type B EDMs

Follow the methodology described in 6.3.5 with the applied voltage to the sensor provided by a variable DC power supply. Carry out one cycle of rising and falling

water levels at each voltage setting. At each voltage, record the level at which the EDM changes status for both rising and falling levels.

If the range between the upper and lower limits is less than 20V, smaller steps shall be used such that readings are obtained at the upper and lower limits and at least 2 intermediate points spaced approximately evenly through the range.

Calculate and report the performance characteristic effect due to supply voltage changes, X_v , using the method in 6.3.3.

6.3.8 Supply voltage - battery powered instruments

The batteries shall be removed and power supplied from a variable DC power supply, initially set to the nominal supply voltage.

Type A EDMs

Provide the sensor with a reference input at test point 4 from Table 4 as appropriate to the instrument under test, see 5.5.2 and record the output. Reduce the supply voltage in 0.5V steps recording the output at each step. Record and report:

- the voltage at which the low battery alarm occurs
- the voltage at which the reading changes by more than 1.0 mm (if this occurs before the instrument switches off)
- the voltage at which the instrument switches off

Identify and report the maximum change in error due to supply voltage, X_v , from the readings taken before the low battery alarm is activated.

Type B EDMs

Follow the methodology described in 6.3.5 with the batteries removed and the applied voltage to the sensor provided by a variable DC power supply, initially set to the nominal supply voltage. Reduce the supply voltage in 0.5V steps recording the output status at each step. Record and report:

- the voltage at which the low battery alarm occurs
- the voltage at which the switch occurs changes by more than 1.0 mm
- the voltage at which the EDM output no longer changes status

Identify and report the maximum change in error due to supply voltage, X_v , from the readings taken before the low battery alarm is activated.

6.3.9 Output impedance

This test shall be applied to EDMs with an analogue mA output.

Connect the analogue output from the EDM to a variable resistance load initially set to the reference value (see Table 3). Provide the sensor with a reference input at test point 4 from Table 4 as appropriate to the instrument under test, see 5.3.2, and record the reading. Adjust the value of the load resistance to the mean of the upper and lower limits of the rated operating conditions, then to the lower limit. At each value of impedance record the value of the analogue output signal. Repeat the procedure a further 2 times.

If no minimum limit is specified a value of 10Ω shall be used for the minimum impedance value.

Calculate and report the performance characteristic effect due to output impedance changes, X_o using the method in 6.3.3.

6.3.10 Water temperature

This test should be applied to all EDMs. (Non-contact sensors may be subject to errors caused by changes to surface properties.)

Type A EDMs

Provide the sensor with a reference input at test point 3 from Table 4 as appropriate to the instrument under test, see 5.3.2. Take readings with the water at a temperature in the ranges 1°C to 5°C (low limit), 15°C to 20°C (reference) and 25°C to 30°C (upper limit). Take 3 discrete readings in each temperature range.

Calculate and report the performance characteristic effect due to water temperature, X_{FT} using the method in 6.3.3.

Type B EDMs

Follow the methodology described in 6.3.5 with the water at a temperature in the ranges 1°C to 5°C (low limit), 15°C to 20°C (reference) and 25°C to 30°C (upper limit). Carry out 3 cycles of rising and falling water levels at each water temperature.

Calculate and report the performance characteristic effect due to water temperature, X_{FT} using the method in 6.3.3.

6.3.11 Ambient air temperature and relative humidity

Place the EDM in a climatic chamber. All components of the EDM that could be exposed to ambient environmental conditions during normal operation shall be placed in the chamber. Sensors which would normally be submerged can be located outside the chamber. Set the temperature to 20°C and allow sufficient time for the EDM temperature to stabilise.

If available an output shall be monitored continuously to identify any transient effects. Data from the output should be reported graphically.

The following conditions shall be set in the climatic chamber in the order given in Table 5, where T_{min} and T_{max} are the minimum and maximum values for the ambient air temperature range over which the EDM is to be certified. The relevant transitional temperatures (steps 2 and 5) may be omitted if T_{max} <40°C or T_{min} >0°C.

