



**Australian Government**

**National Measurement  
Institute**



# NMI M 10-1 Meters Intended for the Metering of Water in Full Flowing Pipes

Part 1: Metrological and Technical Requirements

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## ABBREVIATIONS

$\Delta p$	pressure loss	$P_w$	working pressure
A	cross-sectional area of pipe	Q	flowrate
c	conductivity of the water	$Q_1$	minimum flowrate
$c_v, c_A$	sensitivity coefficients	$Q_3$	permanent flowrate
C	effective cable capacitance	$Q_4$	overload flowrate
EUT	equipment under test	$T_w$	working temperature
F	field frequency during the measuring cycle	$u_A$	standard uncertainty of area
IEC	International Electrotechnical Commission	$u_Q$	combined standard uncertainty
ISO	International Organization for Standardization	$u_v$	standard uncertainty of velocity
k	coverage factor	$U_Q$	expanded uncertainty
MPE	maximum permissible error	v	velocity
OIML	International Organization of Legal Metrology	$V_a$	actual volume
		$V_i$	indicated volume

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## PREFACE

NMI M 10-1 is based on *NMI R 49-1. Water Meters Intended for the Metering of Cold Potable Water and Hot Water. Part 1: Metrological and Technical Requirements* (which in turn is based on OIML R 49-1:2006).

Some meters may have been previously tested and approved in accordance with NMI R 49 or OIML R 49 either in Australia or overseas.

In Australia, meters may be pattern approved against both NMI R 49 and NMI M 10. The pattern approval certificate will indicate against which standard the meter has been approved.

Some test results performed in accordance with NMI R 49 or OIML R 49, due to the similarity of the methodology, will be accepted as part of a pattern approval application for NMI M 10.

All tests performed in accordance with NMI R 49 or OIML R 49 will be recognised as being performed with potable water. Further testing with non-potable water may be required.

As well as minor editorial corrections, this third edition of NMI 10-1 differs from the second edition in that:

- clause 2 has been expanded to include the definitions from NMI M 10-2;
- clauses 5.2.3, 5.2.4, A.2 and Table A.1 have been altered because environmental classes C and I have been renamed O and M;
- clause 5.11.3 on strap-on and insertion measuring devices has been modified;
- clause 5.11.5 on water quality has been added;
- clause 6.2.7 on endurance testing has been modified;
- clause 6.2.8 on water quality disturbance testing has been added;
- clause 6.2.10 on the test for cartridge meters and meters with interchangeable inserts has been added;
- Table A.1 severity levels for water and dust have been added;
- clause A.5.4 reference IEC 61000-4-5 has been added;
- clause A.5.11 severity levels for water have been added; and
- clause A.5.12 severity levels for dust have been added.

## 1. SCOPE

This document specifies the metrological and technical requirements for the pattern approval and verification of water meters (subsequently referred to as meters) used for trade\*, which measure the actual volume of water flowing through fully charged, closed conduits. Such meters shall incorporate devices which indicate the integrated volume. Meters approved against this document are designated as accuracy class 2.5 water meters.

This document also applies to meters based on electrical or electronic principles, and to meters based on mechanical principles incorporating electronic devices. Electronic ancillary devices are optional.

Meters which are essentially self-contained units with their own geometry are normally pattern approved as a single unit. Insertion or strap-on measuring devices capable of being fitted into a range of pipe sizes are also normally pattern approved as a single unit.

This document is not intended to cover the pattern approval, evaluation or testing of modular metering systems, although provision is made to allow for the testing and approval of individual modules or sensors.

NMI M 10-2 [1] specifies the methods of examination and testing procedures and NMI M 10-3 [2] contains the model test report.

NMI M 11-1 [3] specifies the requirements for meters for water flowing in open channels or partially filled pipes.

NMI R 49-1 [4] specifies the requirements for water meters intended for the metering of cold potable water and hot water. Such meters are designated as accuracy class 1 or accuracy class 2 meters.

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\* Under the *National Measurement Act 1960* 'used for trade' means use of a measuring instrument for either:

- determining the consideration in respect of a transaction; or
- determining the amount of a tax.

## 2. TERMINOLOGY

Many of the definitions used in this document conform with the *International Vocabulary of Basic and General Terms in Metrology* [5] and the *International Vocabulary of Terms in Legal Metrology* [6]. In addition, for the purposes of this standard, the following definitions shall apply.

### 2.1 Water Meter and its Constituents

#### 2.1.1 Water Meter

An instrument intended to measure, memorise and display the volume of water passing through the measurement transducer at metering conditions.

Note: A water meter includes at least a measurement transducer, a calculator (including adjustment or correction devices if present) and an indicating device. These three devices may be in different housings.

#### 2.1.2 Metering System

A metering system consists of a number of measuring instruments or modules, which may have been separately pattern approved. These modules may be combined with a structure or emplacement and a calculation methodology to derive a measurement of the volume of water passing through the metering system.

#### 2.1.3 Measurement Transducer

A part of the meter which transforms the flow or the volume of the water to be measured into signals which are passed to the calculator. It can be based on a mechanical, an electrical or an electronic principle. It may be autonomous or use an external power source.

Note: For the purposes of these requirements, the measurement transducer includes the flow sensor or volume sensor.

#### 2.1.4 Flow Sensor or Volume Sensor

Part of the meter (such as a disc, piston, wheel, turbine element, ultrasonic sensor or electromagnetic coil) that senses the velocity, flow rate or volume of water passing through the meter.

### **2.1.5 Non-invasive Sensor**

Sensor for application to pressurised pipes which attaches to the outside of a pipe and requires no tapping, drilling or cutting of the pipe to install.

### **2.1.6 Transmitter**

A device which takes the signal from the sensor and converts it into a visual or electrical output proportional to the flowrate or totalised volume.

Note: The sensor and transmitter may be incorporated in a single housing.

### **2.1.7 Calculator**

A part of the meter which receives the output signals from the transducer(s) and, possibly, associated measuring instruments, transforms them and, if appropriate, stores the results in memory until they are used. In addition, the calculator may be capable of communicating both ways with ancillary devices.

### **2.1.8 Indicating Device**

A part of the meter which displays the measurement results either continuously or on demand.

Note: A printing device which provides an indication at the end of the measurement is not an indicating device.

### **2.1.9 Adjustment Device**

A device incorporated in the meter that only allows the error curve to be shifted generally parallel to itself, with a view to bringing errors of indication within the MPEs.

### **2.1.10 Correction Device**

A device connected to or incorporated in the meter for automatically correcting the volume at metering conditions, by taking into account the flowrate and/or the characteristics of the water to be measured (e.g. temperature and pressure) and the pre-established calibration curves. The characteristics of the water to be measured may either be measured using associated measuring instruments, or be stored in memory in the instrument.

### **2.1.11 Ancillary Device**

A device intended to perform a particular function, directly involved in elaborating, transmitting or displaying measurement results.

The main ancillary devices are:

- zero setting device;
- repeating indicating device;
- printing device;
- memory device;
- tariff control device; and
- presetting device.

Note: Ancillary devices are only subject to metrological control if they are used for trade.

### **2.1.12 Tariff Control Device**

A device that allocates measurement results into different registers depending on tariff or other criteria, each register having the possibility to be displayed individually.

### **2.1.13 Presetting Device**

A device which permits the selection of the quantity to be measured and which automatically stops the flow of the water at the end of the measurement of the selected quantity.

### **2.1.14 Associated Measuring Instruments**

Instruments connected to the calculator, the correction device or the conversion device, for measuring certain quantities which are characteristic of water, with a view to making a correction and/or conversion.

### **2.1.15 Flow Straightener**

Any device installed into the pipe or channel work intended to minimise or eliminate flow disturbances and create smooth, uniform flow. In the context of this document a flow straightener may be used by:

- (a) The testing laboratory in order to eliminate any flow disturbances caused by the configuration of the test rig itself (caused by pumps, bends, valves etc) to ensure the confidence, repeatability and inter-laboratory comparison of test results.

- (b) The meter manufacturer, used as a component of the meter installation, in order to achieve the level of accuracy and performance required by this document. In this case, the details and use of such a device will be included in the pattern approval certificate and listed as a condition of installation.

#### **2.1.16 Equipment under Test (EUT)**

The complete meter, sub-assembly of a meter or an ancillary device that is subjected to a test.

#### **2.1.17 Meter with Interchangeable Inserts (Cartridge Meter)**

A type of meter that comprises a body, or connection interface, and an interchangeable measuring insert or cartridge; both of which must be from the same approved pattern.

#### **2.1.18 Connection Interface**

Pipe fitting specific to the connection of a cartridge meter or meter with interchangeable inserts.

#### **2.1.19 Measuring Insert or Cartridge**

Self-contained unit comprising a measurement transducer, an indicating device, a calculator and/or flow computer which is able to be fitted into a closed conduit by means of a connection interface.

## **2.2 Metrological Characteristics**

### **2.2.1 Actual Volume, $V_a$**

Total volume of water passing through the meter, disregarding the time taken. This is the measurand.

### **2.2.2 Indicated Volume, $V_i$**

Volume of water indicated by the meter, corresponding to the actual volume.

### **2.2.3 Primary Indication**

An indication (displayed, printed or memorised) which is subject to legal metrological control.

### **2.2.4 Error of Indication**

Indicated volume minus the actual volume.

### **2.2.5 Relative Error of Indication**

Error of indication divided by the actual volume.

### **2.2.6 Maximum Permissible Error (MPE)**

The extreme values of the relative error of indication of a meter permitted by these requirements.

### **2.2.7 Intrinsic Error**

The error of indication of a meter determined under reference conditions.

### **2.2.8 Initial Intrinsic Error**

The intrinsic error of a meter as determined prior to all performance tests.

### **2.2.9 Fault**

The difference between the error of indication and the intrinsic error of a meter.

### **2.2.10 Significant Fault**

A fault, the magnitude of which is greater than half of the MPE.

The following are not considered to be significant faults:

1. faults arising from simultaneous and mutually independent causes in the meter itself; and
2. transitory faults being momentary variations in the indication which cannot be interpreted, memorised or transmitted as a measurement result.

### **2.2.11 Durability**

The capability of a meter to keep its performance characteristics over a period of use.

### **2.2.12 Metering Conditions**

The conditions of the water, of which the volume is to be measured, at the point of measurement (example: temperature and pressure of water).

### **2.2.13 First Element of an Indicating Device**

The element which, in an indicating device comprising several elements, carries the graduated scale with the verification scale interval.

#### **2.2.14 Verification Scale Interval**

The lowest value scale division of the first element of an indicating device.

#### **2.2.15 Resolution (of an Indicating Device)**

The smallest difference between indications of an indicating device that can be meaningfully distinguished.

Note: For a digital device, this is the change in the indication when the least significant digit changes by one step.

### **2.3 Operating Conditions**

#### **2.3.1 Flowrate, $Q$**

Quotient of the actual volume of water passing through the meter and the time taken for this volume to pass through the meter. Expressed in megalitres per day, litres per second, cubic metres per hour or kilolitres per hour.

