Draft

Australian Standard

Public Comment is invited for:

DR AS 4747.2:2024, Metering systems for non-urban water supply, Part 2: Technical requirements for closed conduit meters fully charged

During their development process, Australian Standards are available in draft form during the public consultation period to allow any interests concerned with the application of the proposed Standard to review the draft and submit their comments.

This draft is liable to alteration. It is not to be regarded as an Australian Standard until finally issued as such by Standards Australia.

Upon successful conclusion of the Public Comment period it is proposed to publish this Standard as AS 4747.2:202X.

STANDARDS Australia

Preface

This Standard was prepared by the Standards Australia Committee CE-024, Measurement Of Water Flow In Open Channels and Closed Conduits, to supersede AS 4747.2—2013.

The objective of this document is to set out the technical requirements for non-urban metering systems in closed conduit, fully-charged applications.

This document forms part of the AS 4747 series covering the metering of non-urban water supply. A list of all parts in this series can be found in the Standards Australia online catalogue.

The major changes in this edition are as follows:

(a) The relevant terms and definitions from AS 4747.1 have been incorporated into this document. AS 4747.1 has been withdrawn.

(b) An Introduction section has been included to explain the relationship between this document and regulatory documents such as the Metrological Assurance Framework (MAF). AS 4747.8 has been withdrawn and the material previously contained in that document relating to in-service compliance is now covered by the MAF.

(c) Pseudo-regulatory requirements and validation/verification requirements have been removed.

(d) The content in this document has been consolidated so that it is easier to navigate. The document structure has been aligned with AS 4747.3: 202X which deals with open channel metering systems.

(e) The technical requirements have been clarified.

(f) The term “metering system” replaces the use of other terms such as “modular metering system” and “self-contained meter”.

(g) Indirect volumetric calculations have been removed.

(h) The product documentation requirements have been updated, and the purchasing guidelines have been removed.

(i) The appendix related to uncertainty of measurement has been updated.

The terms “normative” and “informative” are used in Standards to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

NOTE This document applies to areas subject to legislation. Refer to the relevant federal, state and territory authorities for the legal and regulatory requirements that apply in that jurisdiction.

Contents

Introduction

The National Water Initiative (NWI) (2004) was established to increase the productivity and efficiency of Australia's water use. The Commonwealth and all Australian states and territories agree to the NWI. Clause 88 of the NWI refers to the development of the National Meter Specification, now known as AS 4747. This Australian Standard contributes to the outcomes of the NWI.

The requirements for non-urban water metering systems are described in the following documents:

(a) Parts 2, 3 and 4 of the AS 4747 series. Parts 2 and 3 describe the construction and technical requirements and Part 4 describes the installation and commissioning requirements for meters to conform to this series.

NOTE 1 AS 4747.1, which was a glossary of terms, has been withdrawn and the relevant terms and definitions are now included in Parts 2, 3 and 4.

NOTE 2 AS 4747.5 and AS 4747.6 have been withdrawn and the content combined to form AS 4747.4.

NOTE 3 AS 4747.8 has been withdrawn and replaced by the Metrological Assurance Framework (MAF).

(b) The National Measurement Institute (NMI) documents NMI M 10 and NMI M 11. These describe the requirements and test methods for the pattern approval and verification of non-urban water metering systems.

AS 4747 references the requirements and test procedures specified in the NMI documents. NMI M 10 and NMI M 11 are freely available from an Australian government website.

(c) The Metrological Assurance Framework 2 (MAF2). This describes —

(i) the nationally consistent compliance management approach for non-urban water meters in Australia; and

(ii) the rules and guidelines used to maintain compliance for non-urban water meters, including methods and practices for validation.

NOTE 4 Compliance is usually maintained by state and territory regulators or irrigation infrastructure operators.

The MAF2 is freely available from an Australian government website.

Pattern approval and verification are regulatory requirements specified under the *National Measurement Act 1960*. This standard does not require meters to be pattern approved or verified. However, testing and evaluation performed for pattern approval purposes can also be used to demonstrate conformance with AS 4747. Pattern approval certificates for approved meters are available from an Australian Government website.

At the time of publication, water meters with a maximum continuous flow rate (Q^3) greater than 16 kL/h are exempt from pattern approval and verification under the *National Measurement Act 1960*.

Verification and validation are separate and distinct requirements described in the above documentation. The requirements for verification are defined under the *National Measurement Act 1960*. The MAF2 describes practices for validation and verification.

NOTES

Australian Standard®

Metering systems for non-urban water supply

Part 2: Technical requirements for closed conduit meters fully charged

Section 1 Scope and general

1.1 Scope

This document sets out the technical requirements for non-urban metering systems in closed conduit, fully-charged applications. The document covers metering principally used for non-urban water supply.

NOTE 1 Metering systems are defined in Clause 1.4 of this document.

NOTE 2 The installation and commissioning requirements for metering systems are specified in AS 4747.4.

This document also covers closed conduit metering systems that will be used in open channel emplacements.

The technical requirements in this document cover all design elements of the metering system including ancillary equipment.

This document excludes the following:

(a) Validation and verification of metering systems.

(b) Telemetry systems.

NOTE 3 Telemetry systems can be subject to regulatory requirements.

(c) Meters covered by AS 3565.1.

1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

NOTE Documents referenced for informative purposes are listed in the Bibliography.