Table 5 - Test cycle for environmental conditions

Step	Temperature °C	Humidity	Minimum exposure time
1. Reference	20	Reference	2 hours
2. Transition	$(T_{max} + 20) \div 2$	Reference	2 hours
3. High T dry	T _{max}	Reference	2 hours
4. Reference	20	Reference	2 hours
5. Transition	$(20 + T_{min}) \div 2$	Reference	2 hours
6. Low T	T _{min}	Reference	2 hours
7. Reference	20	Reference	2 hours
8. High T humid	T _{max}	³95% RH	6 hours
9. Reference	20	Reference	2 hours

Type A EDMs

At each step, after the minimum exposure time, the EDM shall be provided with a reference input at test point 4 from Table 4 and the output recorded. The measurement shall be repeated 3 times to give 3 discrete readings.

After the test measurements any self-cleaning or auto-calibration routines shall be operated at least once. Three further measurements shall then be taken to identify any systematic shifts brought about by operating such routines under different conditions.

It is preferable that any automatic cleaning or calibration routines are initiated remotely to avoid opening the chamber and affecting the climatic conditions.

The 4 measurements at 20°C reference temperature (steps 1, 4, 7 and 9) should be used to check for any permanent changes to the sensor system as a result of any temperature excursions or any sensor drift which may occur during the test. If any sensor drift is indicated then it may be necessary to adjust the measurements to compensate or to repeat the test.

Any effect caused by ambient air temperature changes X_T can be determined using measurements from steps 3, 4 and 6 (high temperature dry, reference, low temperature), and equation 3 (see 6.3.3). If an effect is seen, then additional information can be obtained from steps 2 and 5 if they have been completed.

Reference steps 1 and 7 provide additional information about overall stability of the system.

Any effect caused by high humidity X_{RH} can be calculated using the measurements from steps 3 and 8.

Calculate and report any sensor drift or changes caused by the temperature excursions.

Calculate and report the effect on error due to ambient air temperature, X_T .

Calculate and report the effect on error due to high humidity and temperature, X_{RH} .

Type B EDMs

At each step the sensor shall initially be in a no discharge state. The water level, real or simulated, shall be raised until the output changes state. The value at which it changes state shall be measured and recorded. The level shall be raised by a further 20-25 mm. The level shall then be dropped until the output changes to the no discharge state. The value at which it changes state shall be measured and recorded. The level shall be lowered further by at least 25 mm. This shall be repeated 3 times at each temperature step.

Interpret the test results as described above.

Calculate and report any sensor drift or changes caused by the temperature excursions.

Calculate and report the effect on error due to ambient air temperature, X_T .

Calculate and report the effect on error due to high humidity and temperature, X_{RH} .

6.3.12 Direct solar radiation

This test shall be applied to EDMs that incorporate air firing ultrasonic level sensors.

Install the EDM sensor in an enclosed test space with a controlled environment.

If a manufacturer recommends that a sunshade should be fitted over or around the ultrasonic transducer or external temperature sensor (if used) when installing the instrument in an exposed location, then this test shall be conducted with the sunshades in place.

The test space shall meet the following requirements while the test is being conducted:

- there shall be a source of radiant energy supplied by a lamp or combination of lamps that simulate the solar spectrum
- the mean ambient temperature within the test space shall be within the range 15 to 25°C with a maximum deviation of $\pm 2.5^\circ\text{C}$ around the mean
- there shall be negligible draughts or air currents within the test space other than the convection currents that naturally occur as the air beneath the lamps is heated
- there shall be no other sources of radiant energy (for example lights or radiant heaters) operating in the test space during the test
- to simulate the transducer being in an open environment there shall be at least 600mm of free space above the lamps and the test space shall be at least 1.5m square

Any reference thermometer used to monitor temperature within the ultrasonic path shall be small and offset from the direct line between transducer and target to avoid interference with the ultrasonic signal.

Experimentation has shown that a 500W metal halide lamp (colour temperature 5000 to 5200K) and a 500W tungsten halogen lamp (colour temperature 3000 to 3300K) used together provide sufficient intensities in the visible and infrared parts of the spectrum to simulate the effect of solar radiation on an ultrasonic transducer. The lamps should be in floodlight housings mounted side by side approximately 0.55m above the transducer.

Position the transducer at 50% $\pm 5\%$ of the certification range plus the minimum separation distance from a fixed target surface. The design of the transducer support bracket shall be such that any shading of the transducer by the bracket is minimised.

Apply radiant energy directed at what would be the topmost surface of the transducer in its normal installation configuration. The intensity of the radiation at the topmost surface of the transducer shall be $1 \text{ kW/m}^2 \pm 10\%$.

Set the lamps on an automatic timer such that the test space can be isolated and conditions are allowed to stabilise for at least 6 hours before the lamps are illuminated.