#### **2.3.2 Permanent Flowrate, $Q_3$**

The highest flowrate expressed in megalitres per day, litres per second, cubic metres per hour or kilolitres per hour, within the rated operating conditions, at which the meter is required to operate in a satisfactory manner within the MPE.

#### **2.3.3 Overload Flowrate, $Q_4$**

The highest flowrate expressed in megalitres per day, litres per second, cubic metres per hour or kilolitres per hour, at which the meter is required to operate, for a short period of time, within its MPE, whilst maintaining its metrological performance when it is subsequently operated within its rated operating conditions.

Note: A short period of time can be considered as 1 h in any 24 h period.

#### **2.3.4 Minimum Flowrate, $Q_1$**

The lowest flowrate expressed in megalitres per day, litres per second, cubic metres per hour or kilolitres per hour, at which the meter is required to operate within the MPE.

#### **2.3.5 Nominal Diameter (DN)**

Alphanumeric designation of size for components of a pipe work system, which is used for reference purposes.

Note: It comprises the letters DN followed by a dimensionless whole number that is directly related to the physical size in mm of the bore, or outside diameter of the end connections.

#### **2.3.6 Maximum Admissible Temperature**

The maximum water temperature that a meter can withstand permanently, within its rated operating conditions, without deterioration of its metrological performance.

#### **2.3.7 Maximum Admissible Pressure**

The maximum internal pressure that a meter can withstand permanently, within its rated operating conditions, without deterioration of its metrological performance.

#### **2.3.8 Working Temperature, $T_w$**

The average water temperature in the pipe measured upstream and downstream of the meter.

#### **2.3.9 Working Pressure, $P_w$**

The average water pressure in the pipe measured upstream and downstream of a meter.

#### **2.3.10 Pressure Loss, $\Delta p$**

The head loss, at a given flowrate, caused by the presence of the meter in the pipeline.

### **2.4 Test Conditions**

#### **2.4.1 Test Flowrate**

Mean flowrate during a test, calculated from the indications of a calibrated reference device. Expressed in megalitres per day, litres per second, cubic metres per hour or kilolitres per hour.

#### **2.4.2 Influence Quantity**

A quantity that is not the measurand, but which affects the result of the measurement.



#### **2.4.3 Influence Factor**

An influence quantity having a value within the rated operating conditions of the meter, as specified in these requirements.

#### **2.4.4 Disturbance**

An influence quantity having a value within the limits specified in these requirements, but outside the specified rated operating conditions of the meter.

Note: An influence quantity is a disturbance if for that influence quantity the rated operating conditions are not specified.

#### **2.4.5 Rated Operating Conditions**

Conditions of use giving the range of values of the influence factors, for which the errors of indication of the meter are required to be within the MPEs.

#### **2.4.6 Reference Conditions**

A set of reference values, or reference ranges of influence quantities, prescribed for testing the performance of a meter, or for the intercomparison of the results of measurements.

#### **2.4.7 Limiting Conditions**

The extreme conditions, including flowrate, temperature, pressure, humidity and electromagnetic interference, that a meter is required to withstand without damage, and without degradation of its error of indication, when it is subsequently operated within its rated operating conditions.

#### **2.4.8 Performance Test**

A test intended to verify whether a meter is capable of accomplishing its intended functions.

#### **2.4.9 Endurance Test**

A test intended to verify whether the meter is able to maintain its performance characteristics over a period of use.

#### **2.4.10 Temperature Stability**

Temperature stability has been reached when all parts of the EUT are within 3°C of each other, or as otherwise specified in the relevant specification of its final temperature.

#### **2.4.11 Scanning Rate**

The rate or frequency that an electronic meter measures the flowrate of the water passing through the measurement transducer.

#### **2.4.12 Pre-conditioning**

Treatment of the EUT, with the object of removing, or partly counteracting, the effects of its previous history. Where called for, it is the first process in the test procedure.

#### **2.4.13 Conditioning**

Exposure of the EUT to an environmental condition (influence factor or disturbance) in order to determine the effect of such a condition on it.

#### **2.4.14 Recovery**

Treatment of the EUT, after conditioning, in order that the properties of the EUT may be stabilised before measurement.

#### **2.4.15 Open Channel Emplacement**

A device or mechanism that allows a quantity of water flowing in an open channel to be measured by a closed conduit meter.

### **2.5 Electronic and Electrical Equipment**

#### **2.5.1 Electronic Device**

A device employing electronic subassemblies and performing a specific function. Electronic devices are usually manufactured as separate units and are capable of being tested independently.

Note: Electronic devices, as defined above, may be complete meters or parts of meters, in particular such as those mentioned in clauses 2.1.1 to 2.1.9 and clause 2.1.12.

#### **2.5.2 Electronic Subassembly**

A part of an electronic device, employing electronic components and having a recognisable function of its own.

### 2.5.3 Electronic Component

The smallest physical entity which uses electron or hole conduction in semi-conductors, gases, or in a vacuum.

### 2.5.4 Power Supply Device

A device which provides the electronic devices with the required electrical energy, using one or several sources of AC or DC.

## 2.6 Terms in Metrology

### 2.6.1 Accuracy (of Measurement)

The closeness of the agreement between the result of a measurement and a true (conventional) value of the measured quantity.

### 2.6.2 Error (of Measurement)

The result of a measurement minus a true (conventional) value of the measured quantity.

### 2.6.3 Relative Error (of Measurement)

The error of measurement divided by a true value of the measured quantity.

### 2.6.4 True Value (of a Quantity)

A value consistent with the definition of a given particular quantity.

Notes:

1. This is the value that would be obtained by a perfect measurement.
2. True values by nature are indeterminate.
3. The indefinite article 'a', rather than the definite article 'the', is used in conjunction with 'true value' because there may be many values consistent with the definition of a given particular quantity.

### 2.6.5 Conventional True Value (of a Quantity)

A value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose.

### 2.6.6 Uncertainty of Measurement

A parameter associated with the result of a measurement that characterises the dispersion of the values that could reasonably be attributed to the measured value.

Notes:

1. The parameter may be, for example, a standard deviation (or a given multiple of it), or the half-width of an interval having a stated level of confidence.
2. Uncertainty of measurement comprises, in general, many components. Some of these components may be evaluated from the statistical distribution of the results of a series of measurements and can be characterised by experimental standard deviations. The other components, which can also be characterised by standard deviations, are evaluated from assumed probability distributions based on experience or other information.
3. It is understood that the result is best estimate of the value of the measurand, and that all components of uncertainty, including those arising from systematic effects, such as components associated with corrections and reference standards, contribute to the dispersion.
4. Both 'type A' and 'type B' uncertainties are used in this document. For further information see *Guide to the Expression of Uncertainty in Measurement* [7].

### 2.6.7 Expanded Uncertainty

Expanded uncertainty shall be determined in accordance with the *Guide to the Expression of Uncertainty in Measurement* [7].

#### 2.6.8 Pattern Approval

The process whereby an impartial body examines the pattern of an instrument against a set of national or international metrological specifications. This determines whether an instrument is capable of retaining its calibration over a range of environmental and operating conditions and ensures that the instrument is not capable of facilitating fraud.

#### 2.6.9 Pattern of an Instrument

The definitive design of a measuring instrument of which all components affecting its metrological properties are suitably defined.

#### 2.6.10 Verification

The process whereby instruments are inspected to ensure that they comply with the approved pattern, calibrated to ensure that they are operating within the MPEs, and stamped or certified as evidence of conformity.

#### 2.6.11 Initial Verification

Verification, by an approved person, of a new instrument which does not bear a verification mark and has never been verified before.

#### 2.6.12 Subsequent Verification

Any verification of an instrument by an approved person because the mark is no longer valid due to such reasons as:

- repairs or adjustments have been made that affect metrological performance; or
- the mark has been defaced or removed.

#### 2.6.13 Re-verification

Any verification of an instrument by an approved person to check that:

- the verification mark is valid; and
- the errors do not exceed the MPEs for re-verification; and
- the instrument has not been modified in any way since verification.

#### 2.6.14 In-service Inspection

The examination of an instrument by an approved person to check that:

- the verification mark is valid; and
- the instrument has not been modified since verification.

#### 2.6.15 Certified Maintainer

A person certified by an accredited organisation to undertake meter maintenance activities in accordance with best industry practices and Australian standards or technical specifications.

Certified maintainers may include but are not limited to water service provider staff, State/Territory government officers and irrigation industry contractors.

#### 2.6.16 Manufacturer

The individual or organisation responsible for making an application to NMI for a meter to be pattern approved in accordance with this documentation. In the context of this documentation, this role may also be performed by a supplier or agent acting on behalf of the actual manufacturer of the meter. Also known as the applicant or the submitter.

### 3. METROLOGICAL REQUIREMENTS

#### 3.1 Values of $Q_1$ , $Q_3$ and $Q_4$

The flowrate characteristics of a meter shall be defined by the values of  $Q_1$ ,  $Q_3$  and  $Q_4$  expressed in megalitres per day, litres per second, cubic metres per hour or kilolitres per hour.

A meter shall be designated by the numerical value of  $Q_3$  and the ratio  $Q_3/Q_1$ .

The value of  $Q_3$  shall be nominated by the manufacturer.

The value of the ratio  $Q_3/Q_1$  shall be chosen from the following list:

10 12.5 16 20 25 31.5 40 50 63 80  
100 125 160 200 250 315 400 500 630 800

The list may be extended to higher or lower values in the series.

The ratio  $Q_4/Q_3$  shall be 1.25.

Note: Some meters may be designated by numerical values of other characteristics such as velocity. In this case the manufacturer is required to nominate numerical values and ratios analogous to those specified above.

### 3.2 Maximum Permissible Error

#### 3.2.1 General

This section outlines the MPEs for all types of meters and systems. In order for a meter to comply with this document, it must satisfy all relevant acceptance criteria.

#### 3.2.2 Error of Indication

The error of indication is expressed as a percentage, and is equal to:

$$[(V_i - V_a) / V_a] \times 100$$

Where:  $V_a$  is actual volume  
 $V_i$  is indicated volume

#### 3.2.3 Self-contained Meters

Meters which are essentially self-contained units with their own geometry and which are normally pattern approved and verified as single units shall be designed and manufactured such that their errors of indication do not exceed  $\pm 2.5\%$  across the flowrate range ( $Q_1 \leq Q \leq Q_4$ ) under rated operating conditions.

#### 3.2.4 Meters with Separable Calculator and Transducer

For meters with separable calculator and measurement transducer:

- the calculator (including indicating device) and the measurement transducer (including flow sensor or volume sensor) may be the subject of separate pattern approvals; and
- the MPEs of the combined indicating device and measurement transducer shall not exceed  $\pm 2.5\%$ .

#### 3.2.5 Insertion Devices

Where insertion velocity measuring devices are tested for pattern approval and initial verification they shall be tested in pipe sections whose measurements have been determined to the extent that such dimensions contribute no more than 0.1%

to the expanded uncertainty in the determination of volume. In this case, MPE of the insertion velocity measuring device plus the pipe section shall not exceed  $\pm 2.5\%$  across the flowrate range ( $Q_1 \leq Q \leq Q_4$ ) under rated operating conditions.