AS 1565, *Copper and copper alloys – Ingots and castings*

AS 1722.2, *Pipe threads of Whitworth form, Part 2: Fastening pipe threads*

AS 2345, *Dezincification resistance of copper alloys*

AS 2738, *Copper and copper alloys – Composition and designations of refinery products, wrought products, ingots and castings*

AS 3558.5, *Methods of testing plastics and composite materials sanitary plumbing fixtures, Method 5: Determination of degradation by ultraviolet light*

AS 3565.1, *Meters for cold and heated drinking and non-drinking water supplies, Part 1: Technical requirements*

AS/NZS 1567, *Copper and copper alloys – Wrought rods, bars and sections*

AS ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

AS/NZS ISO/IEC 17065, *Conformity assessment — Requirements for bodies certifying products, processes and services*

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

ASTM A276, *Standard specification for stainless steel bars and shapes*

ASTM A480, *Standard specification for general requirements for flat-rolled stainless and heat-resisting steel plate, sheet and strip*

ASTM A743, *Standard specification for castings, iron-chromium, iron-chromium-nickel, corrosion resistant, for general application*

NMI M 10-1, *Meters intended for the metering of water in full flowing pipes, Part 1: Metrological and technical requirements*

NMI M 10-2, *Meters intended for the metering of water in full flowing pipes, Part 2: Test methods*

1.3 Terms and definitions

For the purposes of this document, the terms and definitions in the *International Vocabulary of Terms in Legal Metrology (VIML)*, ISO/IEC Guide 99 (2007), AS 3778.1 and the following apply.

1.3.1
accuracy (of measurement)
closeness of the agreement between the measured quantity and a reference value

[SOURCE: ISO/IEC Guide 99:2007, 2.13, modified]

1.3.2
adjustment
alteration of the measurement parameters of an instrument to bring them within the allowable maximum permissible errors (MPEs) for an instrument in use

1.3.3
ancillary equipment
ancillary device
device intended to perform a particular function, directly involved in elaborating, transmitting or displaying measurement results

Note 1 to entry: Ancillary devices can include —

(a) zero setting devices;

(b) repeating indicating devices;

(c) printing devices;

(d) memory devices;

(e) tariff control devices; and

(f) pre-setting devices.

[SOURCE: VIML:2022, 5.06, modified]

1.3.4
calibration
set of operations which, under specified conditions, establish the relationship between the quantity values indicated by the measuring instrument and the corresponding reference quantity value with associated measurement uncertainties

Note 1 to entry: to entry: The ISO/IEC Guide 99:2007 (Clause 2.39) provides a more detailed definition of “calibration”, but the definition provided above is suitable for the purposes of this document.

1.3.5
can
indicates the possibility of an option

1.3.6
commissioning
process to check that a metering system is installed according to relevant documents and is ready for service

Note 1 to entry: Relevant documents can include product documentation and certifications.

1.3.7
competent person
person who has acquired, through education, training, qualification or experience or a combination of these, the knowledge and skill enabling that person to perform the task required

1.3.8
configuration
configured
parameters specified in relevant product documentation that are entered into the metering system to enable correct operation

1.3.9
error of indication
indication minus a reference quantity value

[SOURCE: VIML:2022, 0.04]

1.3.10
error (of measurement)
measured quantity value minus a reference quantity value

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

1.3.11
flow disturbance
disturbance
change in upstream or downstream conditions that can cause an asymmetric flow

Note 1 to entry: An asymmetric flow can affect meter performance.

1.3.12
flow rate
Q
quotient of the actual volume of water passing a specified point and the time taken for this volume to pass that specified point

Note 1 to entry: Expressed in megalitres per day (ML/d), litres per second (L/s), cubic metres per hour or kilolitres per hour.

1.3.13
fully charged
pipe completely filled with water

1.3.14
indicating device
display
part of the metering system that displays the measurement results, either continuously or on demand

Note 1 to entry: A printing device that provides an indication at the end of the measurement is not an indicating device.

1.3.15
in-service
metering system that has been commissioned and is used to measure water for a defined purpose

Note 1 to entry: A defined purpose can include trade, water resource management and licensing compliance.

1.3.16
IP rating
coding system to indicate the degrees of protection provided by an enclosure against access to hazardous parts, ingress of solid foreign objects and water, and provide additional information in connection with such protection

1.3.17
maximum permissible error
MPE
extreme value of the measurement error of a metering system

Note 1 to entry: The value of maximum permissible error as permitted by the AS 4747 series.

[SOURCE: VIML:2022, 0.05, modified]

1.3.18
may
indicates the existence of an option

1.3.19
meter
water meter
instrument intended to measure, memorize and display the volume of water passing through the measurement transducer at metering conditions

Note 1 to entry: 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.

[SOURCE: ISO 4064-1:2014, 3.1.1]

1.3.20
metering system
device or group of associated devices that is intended to measure the quantity of water that passes a specified point

Note 1 to entry: The previous editions of this Standard included the terms “self-contained meter” and “modular metering systems”. This definition is intended to cover both of these terms.

Note 2 to entry: A metering system can include only a meter and no other associated devices.

Note 3 to entry: The devices comprising a metering system can include meters, sensors, physical structures (such as weirs, flumes and gates) and other electrical or mechanical equipment / interfaces associated with the metering system.

Note 4 to entry: Displays can be onsite or remote, and can be continuous or on-demand.

1.3.21
open channel
longitudinal boundary surface consisting of the bed and banks or sides within which water flows with a free surface

Note 1 to entry: Open channel includes partially-filled conduits or pipes.

[SOURCE: ISO 772, 3.19]

1.3.22
open channel emplacement
device or mechanism that allows a quantity of water flowing in an open channel to be measured by a closed conduit meter

[SOURCE: NMI M10-1:2010, 2.4.15]

1.3.23
pattern approval
decision of legal relevance, based on the review of the type evaluation report, that the type of a measuring instrument complies with the relevant statutory requirements and results in the issuance of the type approval certificate

Note 1 to entry: This is a process whereby an impartial body examines the pattern of an instrument against a set of national or international metrological specifications, which determines whether an instrument can retain its calibration over a range of environmental and operating conditions and ensures that the instrument is not capable of facilitating fraud.

Note 2 to entry: “Type approval” is equivalent to “pattern approval”. “Type approval” is more commonly used internationally, whereas the term “pattern approval” is more commonly used in Australia.