Operate the lamps continuously for a period of 8 hours. At the end of this period, the lamps shall switch off automatically. The test space shall remain closed for a further minimum period of 6 hours to allow the instrument to reach equilibrium.

Perform at least 2 complete cycles, each cycle comprising unlit, lit and unlit conditions.

During each test cycle, log the instrument output, ambient and mid-path temperature and light intensity at a minimum frequency of 5 minutes.

Repeat the test with the distance between the transducer face and the target set at the minimum separation distance plus 100mm.

For each test cycle, calculate the instrument reading under lit conditions as the average value during the final hour with the lamps on, and the instrument reading under unlit conditions as the average value during the final hour with the lamps off. Calculate the change in the instrument output as the difference between these 2 values.

Identify the maximum change from the completed test cycles and use this value to calculate the effect due to solar radiation, Xsv.

6.3.13 Response time

Type A EDMs

Provide means to rapidly apply a step change to the measured level.

Provide the means of recording the measurement during the test, either by activating an internal memory or attaching a recording device to the instrument output. If these options are not available the EDM measurement can be recorded manually but must be sufficiently frequent to reproduce the instrument response curve.

Set the measured level at 25 mm or more below the alarm point until a constant output reading is obtained.

Change the level as quickly as possible to 25 mm, or more, above the alarm point. The change should be effected in no more than 30 seconds.

Record the time when the reference change starts and is completed.

Record the EDM output and maintain the level until the measurement is stable.

Apply a decreasing step change by reverting to the lower level. Record the time of the reference change and instrument output. Continue to supply this level until the measurement is stable.

From the instrument record, calculate the size of step change and the response time.

The response time is the time required for the instrument output to reach and remain within a band between the initial value plus (for an increased step) or minus (decreased step) 90% and 110% of the step change.

Should the reading fail to maintain a value within 90% to 110% of the step change after the change, report the value that is reached and calculate the response time using the recorded value.

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

Type B EDMs

Following the methodology described in 6.3.5, measure the time difference between when the water level reaches the overflow point and when the output status changes. Repeat a total of 3 times each for rising and falling water levels.

Calculate and report the average response time.

6.3.14 Data logger timing

The EDM shall be installed and operated such that the real or simulated water level is above the overflow level.

The logger clock shall be synchronised with a time source of known accuracy. The logger shall be set to record the discharge status alarm and any water level measurement at 2-minute intervals and logging started. After no less than 72 hours, the logger shall be stopped, and the clock interrogated and compared with the reference time source.

The logged data shall be downloaded.

Verify that the logged data set contains a complete series of data points for the duration of the test. Calculate and report the percentage of data points obtained as:

$$\text{Equation 4: } \frac{\text{Number of data points recorded}}{(\text{Test duration in minutes}/2)} \times 100\%$$

Calculate the clock error in seconds over the duration of the test. Calculate and report the average error per 24-hour period.

For some EDMs it may be appropriate to include this test within the field test.

6.4 Combined performance characteristic

The combined performance characteristic (U_c) shall be calculated using the procedure described below.

It is often convenient to have a single value for an EDM's uncertainty under any circumstances. MCERTS therefore defines a combined performance characteristic by combining the components measured in the individual tests. To combine the characteristics in line with the GUM it is necessary to convert them to standard uncertainties (u) which take account of the probable distribution of errors.

For the purposes of this standard, resolution and all measured characteristics (except repeatability) are assumed to have a rectangular probability distribution. This means there is an equal chance of any value of error occurring within the range that has been measured in any individual test. In the case of a rectangular distribution the standard uncertainty is calculated as follows.

Equation 5:
$$u = \frac{X}{\sqrt{3}}$$

Repeatability has been calculated as a standard deviation at each test point (see equation 2 in 6.3.2) and so represents a normal distribution of errors. The value of repeatability to be used in the calculation of the combined performance characteristic shall be the maximum value measured, excluding that taken at test point 1.

In the GUM, standard uncertainties are combined using a root square sum with due account taken of the contribution of each component through the use of sensitivity coefficients. To determine sensitivity coefficients, it is necessary to know the analytical functions by which each component contributes to the overall error. In the case of instrument testing this will rarely be known, so for the purposes of this standard, the sensitivity coefficients are all taken as 1. However, in specific cases, the certification committee may require particular weighting to be given to certain components and require other values of sensitivity coefficients to be used.