#### 3.2.6 Reverse Flow

The manufacturer shall specify whether or not the meter is designed to measure reverse flow.

If a meter is designed to measure reverse flow, the actual volume passed during reverse flow shall either be subtracted from the indicated volume or the meter shall record it separately. The MPE ( $\pm 2.5\%$ ) shall be met for both forward and reverse flow.

If a meter is not designed to measure reverse flow, the water meter installation shall either prevent reverse flow, or the meter shall withstand accidental reverse flow without deterioration or change in its metrological properties for forward flow.

#### 3.2.7 Additional Requirements

The requirements relating to the MPEs and maximum uncertainties (see clause 3.3) shall be met for all temperature and pressure variations occurring within the rated operating conditions of the meter.

The meter totalisation shall not change when the flowrate is zero. Where a meter is known to be affected by empty pipe conditions, precautions shall be taken to eliminate spurious flow readings.

### 3.3 Maximum Permissible Uncertainty

Meters consisting of one or more measurement transducers and a computational device which are separately pattern approved and verified, shall be manufactured and installed such that the maximum expanded uncertainty in the determination of the volume of water shall not exceed  $\pm 5\%$ . Uncertainty shall be determined in accordance with *Guide to the Expression of Uncertainty in Measurement* [7]. An example of uncertainty calculation is given in Annex B.

### **3.4 Requirements for Meters and Ancillary Devices**

#### **3.4.1 Connections between Electronic Parts**

The connections between the measurement transducer, the calculator and the indicating device shall be reliable, durable and tamper protected in accordance with clause 5.10.

These provisions shall also apply to connections between the primary and secondary devices of electromagnetic meters.

Note: Definitions of primary and secondary devices of electromagnetic meters are given in ISO 6817 [8].

#### **3.4.2 Adjustment Device**

Meters may be provided with an electronic adjustment device, which may replace a mechanical adjustment device. Such devices will be tamper protected in accordance with clause 5.10.2.

#### **3.4.3 Correction Device**

Meters may be fitted with correction devices; such devices are always considered as an integral part of the meter and shall be tamper protected in accordance with clause 5.10. The whole of the requirements which apply to the meter, in particular the MPE and maximum expanded uncertainty specified in clause 3.2, are therefore applicable to the corrected volume at metering conditions.

In normal operation, non-corrected volume shall not be displayed.

The aim of a correction device is to reduce the errors of indication to as close to zero as possible. Meters with electronic correction devices shall satisfy the performance tests of Annex A.5.

All the parameters which are not measured and which are necessary for correcting shall be contained in the calculator at the beginning of the measurement operation.

The pattern approval certificate may prescribe the possibility of checking parameters which are necessary for correctness at the time of verification of the correction device.

The correction device shall not allow the correction of a pre-estimated drift, e.g. in relation to time or volume.

Associated measuring instruments, if any, shall comply with applicable international standards or recommendations. Their accuracy should be good enough to permit the requirements on the meter to be met, as specified in clause 3.2.

Correction devices shall not be used for adjusting the error of indication of a meter to values other than as close as practical to zero, even when these values are within the MPEs.

#### **3.4.4 Calculator**

All parameters necessary for the elaboration of indications that are subject to legal metrological control, such as a calculation table or correction polynomial, shall be present in the calculator at the beginning of the measurement operation.

The calculator may be provided with interfaces permitting the coupling of peripheral equipment. When these interfaces are used, the meter's hardware and software shall continue to function correctly and its metrological functions shall not be capable of being affected.

#### **3.4.5 Electronic Indicating Device**

The continuous display of volume during the period of measurement is not mandatory.

#### **3.4.6 Ancillary Devices**

The relevant requirements of NMI R117 [9] shall be applied when the meter is equipped with any of the following devices:

- zero setting device;
- printing device;
- memory device;
- presetting device.

## **4. METERS EQUIPPED WITH ELECTRONIC DEVICES**

### **4.1 General Requirements**

Meters with electronic devices shall be designed and manufactured in such a way that significant faults do not occur when

they are exposed to the disturbances specified in Annex A.5.

These requirements shall be met durably.

The meter shall also provide visual checking of the entire display which shall have the following sequence:

- displaying all elements (e.g. an ‘eights’ test); and
- blanking all the elements (a ‘blanks’ test).

Each step of the sequence shall last at least 1 s.

#### **4.2 Power Supply Device**

Three different kinds of basic power supplies for meters with electronic devices are covered by these requirements:

- external power supply;
- non-replaceable battery; and
- replaceable battery.

These three types of power supplies may be used alone or in combination. The requirements for each type of power supply are covered by the following paragraphs.

##### **4.2.1 External Power Supply**

Meters with electronic devices shall be designed such that in the event of an external power supply failure (AC or DC), the meter indication of volume just before failure is not lost, and remains accessible for a minimum of one year.

The corresponding memorisation shall occur at least either once per day or for every volume equivalent to 10 min of flow at  $Q_3$ .

Any other properties or parameters of the meter shall not be affected by an interruption of the electrical supply.

Note: Compliance with this clause will not necessarily ensure that the meter will continue to register the volume consumed during a power supply failure.

The power supply shall be secured from tampering or any such tampering will be evident.

##### **4.2.2 Non-replaceable Battery**

The manufacturer shall ensure that the indicated lifetime of the battery exceeds the operational lifetime of the meter by one

year. Therefore, guaranteeing that the meter functions correctly for at least one year longer than the nominal operational lifetime of the meter.

The latest date by which the meter is to be replaced shall be indicated on the meter. Alternatively, provision shall be made to allow this date to be recorded in the memory of the meter upon installation by a certified person.

Note: It is anticipated that a combination of maximum allowable volume, displayed volume, indicated operational lifetime, remote reading and extreme temperature will be considered when specifying a battery and during pattern approval. Alternative means of indicating impending battery failure may be allowed.

##### **4.2.3 Replaceable Battery**

Where the electrical power supply is a replaceable battery, the manufacturer shall give precise rules for the replacement of the battery.

The replacement date of the battery shall be indicated on the meter. Alternatively, provision shall be made to allow this date to be recorded in the memory of the meter upon replacement of the battery and installation of the meter by a certified person.

The properties and parameters of the meter shall not be affected by the interruption of electrical supply when the battery is replaced.

Note: It is anticipated that a combination of maximum allowable volume, displayed volume, indicated operational lifetime, remote reading and extreme temperature will be considered when specifying a battery and during pattern approval. Alternative means of indicating impending battery failure may be allowed.

The operation of replacing the battery shall be carried out in a way which does not necessitate breaking the seal required for metrological verification.

The battery compartment shall be secured from tampering or any such tampering will be evident.

#### **4.2.4 Combination of External Power Supply and Rechargeable Battery**

Where an external power source such as solar energy is used to recharge batteries, meters shall be designed such that in the event of failure of the solar power through damage or shading, the meter indication of volume just before battery failure is not lost, and remains accessible for a minimum of one year.

The corresponding memorisation shall occur once per day or for every volume equivalent to 10 min of flow at  $Q_3$ .

#### **4.2.5 Frequency of Measurement**

For meters operating at constant flowrate with only periodic measurement in order to conserve battery life, flow measurement shall occur at least every 5 min.

#### **4.3 Electromagnetic Meter Connection**

The maximum permissible cable length between primary and secondary devices of an electromagnetic meter, as defined in ISO 6817 [8], shall be no more than 100 m or not more than the value X expressed in metres according to the following formula, whichever is smaller:

$$X = (k \times c) / (f \times C)$$

Where:  $k = 2 \times 10^{-5}$  m

c is the conductivity of the water, in S/m

f is the field frequency during the measuring cycle, in Hz

C is the effective cable capacitance per metre, in F/m

Note: It is not necessary to fulfil these requirements if the manufacturer's solutions ensure equivalent results.

#### **4.4 Software and Firmware**

Details of any software and/or firmware used in the meter shall be specified in the pattern approval application form. The applicant shall advise NMI of any subsequent modifications to software

and/or firmware which may affect the metrology of the meter.

### **5. TECHNICAL REQUIREMENTS**

#### **5.1 Materials and Construction of Meters**

The meter shall be manufactured from materials of adequate strength and durability for the purpose for which the meter is to be used.

The meter shall be manufactured from materials which shall not be adversely affected by water temperature variations, within the working temperature range (see clause 5.6).

All parts of the water meter in contact with the water flowing through it shall be manufactured from materials which are conventionally known to be non-toxic, non-contaminating and biologically inert.

The complete meter shall be manufactured from materials which are resistant to internal and external corrosion or which are protected by a suitable surface treatment.

The indicating device of the meter shall be protected by a transparent window which is resistant to the effects of ultraviolet radiation. A cover of suitable type may also be provided as additional protection.

The meter shall incorporate devices for elimination of condensation, where there is a risk of the condensation forming on the underside of the window of the indicating device of the meter.

#### **5.2 Environmental Requirements**

##### **5.2.1 General**

The rated ranges of use for ambient conditions are divided into three classes. Meters shall be tested at the severity level indicated in Table A.1, according to the environmental class.

Note: The individual components of a meter may belong to different environmental classes. In this case, the cable between them and any

interface device should be suitable for the higher rated of the two classes.

The manufacturer shall state the environmental class(es) of the meter or its individual components. The approving authority shall determine the test requirements for the meter or its individual components.

#### **5.2.2 Environmental Class B**

This class applies to enclosed locations whose temperature and humidity are not controlled. Heating may be used to raise low temperatures, especially when there is a large difference between the conditions of this class and the open air conditions. Meters may be exposed to solar and heat radiation and drafts and may be subject to condensed water, water from sources other than rain and to ice formations. Vibration and shock will be of low significance.

#### **5.2.3 Environmental Class O**

This class applies to open locations with average climatic conditions, excluding polar and desert environments. Levels of vibration and shock will be of low significance.

#### **5.2.4 Environmental Class M**

This class applies to open locations with average climatic conditions, excluding polar and desert environments. Levels of vibration and shock may be high, e.g. meters mounted directly on or near machinery such as irrigation reels, pumps or mobile tankers.

### **5.3 Enclosure**

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 in accordance with IEC 60529 (IP Code) [10]:

- Class B — IP54;
- Class O, M — IP65 or IP68 for non-submersible and submersible components respectively.

For meters or individual components specified to IEC 60529 IP65 or IP68, the

degree of protection for all electrical equipment and connections shall not be degraded below IP65 during routine maintenance procedures or during normal calibration and verification. Where this is not possible, the meter or component shall be clearly marked to indicate that all care must be taken when any procedure is being undertaken.

The minimum degree of protection provided for an electrical flow sensor, including any electrical equipment or termination section provided as part of the sensor unit, shall conform to the requirements of IEC 60529 IP65.

The degree of protection provided for a submersible or insertion electrical flow sensor shall conform to the requirements of IEC 60529 IP68 at a depth to be stated by the manufacturer.

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

### **5.4 Adjustment and Correction**

The meter may be fitted with an adjustment device, and/or correction device.

If these devices are mounted on the outside of the meter, provision for sealing by the appropriate authority shall be made (see clause 5.10).