[SOURCE: VIML:2022, 2.05]

1.3.24
rated operating condition
operating condition that must be fulfilled during measurement in order that a measuring instrument or measuring system performs as designed

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

[SOURCE: VIML:2022, 0.08]

1.3.25
resolution(of a displaying device)
smallest difference between indications of an indicating device that can be meaningfully distinguished

Note 1 to entry: For a digital device, this is the change in the indication when the least significant digit changes by one step.

[SOURCE: ISO/IEC Guide 99:2007, 4.15]

1.3.26
sampling rate
frequency at which the metering system makes discrete measurements

1.3.27
shall
indicates that a statement is mandatory

1.3.28
should
indicates a recommendation

1.3.29
true value (of a quantity)
quantity value consistent with the definition of a quantity

Note 1 to entry: See the ISO/IEC Guide 99 for a more detailed explanation of true value.

[SOURCE: ISO/IEC Guide 99:2007, 2.11]

1.3.30
uncertainty (of measurement)
non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used

Note 1 to entry: Measurement uncertainty includes components arising from systematic effects, such as components associated with corrections and the assigned quantity values of measurement standards, as well as the definitional uncertainty. Sometimes estimated systematic effects are not corrected for but, instead, associated measurement uncertainty components are incorporated.

Note 2 to entry: The parameter may be, for example, a standard deviation called standard measurement uncertainty (or a specified multiple of it), or the half-width of an interval, having a stated coverage probability.

Note 3 to entry: Measurement uncertainty comprises, in general, many components. Some of these may be evaluated by Type A evaluation of measurement uncertainty from the statistical distribution of the quantity values from series of measurements and can be characterized by standard deviations. The other components, which may be evaluated by Type B evaluation of measurement uncertainty, can also be characterized by standard deviations, evaluated from probability density functions based on experience or other information.

Note 4 to entry: In general, for a given set of information, it is understood that the measurement uncertainty is associated with a stated quantity value attributed to the measurand. A modification of this value results in a modification of the associated uncertainty.

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

1.3.31
validation
set of activities that includes inspecting the meter to check that it is installed in accordance with relevant Standards and maintained to an acceptable state of repair, which provides an acceptable level of confidence that the meter will operate within an acceptable range of error under normal operating conditions

Note 1 to entry: Validation is different to verification. The requirements for verification are defined under the *National Measurement Act 1960*.

1.4 Symbols and abbreviated terms

Megalitres (ML) or kilolitres (kL) are the preferred units of volume; however, cubic metres (m^3) is an acceptable alternative to the latter.

Where megalitres (ML), kilolitres (kL) or cubic metres (m^3) are specified in this document, the alternatives are acceptable.

Megalitres per day (ML/d) or litres per second (L/s) are the preferred units for flow rate.

1.5 Evaluation of product conformity

To claim that a metering system is manufactured to the requirements of this document, the product shall meet the product conformity requirements detailed in Appendix A.

Section 2 Materials

2.1 General

Materials shall have the following characteristics:

(a) Metals shall be resistant to internal and external corrosion. See Clause 2.2.

(b) External plastics components shall be tested in accordance with Clause 2.3.

Any other material used in the manufacture of metering systems should conform to the relevant material standards.

Consideration should be given to recyclability of components and the circular economy.

2.2 Resistance to corrosion

2.2.1 General

Metal components that are in contact with either the metered water or buried in the surrounding ground and groundwater shall be —

(a) of corrosion-resistant material; or

(b) rendered resistant by a coating or other surface treatment.

Non-metallic materials in contact with the metered water should resist chemical or physical degradation by the dissolved compounds and suspended matter commonly found in the metered water.

Any construction materials should not affect or inhibit the accurate operation of the metering system during its operational lifetime.

2.2.2 Corrosion-resistant materials

For the purposes of this document, for most water chemistries, the following materials shall be deemed to be corrosion resistant:

(a) Copper alloys conforming to AS 1565, AS/NZS 1567 or AS 2345.

(b) Austenitic stainless steel conforming to ASTM A276 (grades to be suitable for the application).

(c) Stainless steel conforming to ASTM A480 or ASTM A743.

(d) Phosphor bronze conforming to AS 2738 alloy C51800b.

(e) Copper nickel alloy conforming to AS 2738 alloy C71500 or alloy C70610.

(f) Aluminium grades 5083-H321, 5052-H34, 6351 T5, 6352 T5, 6353 T5, 6354 T5, 6355 T5, 6063 T6.

NOTE 1 Where there is a history of corrosion, the type and material composition of the metering system should be considered when choosing a metering system.

NOTE 2 Other materials may be considered, based on demonstrated corrosion-resistance data.

NOTE 3 Combinations of materials can breach the resistance to corrosion requirement.

NOTE 4 High solute or aggressive waters can require site-specific design beyond the scope of this document.

2.3 Material durability tests

2.3.1 Ultraviolet exposure test

Plastics components of metering systems exposed to sunlight shall be tested in accordance with the ultraviolet light exposure test specified in AS 3558.5, using ultraviolet sunlamps F/28, 220 V to240 V, 300 W ± 50 W, or equivalent.

Components shall be exposed for 8 cycles of 16 h on, 8 h off as well as for 48 h continuous. After this there shall be no observed cracking, crazing or other failures.

2.3.2 Polymer-bodied durability test

A durability test is not required for polymer-bodied metering systems for conformance to this document.

However, if a test is performed, the metering systems shall be tested in accordance with the procedure given in Appendix C.

NOTE This testing may be requested based on the use application.

Section 3 Design

3.1 Dimensions and connections

3.1.1 Dimensions

The dimensions of meters should conform to the dimensions specified in ISO 4064.

3.1.2 Threaded end connections

Threaded end connections shall conform to AS 1722.2.

3.1.3 Flanged end connections

Flanged end connections shall conform to relevant Australian or International standards for the maximum pressure corresponding to that of the meter.

Examples of applicable standards include, but are not limited to, AS/NZS 4087, AS 2129 and EN 1092-1.