The requirement for the combined performance characteristic is expressed as an expanded uncertainty. The expanded uncertainty, U , is obtained by multiplying the standard uncertainty by a coverage factor. The coverage factor is determined by the confidence level required. For MCERTS, a 95% confidence is used with a coverage factor assumed to be 2.

Equation 6:
$$U_c = 2 \times u_c$$

Table 6 shows the components which are to be combined when determining the combined performance characteristic, U_c . Specific components depend on the type of EDM, although some may be common to all types of EDM.

Table 6 - Components for the combined performance characteristic

Performance characteristic	Symbol	Test
Mean error	U _A	6.3.5
Repeatability	U _R	6.3.5
Resolution	U _{res}	3.2.11
Supply voltage	U _V	6.3.6, 6.3.7, 6.3.8
Output impedance	U _O	6.3.9
Water temperature	U _{FT}	6.3.10
Ambient air temperature	U _T	6.3.11
Direct solar radiation	U _{SV}	6.3.12

Table note: The larger of U_R and U_{res} shall be used to in the calculation of U_C to avoid double counting.

Where a mean error component is included, it shall be as a standard uncertainty with an assumed rectangular distribution.

Equation 7: $u_A = \frac{(\max \bar{x})}{\sqrt{3}}$

Where max \bar{x} excludes test point 1.

The combined performance characteristic, U_C, is therefore calculated by summing the components as a root sum of their squares and multiplying by the coverage factor, 2.

Equation 8: $U_C = 2 \times \sqrt{U_A^2 + U_R^2 + U_V^2 + U_O^2 + U_{FT}^2 + U_{FT}^2 + U_T^2 + U_{SV}^2}$

7. Field test

The field test requirements are flexible to allow manufacturers to use existing installations, provided that there is some way of validating measurements by one of the reference methods described in section 5.6. Alternative methods may also be acceptable but in such cases, the manufacturer should discuss the matter with the certification body to ensure that the proposed method is acceptable.

The field test requirements take into account 2 scenarios:

- established products that have a track record of use in a variety of applications
- products that are new onto the market and as such do not have data to demonstrate use in a real environment

Emphasis will be placed upon a manufacturer setting out their case justifying, with appropriate evidence, why the product will meet the field test requirements.

Acceptable data might include:

- field test reports from qualified laboratories
- validated reports from users of the equipment
- manufacturers' data validated by an independent third party

This data will be augmented by a rigorous assessment of maintenance and service records carried out during the manufacturing audit. More emphasis will also be placed on continued compliance of the products to the general requirements and this will be carried out during the regular surveillance audits.

Where data from an existing installation is used in support of MCERTS certification, it should be from an EDM of the same type for which certification is sought. Report any options included in the field test device, and any modifications or differences between it and the device used in the laboratory testing stage. The certification body may require the full history of the EDM since its installation, including details of any maintenance or repairs. Corroboration may be sought from the site owner via a confidential questionnaire.

7.1 Objectives of the field test

7.1.1 The objectives of the field test are to demonstrate that the performance of an EDM is maintained under operational conditions and allow an assessment of the proportion of time for which usable measurement data can be obtained.

No 2 field trials will be identical and the nature of the trial will depend on many factors, such as the:

- EDM being tested
- intended applications for the EDM

- availability of existing data from a manufacturer, customer, or both

Guidance and examples of different approaches that may be used to meet the requirements of the field test are available from the certification body.

7.1.2 A test plan detailing the proposed field trial shall be submitted to the certification body for consideration by the certification committee. This shall include:

- nature of site and specific application
- reference method
- traceability
- installation environment

A questionnaire is available from the certification body to assist in collating information the certification committee will need to establish whether data from an existing installation would be acceptable as a basis for certification.

7.1.3 The decision of the certification committee on matters of the test plan and data is final.

7.2 Requirements of the field test

7.2.1 The EDM under test shall be the same model as for the laboratory testing. Any differences between the instruments shall be justified and agreed with the certification body.

7.2.2 For all EDMs the reference measurements shall include a water level sensor that provides a direct, or inferred, measurement of water level.

7.2.3 For all instruments, the field test shall be carried out on a complete measurement system.

7.2.4 At least 3 months continuous operation is required. Only in exceptional cases, which shall be fully justified (for example, in the case of operation-related interruptions or process breakdown), will it be possible to allow shorter testing periods during the field test.

7.2.5 The output of the EDM shall be logged continuously over the period of the field test.

7.2.6 Details of ambient conditions relating to the field test shall be collected to facilitate the understanding of field test data. Where possible, field test data should be supported by any such relevant data on ambient conditions.