### **5.5 Installation Conditions**

#### **5.5.1 General**

Meters shall only be installed in the manner for which they have been approved. Installation conditions (such as those listed below) will be assessed during pattern approval and listed on the pattern approval certificate.

#### **5.5.2 Non-pressurised Systems**

A meter shall be installed such that it is completely filled with water under all



conditions. Non-pressurised systems may require elbows or pipe elevation to ensure that this requirement is met.

If the accuracy of the meter is likely to be affected by the presence of solid particles in the water, it shall be provided with a strainer or filter, fitted at its inlet or in the upstream pipeline.

### **5.5.3 Straight Lengths of Pipe and Flow Straighteners**

If the accuracy of the meter is affected by disturbances in the upstream or downstream pipeline (e.g. due to the presence of bends, elbows, valves or pumps) the meter shall be provided with a sufficient number of straight lengths of pipe (with or without a flow straightener) as specified by the manufacturer, so that the indications of the installed meter meet the requirements of clause 3.2.

Applicants shall submit full details and technical drawings of external flow straighteners to NMI (e.g. model, technical characteristics, position relative to the meter). The details and use of such devices will be included in the pattern approval certificate and listed as a condition of installation.

### **5.5.4 Open Channel Emplacements**

The meter may be tested in an open channel emplacement in accordance with clause 6.2.9.

### **5.5.5 Specified Installations**

The meter may be tested in specified installation conditions such as certain piping configurations in accordance with clause 6.2.9.

## **5.6 Rated Operating Conditions**

The rated operating conditions for a meter shall be as follows:

- Flowrate range:  $Q_1$  to  $Q_3$  inclusive.
- Ambient air temperature range:  $-5$  to  $+55^\circ\text{C}$ .
- Ambient humidity range: 0 to 100% except for remote indicating devices where the ranges shall be 0 to 93%.

- Working water temperature range:  $0.1$  to  $30^\circ\text{C}$ . The maximum admissible temperature is  $50^\circ\text{C}$ . This is a limiting condition for the meter.
- Working water pressure range: minimum  $0.03$  MPa to a value specified by the manufacturer. As a minimum, insertion or strap-on meters shall have the same working pressure range as the pipes in which they are designed to operate in.

Note: Where meters are expected to operate continuously with water temperatures exceeding  $30^\circ\text{C}$ , they shall be tested for both accuracy and endurance in accordance with the requirements of NMI R 49-1 [4].

## **5.7 Pressure Loss**

The pressure loss through a meter shall be indicated in the manufacturer's documentation and tested in accordance with clause 6.2.5.

## **5.8 Marks and Inscriptions**

The following information shall either be clearly and indelibly marked on the meter (either grouped or distributed on the casing, the indicating device dial, an identification plate or on the meter cover if it is not detachable), or recorded in the meter's memory and be easily accessible:

- (a) unit of measurement: megalitre, cubic metre or kilolitre (see clause 5.9.1.1);
- (b) numerical value of  $Q_3$  and the ratio  $Q_3/Q_1$ ;
- (c) pattern approval mark;
- (d) name or trade mark of the manufacturer;
- (e) serial number (as near as possible to the indicating device);
- (f) year of manufacture (optional);
- (g) direction of flow (the direction of flow arrow shall be easily visible under all circumstances);
- (h) maximum admissible pressure;

- (i) letter V or H, if the meter can only be operated in the vertical or horizontal position;
- (j) maximum pressure loss;
- (k) for insertion or strap-on meters, the pipe bore diameter and outside diameter in which the meter is required to operate;

for water meters with electronic devices, the following additional inscriptions where appropriate:

- (l) for an external power supply: the voltage and frequency;
- (m) for a replaceable battery: the latest date that the battery is to be replaced; alternatively provision shall be made to allow this date to be recorded in the memory of the meter upon replacement of the battery and installation of the meter by a certified person;
- (n) for a non-replaceable battery: the latest date by which the meter is to be replaced; alternatively provision shall be made to allow this date to be recorded in the memory of the meter upon installation by a certified person; and
- (o) the IP rating of the meter and its constituent parts.

## 5.9 Indicating Device or Display

### 5.9.1 General Requirements

The indicating device or display:

- shall provide an easily read, reliable and unambiguous visual indication of the indicated volume;
- shall include visual means of testing and calibration;
- may include additional elements for testing and calibration by other methods, e.g. for automatic testing and calibration;
- may display other parameters such as instantaneous or average flowrate.

Table 1. Volumetric (ML) indicating range of a water meter

Q <sub>3</sub> (ML/d)	Indicating range (ML) (minimum values)
Q <sub>3</sub> ≤ 50	9 999
50 < Q <sub>3</sub> ≤ 500	99 999
500 < Q <sub>3</sub> ≤ 5 000	999 999

Table 2. Volumetric (m<sup>3</sup> or kL) indicating range of a water meter

Q <sub>3</sub> (L/s)	Indicating range (m <sup>3</sup> or kL) (minimum values)
Q <sub>3</sub> ≤ 0.5	9 999
0.5 < Q <sub>3</sub> ≤ 5	99 999
5 < Q <sub>3</sub> ≤ 50	999 999

Note: 5 ML/d is approximately equal to 60 L/s.

#### 5.9.1.1 Unit of Measurement, Symbol and its Placement

The indicated volume of water shall be expressed in megalitres, cubic metres or kilolitres. The symbol ML, m<sup>3</sup> or kL shall appear on the dial or immediately adjacent to the numbered display.

#### 5.9.1.2 Indicating Range

The indicating device shall be able to record the indicated volume in megalitres, cubic metres or kilolitres corresponding to at least 200 days of operation at the permanent flowrate Q<sub>3</sub>, without passing through zero. Examples of compliance are shown in Tables 1 and 2.

#### 5.9.1.3 Colour Coding of Indicating Devices

The colour black should be used to indicate megalitres, cubic metres or kilolitres and its multiples.

The colour red should be used to indicate submultiples of a megalitre, cubic metre or kilolitre.

These colours shall be applied to either the pointers, indexes, numbers, wheels, discs, dials or aperture frames.

Other means of indicating the megalitre, cubic metre or kilolitre, its multiples and its submultiples may be used, provided there is no ambiguity in distinguishing between the primary indication and alternative displays, e.g. submultiples for verification testing.

### 5.9.2 Types of Indicating Device

#### 5.9.2.1 Type 1 – Analogue Device

The indicated volume is indicated by continuous movement of either:

- one or more pointers moving relative to graduated scales; or
- one or more circular scales or drums each passing an index.

The value expressed in megalitres, cubic metres or kilolitres for each scale division shall be of the form  $10^n$ , where  $n$  is a positive or negative whole number or zero, thereby establishing a system of consecutive decades. Each scale shall be either graduated in values expressed in megalitres, cubic metres or kilolitres or accompanied by a multiplying factor ( $\times 0.001$ ;  $\times 0.01$ ;  $\times 0.1$ ;  $\times 1$ ;  $\times 10$ ;  $\times 100$ ;  $\times 1000$  etc.).

Rotational movement of the pointers or circular scales shall be clockwise.

Linear movement of pointers or scales shall be left to right.

The movement of numbered roller indicators shall be upwards.

#### 5.9.2.2 Type 2 – Digital Device

The indicated volume is given by a line of adjacent digits appearing in one or more apertures. The advance of a given digit shall be completed while the digit of the next immediately lower decade changes from 9 to 0. The apparent height of the digits shall be at least 4 mm.

For non-electronic devices:

- movement of numbered roller indicators (drums) shall be upwards; and
- if the lowest value decade has a continuous movement, the aperture

shall be large enough to permit a digit to be read unambiguously.

For electronic devices:

- either permanent or non-permanent displays are permitted; for non-permanent displays the volume shall be able to be displayed at any time for at least 10 s; and
- it shall include a feature that enables the correct operation of the display to be checked, e.g. by successive display of the various characters; each step of the sequence shall last at least 1 s.

#### 5.9.2.3 Type 3 – Combination of Analogue and Digital Devices

The indicated volume is given by a combination of an analogue and a digital device and the respective requirements of each shall apply.

### 5.9.3 Supplementary Devices

In addition to the indicating devices described in clause 5.9.2, the meter may include supplementary devices which may be permanently incorporated or added temporarily.

The device may be used to detect movement of the flow sensor before this is clearly visible on the indicating device. The device may be used for testing and verifying the meter, provided that other means guarantee the satisfactory operation of the meter.

Meters shall be fitted with a device or devices capable of communicating data to a location remote from the meter. This may take the form of a reed switch with each contact closure representing a known volume of water.

### 5.9.4 Verification Devices – First Element of an Indicating Device – Verification Scale Interval

#### 5.9.4.1 General Requirements

Every indicating device shall provide means for visual, non-ambiguous verification testing and calibration.

The visual verification scale may have either a continuous or discontinuous movement.

In addition to the visual verification display, an indicating device may include provisions for rapid testing by inclusion of complementary elements (e.g. star wheels or discs) providing signals through externally attached sensors.

#### 5.9.4.2 Value of the Verification Scale Interval

The value of the verification scale interval (expressed in megalitres, cubic metres or kilolitres), shall be of the form  $1 \times 10^n$ , or  $2 \times 10^n$ , or  $5 \times 10^n$ , where  $n$  is a positive or negative whole number or zero.

For analogue and digital indicating devices with continuous movement of the first element, the verification scale may be formed from the division into 2, 5 or 10 equal parts of the interval between two consecutive digits of the first element. Numbering shall not be applied to these divisions.

For digital indicating devices with discontinuous movement of the first element the verification scale interval is the interval between two consecutive digits or incremental movements of the first element.

#### 5.9.4.3 Form of the Verification Scale

On indicating devices with continuous movement of the first element, the apparent scale spacing shall not be less than 1 mm and not more than 5 mm. The scale shall consist of either:

- lines of equal thickness not exceeding one-quarter of the scale spacing and differing only in length; or
- contrasting bands of a constant width equal to the scale spacing.

The apparent width of the pointer at its tip shall not exceed one-quarter of the scale spacing and in no case shall it be greater than 0.5 mm.

#### 5.9.4.4 Resolution of the Indicating Device

The subdivisions of the verification scale shall be small enough to ensure that the resolution error of the indicating device does not exceed 0.5% of the actual volume passed during 1 h 30 min at the minimum flowrate,  $Q_1$ .

Note: When a display of the first element is continuous, an allowance should be made for a maximum error in reading of not more than half the verification scale interval.

When the display of the first element is discontinuous, an allowance should be made for a maximum error in each reading of not more than one digit of the verification scale.

### 5.10 Verification Marks and Protection Devices

A place shall be provided on meters for affixing the main verification mark, which shall be visible without dismantling the meter.

#### 5.10.1 Mechanical Sealing Devices

Meters shall include protection devices which can be sealed so as to prevent, both before and after correct installation of the meter, dismantling or modification of the meter, its adjustment device or its correction device, without damaging these protection devices.