3.1.4 Other end connections

Other end connections shall —

(a) conform to relevant pipe standards, where they exist;

NOTE No pipe standards are suggested for guidance here. This clause is retained to allow for future innovation.

(b) allow for the metering system to be installed and removed, as per the product specifications, without damage to the metering system or the surrounding pipework;

(c) be of robust construction, such that the connections are not likely to be damaged or compromised when exposed to expected conditions of use;

(d) be pressure rated for the intended application;

(e) create a water-tight seal and not allow leaks; and

(f) provide for a safe installation and operating environment.

3.1.5 Other connections

Other connections shall be in accordance with the relevant standards for that connection.

NOTE Other connections include, but are not limited to, electrical connections and signal connections.

3.2 Output

3.2.1 General

Metering systems shall provide output signals capable of interfacing with data recording and/or data transmission equipment.

NOTE 1 The output will be dependent on jurisdictional requirements.

NOTE 2 The output selection can be determined by many factors, including rate of information exchange, available power, form of communication (whether radio or telecom), and the ability or requirement to connect many metering systems to the same link.

Equipment connected to the metering system shall be calibrated to the same range as the metering system. The range and units shall be clearly identified. Such equipment may be calibrated to a subset of the full range where the use conditions of the metering system are well understood.

Settings, calibration and stored data shall be protected from non-authorized modification.

3.2.2 Flow rate

Where the metering system records flow rate, it shall be capable of accurately recording the flow rate at the resolution specified in the product documentation.

3.2.3 Volume

The metering system shall be capable of accurately recording the volume at the resolution specified in NMI M 10-1.

3.2.4 Other data output

The data output can include set and operating parameters, such as the following:

(a) *Metering system identification* — For example, product identity code or reference and meter size, serial number (of both sensor and signal converter), meter tag or location identity, site reference and Q_3 rating.

(b) *Metering system construction* — For example, geometry parameters.

(c) *Metering system set-up* — Details including factors required for flow calculation, adjustments specific to the installation, flow rate and volume output settings, network address if the serial communication is shared among many meters.

(d) *Metering system operational status* — For example, flow rate, accumulated volume, errors, alerts, checksum and other operation integrity details, measuring condition status, battery or supply voltage values, other metering information such as water conductivity or sound speed.

3.3 Electronic data storage

Electronic data storage shall not be lost if battery or power fails.

3.4 Sampling rate

For metering systems with operating principles that depend on instantaneous flow rate measurements (rather than continuous flow rate measurements), the following apply:

(a) The sampling rate shall be set at an appropriate interval based on the intended use application.

(b) The sampling rate shall not result in a measurement error greater than ±5 %.

NOTE 1 Stricter jurisdictional requirements can exist for list items (a) and (b).

Adjustable sampling rates shall be set and protected before placing into service.

NOTE 2 Meters can be protected by mechanical or electronic means.

3.5 Frost protection

Where provided, frost protection devices shall be designed so that they will yield or break under freezing conditions to minimize damage to any other part of the metering system.

3.6 Bypass

There shall be no water that bypasses the metering system.

NOTE Water bypass includes leakage.

3.7 Torque resistance of threaded end connections

When tested in accordance with the test for torque resistance of threaded end connections in AS 3565.1, each meter with threaded end connections shall have no observed cracking, breaking, stripping of threads or other failures.

Section 4 Performance requirements

4.1 General

The following performance requirements apply to metering systems:

(a) Metering systems shall conform to the metrological and technical requirements of NMI M 10-1 when tested in accordance with NMI M 10-2.

NOTE 1 The requirements of NMI M 10 are similar to the International Organization of Legal Metrology (OIML) R 49 and ISO 4064.

(b) All metering systems shall be tested for initial accuracy prior to being placed into service.

(c) All metering systems shall operate within a maximum permissible error (MPE) of ±2.5 % when tested for initial accuracy.

(d) All metering systems shall operate within an MPE of ±5 % when in-service.

Maximum permissible errors and maximum permissible uncertainties are summarized in Table 4.1.

All components that comprise a metering system shall be calibrated/configured before first use.

NOTE 2 See Appendix B for additional information and a worked example about uncertainty of measurement.

Table 4.1 — Maximum permissible errors and uncertainties for metering systems

Flow rate range	Purpose	Maximum permissible error (MPE)	Uncertainty	Notes
$Q^1 \leq Q \leq Q^4$	NMI M 10-2 testing	±2.5 %	±0.5 % ($\frac{1}{5}$ MPE)	Testing generally performed in a laboratory for certification purposes.
	Initial accuracy	±2.5 %	$\pm 0.8\dot{3}$ % ($\frac{1}{3}$ MPE)	Testing generally performed in a laboratory for initial accuracy testing prior to the metering system being placed into service.
	In-service accuracy	±5.0 %	$\pm 1.\dot{6}6$ % ($\frac{1}{3}$ MPE)	Testing generally performed *in situ* to confirm performance after it has been placed into service. However, testing may also be performed in a laboratory. If the one-third of the MPE cannot be practically met, then a greater uncertainty may be acceptable by the relevant jurisdiction. In-service testing refers to testing of meters after they have been installed and placed into service for any period of time.

4.2 Rated operating conditions

The metering system shall operate under fully charged conditions.

NOTE Metering systems designed to operate with closed conduits are designed to operate with minimal entrained air. Every effort should be made to remove entrained air from the system prior to testing.

As described in NMI M 10, metering systems shall maintain their performance under the following rated operating conditions:

(a) Pressure range between 0.03 MPa and an upper value specified in the product specifications.

(b) Minimum working water temperature range between 0.1 °C and 30 °C.

(c) Minimum range for ambient air temperature: −5 °C and 55 °C.

(d) Minimum range for ambient relative humidity: 0 % and 100 % (except for remote indicating devices, where the minimum range is 0 % to 93 %).

Insertion or clamp-on meters should have a working pressure range at least equal to the working pressure range of the pipes to which they are attached.