7.2.7 Similarly, details of the process fluid can also facilitate understanding of field test data and provide an indication of the conditions under which the EDM was operating. Where possible, field test data should be supported by any such relevant data on process conditions.

7.2.8 During the field test, the performance characteristics of the EDM shall be determined under representative operational conditions. This means that the reference measurements shall only be taken when the process is operating normally and all parameters are within the rated operating conditions of the EDM.

7.2.9 Data obtained when conditions are outside the rated operating conditions can be reported to demonstrate performance in excess of the MCERTS requirements.

7.2.10 Field testing for an EDM requires that an event occurs at least 24 times during the field test in order that the response of the EDM may be observed. Ideally it should be carried out on a site which is prone to events due to storm surges or process events. However, it may be difficult to ensure sufficient events in an operational environment and therefore a simulated field test can be considered.

If a simulated field test is proposed then a method to assess the effect of fouling will be required. The detail of that method shall be discussed and agreed with the certification body.

7.3 Error under field test conditions

7.3.1 The error of an EDM is determined by comparing the EDM's outputs with those from a reference method. Possible reference methods for level are listed in section 5.6.

7.3.2 If a second sensor is being used for the reference measurement then, where possible, it should be a certified instrument suitable for the application.

7.3.3 A minimum of 24 pairs of readings (simultaneous determinations from the EDM and the reference method) shall be taken over the duration of the field test. The timing of readings shall be chosen such that:

- they are spread throughout the field test period
- they are carried out at a number of different times during the normal operating cycles for the site, whether these be diurnal, weekly or monthly
- 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
- the determinand value is stable (meaning does not change by more than $\pm 5\%$ whilst each pair of readings is being taken)
- they are spread across as wide a range of fluid levels encountered on the test site as possible

For a Type B EDM, this requires 24 simulated or real discharge events.

7.3.4 For each pair of reference measurements the error shall be determined using the method in 6.3.5 and reported.

7.3.5 Calculate and report the proportion of errors less than or equal to the value for the combined performance requirement (see 4.6 and Table 2).

7.3.6 For some EDMs it may be necessary to do an additional laboratory calibration immediately before and immediately after the field test. If so, care should be taken when removing the EDM and carrying out the second calibration as to not disturb any fouling on the sensor.

This might be required to determine whether there have been any changes to the measurement uncertainty. Any requirement for this test shall be discussed and agreed with the certification body.

7.4 Maintenance

7.4.1 Any maintenance activities, scheduled or otherwise, required during the field test shall be recorded.

7.4.2 Settings and frequency of any automatic maintenance or calibration routines shall be recorded.

7.4.3 Any changes to the frequency of any automatic or scheduled manual maintenance activities during the field test period shall be reported.

7.4.4 If one or more major components (for example, the entire sensor or transmitter) of the EDM are replaced during the field test period, the matter shall be referred to the certification body who shall consider whether additional data is required.

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

- nature of the fault
- actions required to remedy fault
- time taken in staff hours to remedy the fault
- any problems or difficulties experienced in following the manufacturer's recommendations for fault diagnosis and repair
- requirement for manufacturer's attendance on site
- any components replaced
- total time while the EDM was not operational, meaning time from point of failure to the EDM coming back online

7.4.6 If the total time while the EDM is not operational due to failure is more than 2 weeks, the certification body may require an extension of the test to ensure that sufficient operational data are collected.

7.5 Up-time

7.5.1 Up-time is the fraction of the total time for which usable measuring data are available from the EDM. It is calculated using equation 9.

Equation 9:
$$V = 100 \left(\frac{t_G - t_A}{t_G} \right)$$

Where:

- V = up-time
- t_G = total operating time
- t_A = total outage time

7.5.2 The outage time shall be summarised and reported in a table, as shown in Table 7.

Table 7 - Summary of up-time test results

Time	Total
Total operating time (t _G)	Minutes
Outage time: automatic maintenance and calibration times	Minutes
Outage time: scheduled manual interventions	Minutes
Outage time: device malfunction and repairs	Minutes
Outage time: other servicing, adjustment	Minutes
Total outage time (t _A)	Minutes
Up-time	%

7.6 Reporting of field test

7.6.1 The field test shall be summarised in the MCERTS test report. The report shall include:

- information about the site
- description of the reference method
- estimate of the reference uncertainty
- measurement results
- calculation of the proportion of errors less than or equal to the value of the combined performance requirement (see table 2)
- the calculated up-time