#### 5.10.2 Electronic Sealing Devices

- (a) When access to parameters that influence the determination of the results of measurements is not protected by mechanical sealing devices, the protection shall fulfil the following provisions:
- Access shall only be allowed to authorised people, e.g. by means of a code (key word) or of a special device (e.g. a hard key). The code shall be capable of being changed.
  - It shall be possible for at least the last intervention to be memorised. The record shall include the date and a characteristic element identifying the authorised person

making the intervention (see above). The traceability of the last intervention shall be assured for at least two years, if it is not overwritten on the occasion of a further intervention. If it is possible to memorise more than one intervention and if deletion of a previous intervention must occur to permit a new record, the oldest record shall be deleted.

- (b) For meters with parts which may be disconnected one from another and which **are** interchangeable, the following provisions shall be fulfilled:
- it shall not be possible to access parameters that participate in the determination of results of measurements through disconnected points unless the provisions of clause 5.10.2(a) are fulfilled; and
  - interposing any device which may influence the accuracy shall be prevented by means of electronic and data processing securities or, if this is not possible, by mechanical means.
- (c) For meters with parts which may be disconnected one from another and which **are not** interchangeable, the provisions in clause 5.10.2(b) shall apply. Moreover, these meters shall be provided with devices which do not allow them to operate if various parts are not connected according to the manufacturer's configuration.

Note: Disconnections which are not allowed may be prevented, e.g. by means of a device that prevents any measurement after disconnecting and reconnecting.

### 5.11 Requirements Related to Specific Technologies

For meters which calculate the volume and/or flowrate based upon predetermined measurements (pipe diameter or area), such predetermined measurements shall be

traceable to Australia's primary standards of measurement. The uncertainty associated with these measurements shall be incorporated in the overall uncertainty of measurement for the meter.

#### 5.11.1 Self-contained Meters

Self-contained meters shall be approved as complete meters. The MPEs of such meters shall not exceed the value given in clause 3.2 ( $\pm 2.5\%$ ).

#### 5.11.2 Flow Computers

Where a flow computer computes flowrate and volume from inputs of one or more properties (such as area and speed of sound measured by ultrasonic means), the flow computer and the manufacturer's documentation shall be examined to determine whether the flow computer incorporates means to perform these computations.

All of the parameters which are not measured and which are necessary for computation shall be contained in the flow computer at the beginning of the measurement operation.

Flow computers shall be tested for accuracy over the range of input parameters and reference conditions and shall be tested for the effects of the applicable influence factors and disturbances listed in Annex A. During these tests, measured input parameters may be actual or simulated.

Where total volume is determined by averaging flowrate and multiplying by time, the time interval over which the flowrate is averaged shall be suitable to ensure that the overall MPE for the meter is not exceeded. The uncertainty associated with this averaging process shall be incorporated in the overall uncertainty of measurement for the meter.

Where total volume is determined by extrapolating velocity measurements which are taken intermittently to infer velocity over the time period, such extrapolation process shall be clearly defined and such meters shall not be installed where this process would lead to the MPEs being

exceeded due to this process. The uncertainty associated with this extrapolation process shall be incorporated in the overall uncertainty of measurement for the meter.

#### **5.11.3 Insertion or Strap-on Measurement Devices**

Insertion or strap-on measurement devices shall be tested in a pipe of known internal area over the range of water velocities for which they are intended to be used. In consultation with the manufacturer, tests shall be specified to determine the effect of misalignment of the velocity-sensing transducer with the axis of water flow. The limits of misalignment shall be stated on the pattern approval certificate.

Insertion and strap-on devices shall be tested across a range of different pipe diameters and pipe materials.

Where insertion or strap-on measurement devices have a range of gears to suit varying pipe diameters, at least the gear sets for the maximum and minimum pipe diameters shall be tested.

The intended scope of the approval of a strap-on or insertion measurement device may exceed the testing capabilities available.

In these cases, a detailed uncertainty analysis, combined with suitable laboratory and in-field testing may be accepted as the basis for extending the scope of the pattern approval of a strap-on or insertion measurement device. Such analysis shall be undertaken in accordance with the *Guide to the Expression of Uncertainty in Measurement* [7].

#### **5.11.4 Modular Metering Systems**

This document is not intended to cover the pattern approval, evaluation or testing of modular metering systems, although provision is made to allow for the testing and approval of individual modules or sensors such as those defined in clauses 2.1.2 to 2.1.8. The overall expanded uncertainty of measurement of metering

systems shall be determined in accordance with the *Guide to the Expression of Uncertainty in Measurement* [7] with a coverage factor,  $k = 2$  and shall not exceed the value given in clause 3.2.

The installation and putting into service of modular metering systems may involve the taking of measurements such as length or diameter. Instruments used to make such measurements shall have a calibration certificate from a NATA-accredited facility showing the error, uncertainty and traceability to Australia's primary standards of measurement.

Where a flow computer computes flowrate and volume from inputs of one or more properties, apply the requirements in clause 5.11.2.

#### **5.11.5 Water Quality**

Different metering technologies may be affected by the presence of particulate matter in the water supply.

The meter manufacturer shall define the class or classes of water quality at which the meter shall be tested. The pattern approval certificate will indicate the quality of water for which the meter is approved subject to performance testing. Additional or alternative testing involving potable or non-potable water may be accepted and recognised as part of the pattern approval process. All such testing shall be performed in accordance with NMI requirements concerning the acceptance of test results for pattern approval purposes.

## **6. METROLOGICAL CONTROLS**

### **6.1 Reference Conditions**

When meters and modules are tested under laboratory conditions, all influence quantities except for the influence quantity being tested shall be held to the following values during pattern approval tests on the meter or module. NMI can provide guidance on any issues related to permissible reference conditions.

### 6.1.1 Flowrate and Power Supply

Flowrate:

$$0.7 \times (Q_1 + Q_3) \pm 0.03 \times (Q_1 + Q_3)$$

Module measurement parameter:

$$0.7 \times (\min + \max) \pm 0.03 (\min + \max)$$

where min and max are the minimum and maximum boundaries of the range over which the module is claimed to be within accuracy limits

Power supply voltage (mains AC):

$$\text{nominal voltage } (U_{\text{nom}}) \pm 5\%$$

Power supply frequency:

$$\text{nominal frequency } (f_{\text{nom}}) \pm 2\%$$

Power supply voltage (battery):

$$\text{a voltage } V \text{ in the range } U_{\text{min}} \leq V \leq U_{\text{max}}$$

### 6.1.2 Temperature

The ambient and working temperature ranges given below allow for seasonal and climatic variations. However during all performance testing the ambient and working temperature shall not vary by more than  $\pm 5^\circ\text{C}$  over the period of the testing.

Working water temperature:  $20 \pm 10^\circ\text{C}$

Ambient air temperature:  $20 \pm 10^\circ\text{C}$

### 6.1.3 Humidity and Pressure

The values given below for ambient relative humidity and atmospheric pressure are the recommended ranges over which pattern approval testing should be conducted. These conditions shall be recorded appropriately.

Ambient relative humidity:  $60 \pm 15\%$

Ambient atmospheric pressure: 86 to 106 kPa

## 6.2 Pattern Approval

Meters and modules shall undergo the pattern approval tests indicated below. Pattern approval shall be carried out by an approving authority appointed in accordance with the National Measurement Regulations. Where the module is a velocity measuring device, the device will be assembled into or onto a pipe of known nominal diameter and tested as if it is a self-contained meter. The device may be tested across a range of nominal diameters.

Before undergoing pattern approval tests, each pattern of meter or module submitted shall be inspected externally to ensure that it

complies with the provisions of the relevant preceding clauses of these requirements.

The approval tests shall be made on the minimum number of samples of each pattern shown in Table 3 as a function of the meter designation  $Q_3$  (in L/s) of the pattern presented. The authority responsible for pattern approval may request further specimens.

Table 3. Number of meters to be tested

Meter designation $Q_3$ (L/s equivalent)	Minimum number of meters
$Q_3 \leq 44$	3
$44 < Q_3 \leq 1\,440$	2
$1\,440 < Q_3$	1

Note: Additional samples are required for meters equipped with electronic devices.

The requirements of clause 3.2 shall apply to all meters tested.

During the tests, the water pressure at the meter outlet shall be at least 0.03 MPa.

### 6.2.1 Static Pressure Test

A meter shall be capable of withstanding the following test pressures without leakage or damage:

- 1.6 times the maximum admissible pressure applied for 15 min; and
- twice the maximum admissible pressure applied for 1 min.

### 6.2.2 Errors of Indication

The errors of indication of the meter (in the measurement of the actual volume) shall be determined for at least the following flowrates, the error at each flowrate being measured twice:

- between  $Q_1$  and  $1.1 Q_1$ ;
- between  $0.33 (Q_1 + Q_3)$  and  $0.37 (Q_1 + Q_3)$ ;
- between  $0.67 (Q_1 + Q_3)$  and  $0.74 (Q_1 + Q_3)$ ;
- between  $0.9 Q_3$  and  $Q_3$ ; and
- between  $0.95 Q_4$  and  $Q_4$ .

The errors of indication observed for each of the five flowrates shall not exceed the MPEs given in clause 3.2 ( $\pm 2.5\%$ ). If the

error of indication observed on one or more meters is greater than the MPE at one flowrate only, the test at that flowrate shall be repeated. The test shall be declared satisfactory if two out of the three results lie within the MPE and the arithmetic mean of the results for the three tests at that flowrate is less than or equal to the MPE.

If all the errors of indication of the meter have the same sign, at least one of the errors shall not exceed half the MPE.

If the meter is marked as only operating in certain orientations, then the meter shall be tested in these orientations.

In the absence of such marks, the meter shall be tested in at least three orientations.

It is recommended that the characteristic error curve for each meter be plotted in terms of error against flowrate, so that the general performance of the meter over its flowrate range can be evaluated.

#### **6.2.3 Pressure Test**

The meter shall be tested to determine the effect of internal water pressure on errors of indication. The errors of indication observed for this test shall not exceed the MPEs given in clause 3.2 ( $\pm 2.5\%$ ).

#### **6.2.4 Reverse Flow Test**

The manufacturer shall specify whether or not the meter is designed to measure reverse flow.

If a meter is designed to measure reverse flow, the actual volume passed during reverse flow shall either be subtracted from the indicated volume or the meter shall record it separately. The MPE ( $\pm 2.5\%$ ) shall be met for both forward and reverse flow.

If a meter is not designed to measure reverse flow, the water meter installation shall either prevent reverse flow, or the meter shall withstand accidental reverse flow without deterioration, or change in its metrological properties for forward flow.

#### **6.2.5 Pressure Loss**

The pressure loss value shall be determined at least at a flowrate of  $Q_3$ . Where pressure loss is determined at a flowrate other than  $Q_3$ , the pressure loss at  $Q_3$  is equal to:

$$\frac{Q_3^2}{\text{measured flowrate}^2} \times \text{measured pressure loss}$$

#### **6.2.6 Flow Disturbance Test**

The meter will be subjected to a number of standard disturbances. The relative error of indication of the meter shall not exceed the MPE given in clause 3.2 for any of the tests, and the error shift shall be less than one-third of the MPE given in clause 3.2 (the expanded uncertainty of the test method plus an allowance for the repeatability of the meter under test).