4.3 Measurement of performance

4.3.1 General

Metering system performance shall be evaluated by direct volumetric comparison.

NOTE It is typical for closed conduit metering systems to be tested before use by direct volumetric comparison. If testing by this method cannot be achieved, for example, due to the size or design of the meter or the metering system, then alternative methods can be conducted in consultation with the regulator. Indirect volumetric comparison may be used for open channel metering systems (refer to AS 4747.3) but is not used for closed conduit metering systems.

4.3.2 Direct volumetric comparison

Where direct volumetric comparison is used for metering system evaluation, performance shall be measured via direct comparison with a reference device. This is undertaken by comparing the volumetric measurement of the metering system under test with the volumetric measurement of the reference device by passing the same volume of water through both.

The difference between the two measurements is defined as the error of indication of the metering system under test and is expressed as a percentage as follows:

$$\frac{(V_\mathrm{i} - V_\mathrm{a})}{V_\mathrm{a}} \times 100$$

where

V_a = actual volume as determined by the reference equipment

V_i = indicated volume of the metering system under test

Other recognized formulae may also be used, including those —

(a) published by Standards Australia;

(b) published by the International Standardization Organization; and

(c) specified in documentation provided by the manufacturer.

The reference device may be a direct volumetric measure, a gravimetric system, a calibrated reference meter or similar volumetric measuring device.

The MPE for pre-service and in-service volumetric performance testing shall be the values given in Clause 4.1. The reference method uncertainty shall be in accordance with Clause 4.1.

NOTE 1 For information on volumetric methods through closed conduits, refer to AS 2360.6.1 and AS 2360.6.2.

NOTE 2 The reference device and corresponding methodology used by the test facility for volumetric comparisons will have an associated measurement uncertainty. The evaluation of this uncertainty is part of the facility's accreditation and is beyond the scope of this document.

Section 5 Product documentation

Product documentation shall include the following information:

(a) Handling information, including workplace, health and safety, transport and storage advice.

(b) Serial numbers and any other identifiers.

(c) Product certifications and/or approvals (where applicable).

NOTE 1 This may include pattern approval certificates.

(d) The calibration and configuration data that describes the metrological testing.

(e) Installation manuals and instructions that include any limitations, conditions or requirements for installation (refer to AS 4747.4).

NOTE 2 This can include information about the effect on measurement performance of flow disturbances caused by bends, pumps, partially open valves, junctions, pipe reductions and other disturbances, and measures to manage flow disturbances.

(f) Metering system performance while operating in various water conditions.

NOTE 3 This can be influenced by sedimentation, suspended solids in the water or conductivity of the water on metering system performance.

(g) An operational instruction manual for all components that includes the following:

NOTE 4 An instruction manual can include hard copy or electronic resources.

(i) A description of the metering system, its components and its rated operating conditions.

(ii) The function, application and technical specifications for all equipment, including subassemblies, wiring and schematic diagrams.

(iii) Information and instruction about configurable variables.

(iv) Parameters to be transferred at each interrogation (see Clause 3.2.4).

NOTE 5 Refer to jurisdictional requirements for parameters relevant to that jurisdiction.

(v) Relevant product ratings for each meter or component.

NOTE 6 This can include ingress protection (IP rating), metrological, mechanical and electrical ratings.

(vi) Maintenance requirements and service schedules, including a suggested list of maintenance processes for validation.

NOTE 7 This should include required spare parts and consumables.

(vii) Description of interfaces and diagnostic tools.

NOTE 8 Interfaces and diagnostic tools can facilitate —

(a) *in situ* testing of functions and performance to specifications; and

(b) integration of the metering system with external data logging or telemetry devices.

(viii) Commissioning requirements (refer to AS 4747.4).

The instruction manual should also include the following:

(A) A list of contents, including illustrations and drawings.

(B) Dimensional drawings, weights and specifications.

(C) Troubleshooting procedures.

(D) Dismantling and re-assembly procedures (where applicable).

NOTE 9 This should include instructions for re-validation if the metering system metrology is affected.

(E) List of spare parts that are available.

(F) Decommissioning and end-of-life equipment disposal requirements (where applicable).

NOTE 10 End-of-life is generally defined as when a metering system cannot attain the MPE of ±5 % or cannot be repaired to attain the MPE of ±5 %.

Appendix A
(normative)

Demonstration of conformance

Laboratories that perform the tests outlined in this document shall meet the requirements of AS ISO/IEC 17025.

NOTE 1 Accreditation bodies which are signatories to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA) for testing laboratories may be able to offer accreditation against the requirements of AS ISO/IEC 17025. A list of ILAC signatories is available from the ILAC website (www.ilac.org). In Australia and New Zealand, the National Association of Testing Authorities (NATA), Joint Accreditation System of Australia and New Zealand (JAS-ANZ) and International Accreditation New Zealand (IANZ) are signatories to the ILAC MRA.

NOTE 2 In Australia, the signatory to the International Accreditation Forum Multi-Lateral Recognition Arrangement (IAF MLA) for accreditation bodies is JAS-ANZ.

Any changes to the metering system design shall be evaluated in accordance with the requirements of this document. These are summarized in Table A.1. Re-evaluation, and re-testing if necessary, shall be undertaken to confirm product conformity.

NOTE 3 Alternatives to re-testing or re-evaluation could be achieved by demonstrating process control, quality plans and/or documented procedures, as considered adequate by the certification body.

NOTE 4 Design changes may include changes to firmware or software, and changes to the hardware.

Product evaluation and the need for re-testing is the responsibility of the certification body.

NOTE 5 Statements of conformance to this document on product, packaging or promotional material related to that product should ensure that such conformance is capable of being verified.

Evaluation of conformity shall be performed by a competent person.

NOTE 6 Conformance to this document does not necessarily imply a metering system has gained pattern approval.

NOTE 7 A competent person may be defined by JAS-ANZ or by the relevant jurisdiction.