#### **6.2.7 Endurance Test**

Meters are required to maintain their performance characteristics and a required level of metrological accuracy over an extended period of operation.

After initial error testing, the meter shall be installed into specified metering site. The meter shall register a volume of water corresponding to at least 1000 h of continuous flow at a flowrate of  $Q_3$  at that metering site.

Metering sites may be selected by the manufacturer. No minimum or maximum conditions are specified for metering sites; however details of each metering site shall be submitted to the NMI. The meter may not be removed from the metering site until the required volume has been registered.

The meter will subsequently be tested to determine the final errors of indication. The following acceptance criteria apply:

- the difference between the error of indication at the initial test and the final test following the endurance regime shall not exceed 1.5% at each point on the curve;
- the error of indication curve shall not exceed a maximum error limit of  $\pm 4\%$ .



### 6.2.8 Water Quality Disturbance Testing

The meter shall be subjected to a discontinuous flow regime in order to determine the effect on the metrological performance of the meter caused by the presence of particulate matter in the water supply. The meter manufacturer shall define the class or classes of water quality used in the discontinuous flow regime.

The meter will subsequently be tested to determine the final errors of indication. The following acceptance criteria apply:

- the difference between the error of indication at the initial test and the final test following the endurance regime shall not exceed 1.5% at each point on the curve;
- the error of indication curve shall not exceed a maximum error limit of  $\pm 4\%$ .

### 6.2.9 Specified Emplacement and Installation Tests

The meter may be tested in an open channel emplacement or a certain installation configuration (as specified by the manufacturer) in which case the errors of indication shall be determined in accordance with clause 6.2.2 and shall not exceed the MPE given in clause 3.2 for any of the tests.

If the meter is tested in an emplacement:

- (a) The meter shall be subjected to a standard disturbance. The relative error of indication of the meter shall not exceed the MPE given in clause 3.2 for any of the tests, and the error shift shall be less than one-third of the MPE given in clause 3.2 (the expanded uncertainty of the test method plus an allowance for the repeatability of the meter under test).
- (b) The meter shall be tested to determine the maximum head loss through the meter at any flowrate between  $Q_1$  and  $Q_3$ .

### 6.2.10 Test for Cartridge Meters and Meters with Interchangeable Inserts

Cartridge meters and meter with interchangeable inserts may be tested in order to confirm that the cartridges or inserts are insensitive to the influence of connection interfaces produced in series production.

Five connection interfaces and two cartridges or measuring inserts shall be selected from the number of meters presented for approval.

The errors of indication shall be determined for each of the ten combinations of interfaces and measuring inserts. The following acceptance criteria apply:

- the relative errors of indication for all of the tests shall not exceed the MPE in clause 3.2;
- error variation within the five tests corresponding to each measuring insert shall not exceed 1/5 of the MPE in clause 3.2 (i.e.  $\pm 0.5\%$ ).

### 6.2.11 Maintenance Tests

The policy paper *National Framework for Non-urban Water Metering* [11] allows a manufacturer to test a specified maintenance activity on the meter under test as part of the pattern approval process.

The pattern approval certificate will list the specified maintenance procedures that have been tested and are deemed to have no adverse effect on the metrological performance of a meter when undertaken by a suitably trained and certified maintainer. Any and all other maintenance procedures that are performed on a meter, that are not listed on the pattern approval certificate (which require the verification seal(s) to be broken), are deemed to affect the metrological performance of the meter and therefore subsequent verification is required.

All information included on a pattern approval certificate relating to the maintenance of a meter is intended as guidance only.

### 6.2.12 Pattern Approval of a Meter or Module with Electronic Device

In addition to the examinations or tests described in the preceding paragraphs, a meter or module with electronic devices shall be subject to the following examinations and tests.

#### 6.2.12.1 Design Inspection

This examination of documents aims at verifying that the design of electronic devices and their checking facilities, if applicable, comply with the provisions of these requirements, in particular clause 4. It includes:

- an examination of the mode of construction and of the electronic subsystems and components used, to verify their appropriateness for their intended use; and
- consideration of faults likely to occur, to verify that in all considered cases these devices comply with the provisions of clauses 4.1 and 4.4.

#### 6.2.12.2 Performance Tests

The performance tests specified in Annex A aim at verifying that the meter complies with the provisions of clauses 3.2 and 4.1 with regard to influence quantities.

##### (a) Performance under the Effect of Influence Factors

When subjected to the effect of influence factors as provided for in Annex A, the equipment shall continue to operate correctly and the errors of indication shall not exceed the MPEs.

##### (b) Performance under the Effect of Disturbances

When subjected to external disturbances as provided for in Annex A, the equipment shall continue to operate correctly and significant faults shall not occur.

#### 6.2.12.3 Equipment under Test

Where the electronic devices form an integral part of the meter, tests shall be carried out on the complete meter.

If the electronic devices of a meter are in a separate housing, their electronic functions may be tested independently of the

measurement transducer of the meter by simulated signals representative of the normal operation of the meter, in which case the electronic devices shall be tested in their final housing.

In all cases, ancillary equipment may be tested separately.

### 6.2.13 Documentation

Application for approval of a pattern of a meter shall be made according to NMI P 106 [12].

In accordance with the National Measurement Regulations:

- a certificate of approval shall be issued in accordance with Regulation 63; and
- under Regulation 59 an approval holder shall make application to vary such approval following any modification or addition which concerns such approved pattern.

### 6.3 Initial Verification

Meters shall undergo the initial verification tests indicated below or as indicated on the pattern approval certificate. This verification shall be carried out by a verifying authority appointed in accordance with section 18ZC of the National Measurement Act.

Requirements for verification are given in section 18V of the Act.

Meters of the same size and the same pattern may be tested in series however, in this case, the requirements of clause 6.2.3 (concerning meter outlet pressure), shall be met for each meter and there shall be no significant interaction between meters.

The errors of indication of the water meters in the measurement of actual volume shall be determined for at least the following three flowrates:

- (a) between  $Q_1$  and  $1.1Q_1$ ;
- (b) between  $0.5Q_3$  and  $0.6Q_3$ ; and
- (c) between  $0.9Q_3$  and  $Q_3$ .

However, depending on the shape of the error curve, the design and specifications of the meter and typical installation conditions, alternative flowrates (or

flowrate ranges) may be specified in the pattern approval certificate.

During a test, all influence factors shall be held within the rated operating conditions.

The errors of indication ascertained at each of the above flowrates shall not exceed the MPEs given in clause 3.2 ( $\pm 2.5\%$ ).

## **7. TEST METHOD AND MODEL TEST REPORT**

### **7.1 Test Method**

The methods of examination and testing described in NMI M 10-2 [1] shall apply to pattern approval and verification of a meter.

In addition, the performance tests in Annex A shall apply to meters with electronic devices.

When a test is conducted, the expanded uncertainty in the determination of the actual volume passing through the meter shall not exceed one-fifth of the applicable MPE for pattern approval and one-third of the applicable MPE for verification.

The expanded uncertainty shall be estimated according to *Guide to the Expression of Uncertainty in Measurement* [7] with a coverage factor,  $k = 2$ .

When a test is conducted, the error arising from the resolution of the meter under test shall not exceed values given in clause 5.9.4.3.

### **7.2 Model Test Report**

The results of pattern approval and verification examinations and tests shall be presented in the format given in NMI M 10-3 [2].

## ANNEX A. PERFORMANCE TESTS FOR METERS WITH ELECTRONIC DEVICES (MANDATORY)

### A.1 General

This annex defines the performance tests intended to verify that meters with electronic devices perform and function as intended in a specified environment and under specified conditions. Each test indicates, where appropriate, the reference conditions for determining the intrinsic error.

These tests supplement any other prescribed test.

When the effect of one influence quantity is being evaluated, all other influence quantities are to be held relatively constant, at values close to reference conditions (see Annex A.3).

### A.2 Environmental Classification (see [13] and clause 5.2)

For each performance test, typical test conditions are indicated which correspond to the climatic and mechanical environmental conditions to which meters are usually exposed.

Meters with electronic devices are divided into three classes according to climatic and mechanical environmental conditions:

- class B for fixed meters installed in a building;
- class O for fixed meters installed outdoors; and
- class M for mobile meters.

They are also divided into two electromagnetic environment classes:

- class E1 residential, commercial and light industrial; and
- class E2 industrial.

Following consultation and agreement with NMI, the pattern approval applicant may also indicate specific environmental conditions in the documentation supplied to the approving authority, based on the intended use of the meter. In this case, the approving authority will carry out performance tests at severity levels corresponding to these environmental conditions.

If pattern approval is granted, the data plate shall indicate the corresponding limits of use. Manufacturers shall inform potential users of the conditions of use for which the meter is approved. The approving authority shall verify that the conditions of use are met.

### A.3 Reference Conditions

Ambient air temperature:  $20 \pm 5^\circ\text{C}$

Ambient relative humidity:  $60 \pm 15\%$

Ambient atmospheric pressure:  
86 kPa to 106 kPa

Power voltage:

nominal voltage ( $U_{\text{nom}}$ )  $\pm 5\%$

Power frequency:

nominal frequency ( $f_{\text{nom}}$ )  $\pm 2\%$

During each test, the temperature and relative humidity shall not vary by more than  $5^\circ\text{C}$  or 10% respectively within the reference range.

Note: The reference conditions given in this section differ from those that apply to the testing in clauses 6.2 and 6.3 (see clause 6.1).

### A.4 Pattern Approval of a Module

When an electronic module is submitted for separate pattern approval, pattern approval tests shall be conducted on the module (including indicating device) alone, simulating different inputs with appropriate standards.

Tests include an accuracy test on the indications of measurement results. For this purpose, the error obtained on the indication of the result is calculated considering that the true value is the one which takes into account the value of the simulated quantities applied to inputs of the module and using standard methods for calculation. The MPEs are those given in clause 3.2.

The examinations and tests for electronic instruments described in clause 6.2.12 shall be performed.

.Table A.1 Tests involving the electronic part of the meter or its devices

Test	Nature of the influence quantity [13]	Severity level for the class		
		B	O	M
A.5.1 Dry heat	Influence factor	3	3	3
A.5.2 Cold	Influence factor	1	2	2
A.5.3 Damp heat, cyclic (condensing)	Influence factor	1	2	2
A.5.4 Power voltage variation	Influence factor	1	1	1
A.5.5 Vibration (random)	Disturbance	—	—	2
A.5.6 Mechanical shock	Disturbance	—	—	2
A.5.7 Short time power reductions	Disturbance	1a and 1b	1a and 1b	1a and 1b
A.5.8 Bursts	Disturbance	2 or 3	2 or 3	2 or 3
A.5.9 Electrostatic discharge	Disturbance	1	1	1
A.5.10 Electromagnetic susceptibility	Disturbance	2 or 3	2 or 3	2 or 3
A.5.11 Water	Disturbance	1	2	2
A.5.12 Dust	Disturbance	—	1	1

## A.5 Performance Tests

The tests indicated in Table A.1 involve the electronic part of the meter or its devices and may be carried out in any order.