Table A.1 — Summary of conformance requirements

Characteristics	Clause	Requirement	Method	Frequency
Material properties	2.1	Materials	Review materials parts list and compliance certificates	At any change in materials
	2.2	Resistance to corrosion	See list of standards in Clause 2.2.2	
	2.3.1	Ultraviolet exposure test	AS 3558.5	
	2.3.2	Polymer-bodied durability test	Appendix C (if required)	
Design	3.1.2	Threaded end connections	AS 1722.2	At any change in design
	3.1.3	Flanged end connections	AS 4087[a] or AS 2129[a]	
	3.1.4	Other end connections	Relevant standards	
	3.1.5	Other connections	Relevant standards	
	3.2	Output	Review specifications	

Table A.1 *(continued)*

Characteristics	Clause	Requirement	Method	Frequency
	3.7	Torque resistance of threaded end connections	AS 3565.1	
	4.1	General performance requirements	NMI M 10	
	4.2	Rated operating conditions	NMI M 10	
Product documentation	5	Manual and documentation requirements	Review documentation	At any change in design

[a] These standards cover mechanical test procedures for the flange design. The requirements for the flange connections within a flow meter are specified in NMI M 10.

Appendix B
(informative)

Uncertainty of measurement example

B.1 General

This appendix provides introductory information about uncertainty of measurement, including a worked example.

NOTE 1 Refer to the ISO/IEC Guide 98-3 for more information about uncertainty of measurement.

NOTE 2 The JCGM 100 *Guide to the expression of uncertainty in measurement* is equivalent to ISO/IEC Guide 98-3.

B.2 Nature of errors

All measurements have errors even after corrections and calibrations have been applied. The errors can be positive or negative and can vary in magnitude. Many errors vary with time, whether hourly, daily, weekly, seasonally or yearly.

Errors that are constant or apparently constant during testing are typically called systematic errors. These errors can be determined only when measurements are compared with the true quantity value. This is rarely possible, though 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.

The terms "error" and "uncertainty" should not be confused. 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.3 Worked example of an uncertainty calculation

B.3.1 Introduction

The following example demonstrates the process for determining uncertainty of measurement. It is by no means comprehensive because there are many variables that can affect the uncertainty, such as ovality, device alignment and centring. The accuracy of the calculation can also be improved by making actual measurements.

The measurement model is:

$$Q = v \times A$$

The uncertainty calculation is:

$$U_{\mathrm{Q}} = k \times u_{\mathrm{Q}}$$

$$u_{\mathrm{Q}} = \left[\left(u_{\mathrm{v}} \times c_{\mathrm{v}} \right)^2 + \left(u_{\mathrm{A}} \times c_{\mathrm{A}} \right)^2 \right]^{0.5}$$

where

Q = flow rate

v	=	velocity
A	=	cross-sectional area of pipe
k	=	coverage factor
U_Q	=	expanded uncertainty
u_Q	=	combined standard uncertainty
u_V	=	standard uncertainty of velocity
u_A	=	standard uncertainty of area
c_v	=	sensitivity coefficient of velocity
c_A	=	sensitivity coefficient of area

B.3.2 Example

An insertion velocity measurement device which has been factory calibrated measures velocity within ±2 % of true value. The internal area of the pipe into which the velocity measuring device is inserted is based on measurements. A tolerance of ±2 mm on an internal pipe diameter of 150 mm is accepted. In this example, it is assumed that the pipe is perfectly round.

B.3.3 Step 1: Calculate the water velocity through the pipe

When the flow rate (Q) through the 150 mm diameter pipe (D = 0.15 m) is 0.056 m^3/s, the velocity (v) is 3.174 m/s. This is calculated as follows:

$$v = Q/A$$

where

$$A = \pi\left(\frac{D}{2}\right)^2$$

$$A = \pi\left(\frac{0.15}{2}\right)^2$$

$A = 0.0177$ m^2

Therefore, since $v = Q/A$

$v = 0.056/0.0177$

$v = 3.17$ m/s

B.3.4 Step 2: Calculate the standard uncertainty of velocity measurement

The device measures velocity within ±2 % of the true value (in accordance with JCGM 100 Guide to the expression of uncertainty in measurement). This is a type B rectangular uncertainty (√3) with the semi-range value of 2 %.

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

$$u_{\text{v}} = \frac{v \times \%\ value}{type\ B\ rectangular\ uncertainty}$$

$$u_{\text{v}} = \frac{3.17 \times 2\%}{\sqrt{3}}$$

$u_v = 0.0366$ m/s

B.3.5 Step 3: Calculate standard uncertainty on pipe area

The error value of the area of a pipe with an internal diameter of 150 mm and a tolerance of ±2 mm is equal to the difference between the area of a pipe of 150 mm diameter and the area of a pipe of 148 mm diameter (i.e. 150 mm − 2 mm). This difference in area is 0.000468 m^2. It is illustrated in the following formula:

$$A_{dif} = \pi\left(\frac{D}{2}\right)^2 - \pi\left(\frac{D - tolerance}{2}\right)^2 \quad A_{dif} = \pi \times \left(\frac{0.150}{2}\right)^2 - \pi \times \left(\frac{0.150 - 0.002}{2}\right)^2$$

$$A_{dif} = 0.000468 \text{ m}^2$$

This again is a type B rectangular uncertainty.

The standard uncertainty on area then becomes:

$$u_{\text{A}} = \frac{A_{dif}}{type\ B\ rectangular\ uncertainty}$$

$$u_{\text{A}} = \frac{0.000468}{\sqrt{3}}$$

$$= 0.00027 \text{ m}^2$$

B.3.6 Step 4: Calculate combined standard uncertainty

The following equation (from Clause B.3.1) is used to calculate the combined uncertainty:

$$U_{\text{Q}} = k \times u_{\text{Q}}$$

where

$$u_{\text{Q}} = \left[\left(u_{\text{v}} \times c_{\text{v}}\right)^2 + \left(u_{\text{A}} \times c_{\text{A}}\right)^2\right]^{0.5}$$

The sensitivity coefficient (c_{V}) is the partial derivative:

$$c_{\text{V}} = \partial_{\text{Q}} / \partial_{\text{V}} = A \text{ and } c_{\text{A}} = \partial_{\text{Q}} / \partial_{\text{V}} = v$$

The combined standard uncertainty is:

$$u_{\text{Q}} = \left[\left(u_{\text{v}} \times c_{\text{v}}\right)^2 + \left(u_{\text{A}} \times c_{\text{A}}\right)^2\right]^{0.5}$$

$u_{\text{Q}} = [(0.0366 \times 0.0177)^2 + (0.00027 \times 3.17)^2]^{0.5}$

u_Q = 0.00107 m^3/s (1.07 L/s)

In this example, k = 2. Therefore, the combined standard uncertainty is:

$U_Q = k \, . \, u_Q$

U_Q = 2 × 0.00107

U_Q = 0.00215 m^3/s

U_Q = 2.15 L/s

In summary, the expanded uncertainty is 0.00215 m^3/s (2.15 L/s). This equates to 3.8 % of the flow rate of 0.056 m^3/s (56 L/s).

Appendix C
(normative)

Material durability tests

C.1 Scope

This appendix sets out the method for testing material durability of a complete meter.

C.2 Testing sequence

Meters shall be tested in the following sequence:

(a) Initial static pressure and baseline accuracy tests (see Clause C.3).

(b) Cyclic temperature test (see Clause C.4).

(c) Interim assessment (see Clause C.5).

(d) Cyclic pressure test (see Clause C.6).

(e) Final accuracy test (see Clause C.7).

(f) Comparison of accuracy test results (see Clause C.8).

The decision tree for the test sequence is illustrated in Figure C.1.

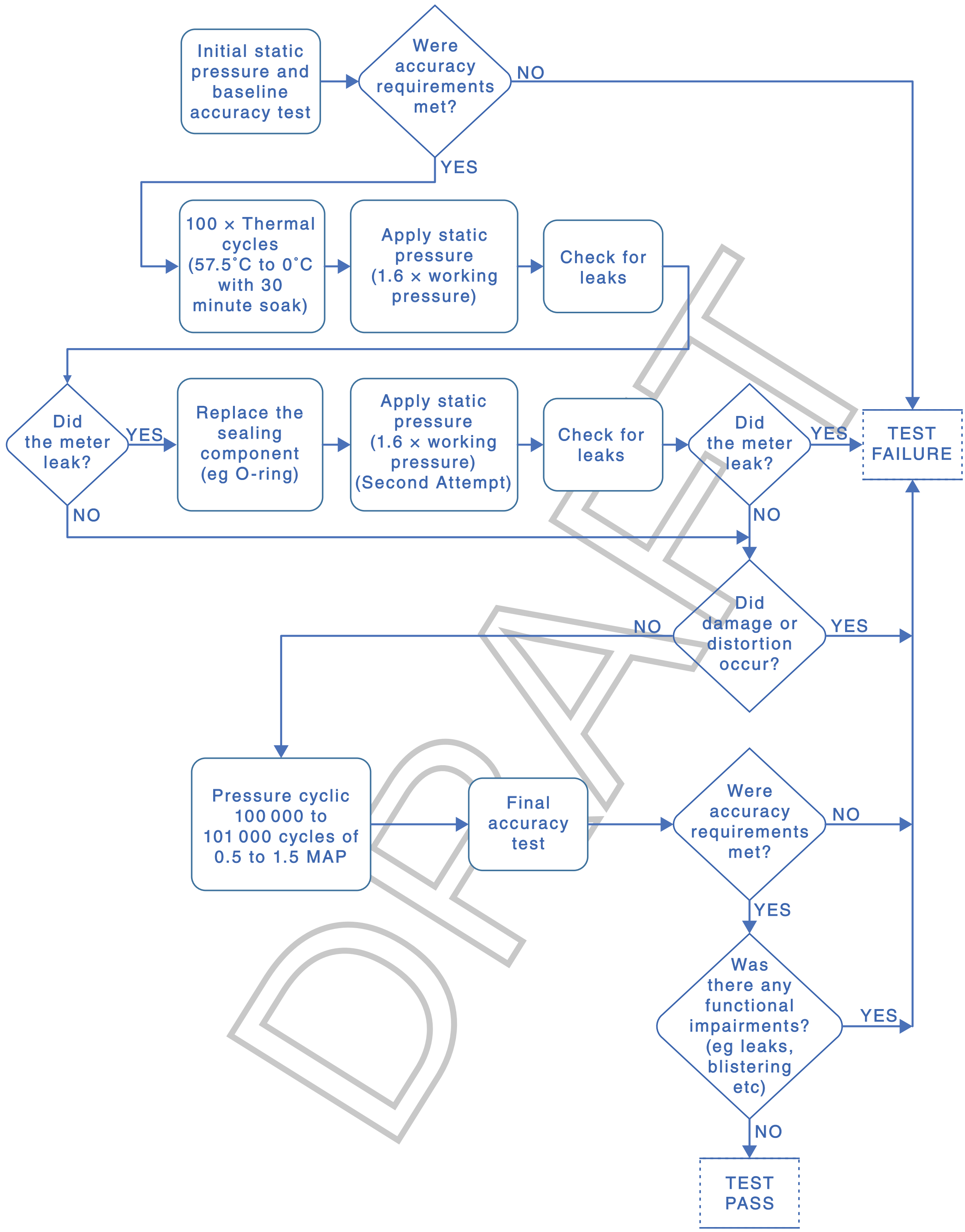

Figure C.1 — Decision tree for the material durability test process

C.3 Initial static pressure and baseline accuracy tests

C.3.1 Initial static pressure

A static pressure test shall be conducted in accordance with the "Object of Test" test within NMI M 10-2, to verify that the meter can withstand the specified hydraulic test pressure for the specified time without leakage or damage.