The following rules shall be taken into consideration for these performance tests:

### (1) Test Volumes

Some influence quantities should have a constant effect on measurement results and not a proportional effect related to the measured volume. The value of the significant fault is related to the measured volume; therefore, in order to be able to compare results obtained in different laboratories, it is necessary to perform a test on a minimum volume corresponding to that delivered in 1 min at the overload flowrate,  $Q_4$ . Some tests, however, may require more than 1 min, in which case they shall be carried out in the shortest possible time taking into consideration the measurement uncertainty.

### (2) Influence of the Water Temperature

Temperature tests concern the ambient temperature and not the temperature of the water used. It is therefore advisable to use a simulation test method so that the

temperature of the water does not influence the test results.

### A.5.1 Dry Heat

#### Test Method

Dry heat (non-condensing)

#### Object of the Test

To verify compliance with the provisions in clause 3.2 under conditions of high ambient air temperature.

#### References

IEC 60068-2-2 [14]

IEC 60068-3-1 [15]

IEC 60068-1 [16]

#### Test Procedure in Brief

The test consists of exposure of the EUT to a temperature of 55°C under free air conditions for a 2 h period, after the EUT has reached temperature stability.

The EUT shall be tested at the reference flowrate (or simulated flowrate) and:

- at the reference temperature of 20°C following conditioning;
- at the temperature of 55°C, 2 h after temperature stabilisation; and
- after recovery of the EUT at the reference temperature of 20°C.

**Test Severities**

Temperature: severity level 3: 55°C

Duration: 2 h

**Number of Test Cycles**

One cycle

**Maximum Allowable Variations**

All functions shall operate as designed and all the errors of indication measured during the application of the influence factor shall be within the MPE.

**A.5.2 Cold****Test Method**

Cold

**Object of the Test**

To verify compliance with the provisions in clause 3.2 under conditions of low ambient air temperature.

**References**

IEC 60068-2-1 [17]

IEC 60068-3-1 [15]

IEC 60068-1 [16]

**Test Procedure in Brief**

The test consists of exposure of the EUT to a temperature of either –10°C (class C or I) or +5°C (class B) under free air conditions for a 2 h period after the EUT has reached temperature stability. The EUT shall be tested at the reference flowrate (or simulated flowrate):

- at the reference temperature of 20°C following conditioning;
- at a temperature of –10°C or +5°C, 2 h after temperature stabilisation; and
- after recovery of the EUT at the reference temperature of 20°C.

**Test Severities**

Temperature: severity level 1: +5°C  
severity level 2: –10°C

Duration: 2 h

**Number of Test Cycles**

One cycle

**Maximum Allowable Variations**

All functions shall operate as designed and all the errors of indication measured during application of the influence factor shall be within the MPE.

**A.5.3 Damp Heat, Cyclic (Condensing)****Test Method**

Damp heat, cyclic (condensing)

**Object of the Test**

To verify compliance with the provisions in clause 3.2 under conditions of high humidity when combined with cyclic temperature changes.

**References**

IEC 60068-2-30 [18]

IEC 60068-3-4 [19]

**Test Procedure in Brief**

The test consists of exposure of the EUT to cyclic temperature variations between 25°C and an upper temperature of 55°C (class C or I) or 40°C (class B), maintaining the relative humidity above 95% during the temperature changes and during the phases at low temperature, and at 93% at the upper temperature phases.

Condensation should occur on the EUT during the temperature rise.

A standard stabilising period before and recovery after the cyclic exposure is indicated in IEC 60068-2-30 [18].

The power supply is turned off when the influence factor is applied.

**Test Severities**

Upper temperature: severity level 1: 40°C  
severity level 2: 55°C

Duration: 24 h

**Number of Test Cycles**

Two cycles

**Maximum Allowable Variations**

After the application of the influence factor and recovery, all functions shall operate as designed and all the errors of indication measured shall be within the MPE.

## A.5.4 Power Voltage Variation

### A.5.4.1 Meters Powered by Direct AC or AC/DC Converters

#### Test Method

Variation in AC mains power supply (single phase)

#### Object of the Test

To verify compliance with the provisions in clause 3.2 under conditions of varying AC mains power supply.

#### References

IEC 61000-4-11 [20]  
IEC 61000-2-1 [21]  
IEC 61000-2-2 [22]  
IEC 61000-4-1 [23]  
IEC 60654-2 [24]  
IEC 61000-2-12 [25]  
IEC 61000-4-5 [26]

#### Test Procedure in Brief

The test consists of exposure of the EUT to power voltage variations, while the EUT is operating under normal atmospheric conditions.

#### Test Severities

Single voltage: mains voltage  
upper limit:  $U_{\text{nom}} + 10\%$   
lower limit:  $U_{\text{nom}} - 15\%$

Voltage range: mains voltage  
upper limit:  $U_u + 10\%$   
lower limit:  $U_l - 15\%$

#### Maximum Allowable Variations

All functions shall operate as designed and all errors of indication measured during the application of the influence factor shall be within the MPEs.

### A.5.4.2 Meters Powered by Primary Batteries

#### Test Method

Variation in DC primary battery power supply

#### Objective of the Test

To verify compliance with the provisions in clause 3.2 under conditions of varying DC power supply.

#### References

None available

#### Test Procedure

The meter error of indication shall be measured with the maximum and the minimum operating voltages of the battery, as specified by the meter supplier, applied throughout the test.

#### Test Severities

Voltage: upper limit (battery maximum):  $U_{\text{max}}$   
lower limit (battery minimum):  $U_{\text{min}}$

#### Maximum Allowable Variations

All functions shall operate as designed and all errors of indication measured during the application of the influence factor shall be within the MPEs.

## A.5.5 Vibration (Random)

#### Test Method

Random vibration

#### Object of the Test

To verify compliance with the provisions in clause 3.2 under conditions of random vibration. This test should normally apply to mobile installations only or installations where vibration is likely to occur.

Note: While this test is only mandatory for meters mounted in mobile installations (class M), it is recommended that all meters be subjected to the testing described in this section.

#### References

IEC 60068-2-64 [27]  
IEC 60068-2-47 [28]

#### Test Procedure in Brief

The test consists of exposure of the EUT to the required vibration level for the defined period of time. The EUT shall, in turn, be tested in three, mutually perpendicular axes mounted on a rigid fixture by its normal mounting means.

The EUT shall normally be mounted so that the gravitational force acts in the same direction as it would in normal use. Where the effect of gravitational force is not important the EUT may be mounted in any position.

The EUT shall not be operating and not filled with liquid when the disturbance is applied.

**Test Severities: Severity Level 2**

Frequency range: 10 to 150 Hz  
Total RMS level:  $7 \text{ m.s}^{-2}$   
ASD level 10 to 20 Hz:  $1 \text{ m}^2.\text{s}^{-3}$   
ASD level 20 to 150 Hz:  $-3 \text{ dB/octave}$   
Number of axes: 3

**Duration per Axis**

2 min

**Maximum Allowable Variations**

After the application of the disturbance and recovery, all functions shall operate as designed and all the errors of indication measured shall be within the MPEs.

**A.5.6 Mechanical Shock**

**Test Method**

Dropping onto face

**Object of the Test**

To verify compliance with the provisions in clause 3.2 under conditions of mechanical shocks. This test should normally apply to mobile installations only or installations where shock is likely to occur.

Note: While this test is only mandatory for meters mounted in mobile installations (class M), it is recommended that all meters be subjected to the testing described in this section.

**References**

IEC 60068-2-31 [29]  
IEC 60068-2-47 [28]

**Test Procedure in Brief**

The EUT, placed in its normal position of use on a rigid surface, is tilted towards one bottom edge and it is then allowed to fall freely on to the test surface.

The EUT shall not be operating and not filled with liquid when the disturbance is applied.

**Test Severities**

Severity level: 2  
Height of fall: 50 mm

**Number of Falls (on each Bottom Edge)**

One

**Maximum Allowable Variations**

After the application of the disturbance and recovery, all functions shall operate as designed and all the errors of indication measured shall be within the MPEs.

**A.5.7 Short Time Power Reductions**

**Test Method**

Short time interruptions and reductions in mains voltage

**Object of the Test**

To verify compliance with the provisions in clause 3.2 under conditions of short time mains voltage interruptions and reductions.

**References**

IEC 61000-4-11 [20]  
IEC 61000-2-1 [21]  
IEC 61000-2-2 [22]  
IEC 61000-4-1 [23]

**Test Procedure in Brief**

The test consists of subjecting the EUT to voltage interruptions from nominal voltage to zero voltage for a duration equal to half a cycle of line frequency (severity level 1a), and reductions from nominal voltage to 50% of nominal for a duration equal to one cycle of line frequency (severity level 1b). The mains voltage interruptions and reductions shall be repeated 10 times with a time interval of at least 10 s.

**Test Severities**

100% voltage interruption for a period equal to half a cycle. 50% voltage reduction for a period equal to one cycle.

**Number of Test Cycles**

At least 10 interruptions and 10 reductions, each with a minimum of 10 s between tests.

The interruptions and reductions are repeated throughout the time necessary to perform the whole test. For this reason, more than 10 interruptions and reductions may be necessary.

**Maximum Allowable Variations**

The difference between the error of indication during the test and the intrinsic error shall not



exceed the value given in clause 2.2.10 or significant faults are detected and acted upon by means of a checking facility.

### **A.5.8 Bursts**

#### **Test Method**

Electrical bursts

#### **Object of the Test**

To verify compliance with the provisions in clause 3.2 under conditions where electrical bursts are superimposed on the mains voltage.

#### **References**

IEC 61000-2-1 [21]  
IEC 61000-2-2 [22]  
IEC 61000-4-1 [23]  
IEC 61000-4-4 [30]

#### **Test Procedure in Brief**

The test consists of subjecting the EUT to bursts of double exponential waveform transient voltages. Each spike shall have a rise time of 5 ns and a half amplitude duration of 50 ns. The burst length shall be 15 ms and the burst period (repetition time interval) shall be 300 ms. All bursts shall be applied asynchronously in asymmetrical mode (common mode).

#### **Test Severities**

class E1 amplitude (peak value): 1 000 V  
class E2 amplitude (peak value): 2 000 V

#### **Test Duration**

The bursts should be applied for at least 1 min during the measurement, or simulated measurement, for each polarity.

#### **Maximum Allowable Variations**

The difference between the error of indication during the test and the intrinsic error shall not exceed the value given in clause 2.2.10 or significant faults are detected and acted upon by means of a checking facility.

### **A.5.9 Electrostatic Discharge**

#### **Test Method**

Electrostatic discharge

#### **Object of the Test**

To verify compliance with the provisions in clause 3.2 under conditions of direct and indirect electrostatic discharges.

#### **References**

IEC 61000-2-1 [21]  
IEC 61000-2-2 [22]  
IEC 61000-4-1 [23]  
IEC 61000-4-2 [31]

#### **Test Procedure in Brief**

A capacitor of 150 pF is charged by a suitable DC voltage source. The capacitor is then discharged through the EUT by connecting one terminal to ground (chassis) and the other via 330  $\Omega$  to surfaces which are normally accessible to the operator. The test includes the paint penetration method, if appropriate.

For direct discharges the air discharge method shall be used where the contact discharge method cannot be applied.

#### **Test Severities**

8 kV for air discharges  
6 kV for contact discharges

#### **Number of Test Cycles**

At each test point, at least 10 direct discharges shall be applied at intervals of at least 10 s between discharges, during the same measurement or simulated measurement.

For indirect discharges, a total of 10 discharges shall be applied on the horizontal coupling plane and a total of 10 discharges for each of the various positions of the vertical coupling plane.

#### **Maximum Allowable Variations**

The difference between the error of indication during the test and the intrinsic error shall not exceed the value given in clause 2.2.10 or significant faults are detected and acted upon by means of a checking facility.

Where a meter has been proven to be immune from electrostatic discharges, within the rated operating conditions for flowrate, the approving body shall be free

to choose a flowrate of zero during the electrostatic discharge test. During a zero flowrate test the meter totalisation shall not change by more than the value of the verification scale interval.

#### **A.5.10 Electromagnetic Susceptibility**

##### **Test Method**

Electromagnetic fields (radiated)

##### **Object of the Test**

To verify compliance with the provisions in clause 3.2 under conditions of electromagnetic fields.

##### **References**

IEC 61000-2-1 [21]  
IEC 61000-2-2 [22]  
IEC 61000-4-1 [23]  
IEC 61000-4-3 [32]  
IEC 61000-4-20 [33]

##### **Test Procedure in Brief**

The EUT shall be exposed to the electromagnetic field strength as specified by the severity level.

The field strength can be generated in various ways:

- the strip line is used at low frequencies below 30 MHz (or in some cases 150 MHz) for small EUTs;
- the long wire is used at low frequencies (below 30 MHz) for larger EUTs;
- dipole antennas or antennas with circular polarisation placed 1 m from the EUT are used at high frequencies.

The specified field strength shall be established prior to the actual testing without the EUT in the field.

The field shall be generated in two orthogonal polarisations. If antennas with circular polarisation (i.e. log-spiral or helical antennas) are used to generate the electromagnetic field, a change in the position of the antennas is not required.

When the test is carried out in a shielded enclosure, to comply with international laws prohibiting interference to radio communications, care should be taken to

handle reflections from the walls. Anechoic shielding may be necessary.

##### **Test Severities**

Frequency range: 26 to 1 000 MHz  
Field strength: class E1 3 V/m  
class E2 10 V/m  
Modulation 80% AM, 1 kHz sine wave

##### **Maximum Allowable Variations**

The difference between the error of indication during the test and the intrinsic error shall not exceed the value given in clause 2.2.10 or significant faults are detected and acted upon by means of a checking facility.

#### **A.5.11 Water**

##### **Test Method**

Spraying, splashing or immersion in water.

##### **Object of the Test**

To verify compliance with the provisions in clause 3.2 during spraying, splashing or immersion in water.

##### **References**

IEC 60068-2-18 [34]  
IEC 60512-14-7 [35]  
IEC 60529 [10]

##### **Test Procedure in Brief**

*For classes B, C and I non-submersible components:* mount the EUT on an appropriate fixture and subject it to impacting water generated from either an oscillating tube or a spray nozzle simulating spraying or splashing water.

*For class C and I submersible components:* immerse to a depth agreed to with the manufacturer.

##### **Test Severities**

Severity level 1: spraying and splashing  
Severity level 2: spraying, splashing and immersion

##### **Maximum Allowable Variations**

The difference between the error of indication during the test and the intrinsic error shall not exceed the value given in clause 2.2.10 or significant faults are detected and acted upon by means of a checking facility.

## **A.5.12 Dust**

### **Test Method**

Application of dust-laden atmosphere.

### **Object of the Test**

To verify compliance with the provisions in clause 3.2 under dust-laden atmosphere.

### **References**

IEC 60512-11-8 [36]

IEC 60529 [10]

IEC 60721-2-5 [37]

IEC 60068-2-68 [38]

### **Test Procedure in Brief**

Mount the EUT in a dust chamber and whilst cycling the temperature between 30°C and 65°C in accordance with clause 3.2.3 in IEC 60512-11-8 [36] apply the dust conditions described in IEC 60529 [10].

### **Test Severities**

Air speed: between 3 m/s and 10 m/s

Concentration:  $5 \text{ g/m}^3 \pm 1.5 \text{ g/m}^3$

### **Maximum Allowable Variations**

The difference between the error of indication during the test and the intrinsic error shall not exceed the value given in clause 2.2.10 or significant faults are detected and acted upon by means of a checking facility.

## ANNEX B. UNCERTAINTY EXAMPLE (INFORMATIVE)

### B.1 Nature of Errors

All measurements have errors even after all corrections and calibrations have been applied. The errors may be positive or negative and may be of a variable magnitude. Many errors vary with time. Some have very short periods while others vary daily, weekly, seasonally or yearly.

Those errors which remain constant (or apparently constant) during a test are sometimes called systematic errors. The actual or systematic errors can be determined only when measurements are compared with the true value of the quantity, which is rarely possible. However, upper bounds on the errors can be estimated. The objective is to construct an uncertainty interval (sometimes referred to as a range) within which the true value will lie with a stated probability.

### B.2 Explanation of Terms

#### B.2.1 Uncertainty of Measurement

A parameter associated with the result of a measurement that characterises the dispersion of the values that could reasonably be attributed to the measured value [5].

#### B.2.2 What is Uncertainty of Measurement?

Uncertainty of measurement is the doubt that exists about the result of any measurement. For every measurement, even the most careful, there is always a margin of doubt. Uncertainty of measurement tells us something about the quality of the measurement.

Uncertainty of measurement is expressed as ‘how big is the margin’ and ‘how bad is the doubt’? For example, the flowrate of water passing through a gate in a channel is 10 ML/day  $\pm$  0.05 ML/day at a level of confidence of 95%. This means we are 95% confident that the flowrate is between 9.95 ML/day and 10.05 ML/day.

#### B.2.3 Error versus Uncertainty

It is important not to confuse the terms ‘error’ and ‘uncertainty’. Error is the difference between the measured value and the true value of the thing being measured. Uncertainty is a quantification of the doubt about the measurement result.

#### B.2.4 True Value (of a Quantity)

A value consistent with the definition of a given particular quantity.

Notes:

1. This is the value that would be obtained by a perfect measurement.
2. True values by nature are indeterminate.
3. The indefinite article ‘a’, rather than the definite article ‘the’ is used in conjunction with ‘true value’ because there may be many values consistent with the definition of a given particular quantity.

#### B.2.5 Conventional True Value (of a Quantity)

A value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose.

### B.3 Error and Uncertainty

#### B.3.1 Making the Measurement

Water is measured by devices consisting of a transducer or multiple transducers which detect characteristics of the water flow and pass the results to a computational device which calculates flowrate or volume and the result is displayed. In a simple, full flowing pipe situation, a device (e.g. a propeller) detects water velocity, and the volume is calculated through a computational device (e.g. a gear train) and the result displayed on the register. At a bulk off-take, the velocity of the water at one or several parts of the flow profile may be measured using ultrasonic devices. The height of the surface may be measured using ultrasonic, pressure or float devices. These measurements, along with previously determined hydrographical details of the flow profile are used to calculate mean velocity, flowrate and volume.

#### B.3.2 Determination of True Value

In the first example above of a propeller-actuated meter, the true value of the measured quantity may be determined by placing the device in a laboratory test rig and flowing water through the propeller-actuated meter and into a calibrated collection vessel. The volume in the collection vessel can be considered as the

true value because the collection vessel has been calibrated with traceability to Australia's standards of measurement. Alternatively, the propeller-actuated meter may be compared to a calibrated master meter either in a laboratory or in the field.

In the second example of bulk off-take metering, determination of true value of volume is not practical as flowing into a collection vessel or through a calibrated device is not feasible. Each of the devices providing input to the computation of flow can be calibrated against reference devices with traceability to Australia's standards of measurement. Each of those calibrations will have an error and an uncertainty associated with it. All of these errors and uncertainties along with other relevant factors contribute to the uncertainty associated with the computation of flow.

### B.3.3 Error or Uncertainty

In the case of the propeller-actuated meter, it is possible to determine how much the value measured by the meter varies from the true value. This is the error and it is likely that the error will be different at various flowrates. For each determination of error there is an associated uncertainty. In an ideal world, corrections should be made to measured values in order to bring them as close as possible to true value. If corrections are not made the error is another source of uncertainty.

### B.4 Example of Uncertainty Calculation

Below is an example which demonstrates the process of determining the uncertainty of measurement. It is by no means a comprehensive example as there are a number of other variables which could affect the uncertainty such as ovality and device alignment and centring. In addition, actual measurements with associated uncertainties could be used to improve the calculation.

An insertion velocity measurement device has been factory calibrated and the supplier advises that it will measure velocity within  $\pm 2\%$  of true value. The internal area of the

pipe into which the velocity measuring device is to be inserted may be based upon measurements. In this example, the pipe manufacturer's tolerance of  $\pm 2$  mm on an internal diameter of 150 mm is accepted

The measurement model is:

$$Q = v \times A$$

The uncertainty calculation is:

$$U_Q = k \times u_Q$$

$$u_Q = ((u_v \times c_v)^2 + (u_A \times c_A)^2)^{0.5}$$

where: Q is flowrate

v is velocity

A is cross-sectional area of pipe

k is coverage factor (2 in this example)

$U_Q$  is the expanded uncertainty

$u_Q$  is combined standard uncertainty

$u_v$  is standard uncertainty of velocity

$u_A$  is standard uncertainty of area

$c_v, c_A$  are sensitivity coefficients

With a flowrate of 56 L/s in the 150 mm diameter pipe, the velocity v is 3.17 m/s. The manufacturer has stated that the device will measure within  $\pm 2\%$  of the true value. In accordance with *Guide to the Expression of Uncertainty in Measurement* [7], this is a type B rectangular uncertainty with the semi-range value of 2%.

The standard uncertainty of velocity measurement at 3.17 m/s is:

$$u_v = 3.17 \times 2\% / \sqrt{3} = 0.036 \text{ m/s}$$

With an internal diameter of 150 mm and a tolerance of  $\pm 2$  mm, the semi-range value of area is the area for a diameter of 150 mm minus the area for a diameter of 148 mm (150 - 2). This is 0.000 468 m<sup>2</sup>. This again is a type B rectangular uncertainty.

The standard uncertainty on area then becomes:

$$u_A = 0.000 468 / \sqrt{3} = 0.000 27 \text{ m}^2$$

The sensitivity coefficient,  $c_v$ , is the partial derivative  $\partial Q / \partial v = A$  and  $c_A = \partial Q / \partial A = v$ .

The combined standard uncertainty is:

$$u_Q = ((u_v \times c_v)^2 + (u_A \times c_A)^2)^{0.5} = 1.0731 \text{ L/s}$$

The expanded uncertainty with a coverage factor of 2 is 2.146 L/s which is 3.8% of the flowrate of 56 L/s.

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