The test results shall be recorded in the format specified in Clause C.10.

C.3.2 Initial baseline accuracy

The initial baseline accuracy test shall be conducted in accordance with "Determination of intrinsic errors (of indication) and the effects of meter orientation" test of NMI M 10-2. The test results shall be recorded in the format specified in Clause C.10.

C.4 Cyclic temperature test

C.4.1 General

This test sets out the method for subjecting a meter to cyclic temperature variation.

C.4.2 Apparatus and testing conditions

The apparatus shall be as follows:

(a) A temperature chamber maintained at 57.5 ± 2.5°C.

(b) A temperature chamber maintained at 0 ± 2°C.

The temperature chamber shall be operated in accordance with IEC 60068-2-1 and IEC 60068-2-2.

NOTE Additional guidance is given in IEC 60068-1 and IEC 60068-3-1.

The ambient temperature during testing shall be 20 ± 5°C.

C.4.3 Procedure

The procedure shall be as follows:

(a) Place a complete meter in the temperature chamber at 57.5 ± 2.5°C. Leave the components in the temperature chamber for 30 min.

(b) Remove the components from the temperature chamber and allow them to cool down under ambient conditions for 30 min.

(c) Place the components in the temperature chamber at 0 ± 2°C. Leave the components in the temperature chamber for 30 min.

(d) Remove the components from the temperature chamber and allow them to warm up under ambient conditions for 30 min.

NOTE Where the temperature chamber is capable of heating and cooling, removal of the meter is not required; however, the requirements of Steps (a), (b) and (c) above apply.

(e) Repeat Step (a) to Step (d) 99 times (i.e. a total of 100 cycles). If necessary, the test cycle may be interrupted only when the components under test are at ambient conditions.

C.5 Interim assessment

The interim assessment of the meter shall be as follows:

(a) Subject the meter to a pressure of 1.6 times the nominal working pressure for 15 min and check for conformance with the static pressure test of NMI M10-1.

(b) If the meter leaks after Step (a), then —

(i) replace the sealing component (e.g. O-ring). The sealing component shall only be replaced once. This clause shall apply to sealing components that are not an integral component of the meter.

NOTE An integral component is one that is supplied with the meter and nominated in the product instructions.

(ii) repeat Step (a).

The meter is deemed to fail and no further testing is necessary if —

(i) a meter component, excluding the measuring assembly or lens, breaks during replacement of the watertight seal; or

(ii) any component is distorted such that the meter cannot be re-assembled when replacing the watertight seal.

C.6 Cyclic pressure test

C.6.1 General

This test sets out the method for subjecting a meter to cyclic pressure variation.

C.6.2 Apparatus

The apparatus shall be that specified for the static pressure test of NMI M 10-2 and with the following additional capabilities:

(a) A timing device that operates a controlled pressure supply for 100 000 cycles.

(b) A controlled pressure supply device to regulate the water pressure in the meters under test.

(c) Devices for ensuring the correct operation of the timing and pressure supply devices.

C.6.3 Procedure

C.6.3.1 Test cycle

A complete cycle shall comprise of the following phases:

(a) A period of 1 s at a constant high test pressure of 1.5 times MAP (maximum admissible pressure).

NOTE The MAP is specified in the product specifications.

(b) A pressure fall time of 0.4 ± 0.1 s.

(c) A period of 1 s at a constant low test pressure of 0.5 times MAP.

(d) A pressure rise time of 0.4 ± 0.1 s.

C.6.3.2 Test procedure

The test procedure shall be as follows:

(a) Connect the meters under test to the cyclic test apparatus in their operating position.

(b) Subject the meter to the test cycle in C.6.3.1 at least 100 000 times but not exceeding 101 000 times.

C.7 Final accuracy test

A final accuracy test shall be performed in accordance with "Determination of intrinsic errors (of indication) and the efforts of meter orientation" test of NMI M 10-2. The test results shall be recorded in the format specified in Clause C.10.

C.8 Comparison of results

The instrument shall be evaluated for conformance with the acceptance criteria specified in Clause C.9. For each flow rate, calculate the variation in error by subtracting the error value obtained in the initial baseline test (Clause C.3) from the error value obtained in the final accuracy test (Clause C.7).

The variation in error shall be recorded in the format specified in Clause C.10.

C.9 Acceptance criteria

At the conclusion of the cyclic temperature, cyclic pressure and accuracy tests, the meter shall —

(a) not have any functional impairments (e.g. leaks); and

(b) not be cracked, crazed, blistered or peeling.

The error curve variation shall not exceed 2.5 % for flow rates in the zone ($Q_1 \leq Q < Q_4$). For the purpose of determining these requirements, the mean values of the errors (of indication) at each flow rate shall apply.

C.10 Test report

The test report shall include the following information for each meter:

(a) The make, model and serial number of the test meter.

(b) Reference to this test method, i.e. Appendix C, AS 4747.2:202X.

(c) The results of the following tests for each meter, including reference to the clause that explains how the results were calculated:

(i) Initial static pressure and baseline accuracy test.

(ii) Cyclic temperature.

(iii) Cyclic pressure.

(iv) Final accuracy test.

(v) The variation in error between the initial baseline test and the final accuracy test.

(d) Test conditions at the time of the test (e.g. water temperature, water pressure). See NMI M 10-2.

(e) Ambient conditions are the time of the test (e.g. air temperature, humidity). See NMI M 10-2.

(f) Any deviations from the test procedure.

(g) Any unusual features observed. This includes any observed cracking, crazing or other failures, including seal replacement.

(h) The date of the test.

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For information regarding the development of Standards contact:
Standards Australia Limited
GPO Box 476
Sydney NSW 2001
Phone: 02 9237 6000
Email: mail@standards.org.au
www.standards.org.au

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