



Asia-Pacific
Economic Cooperation



Asia-Pacific
Legal Metrology
Forum

OIML R 49-2

Water meters intended for the metering of cold potable
water and hot water meters

TEST METHODS

APEC/APLMF Training Courses in Legal Metrology

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Hanoi, Vietnam



ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY



Measurement
Canada

Mesures
Canada

An Agency of
Industry Canada

Un organisme
d'Industrie Canada

Canada

SCOPE

- Applicable to type evaluation and initial verification testing
- Applicable to cold potable and hot water
- Sets out details of the test program, principles, equipment and procedures to be used
- Applicable to complete meters or selected components

SELECTED TERMINOLOGY

2.11 Pre-conditioning

Treatment of the equipment under test, with the object of eliminating or partially counteracting the effects of its previous history. Where called for, this is the first process in the test procedure.

2.12 Conditioning

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

2.13 Recovery

Treatment of the equipment under test, after conditioning, in order that the properties of the equipment under test may be stabilized before measurement.

REFERENCE CONDITIONS

Reference flowrate	$0.7 \times (Q_2 + Q_3) \pm 0.03 \times (Q_2 + Q_3)$
Water temperature:	Within ± 5 °C of 20 °C (T 30)
Water pressure	Within rated operating conditions (See 5.4 of R 49-1 [1])
Ambient temperature range:	15 °C to 25 °C
Ambient relative humidity range:	45 % to 75 %
Ambient atmospheric pressure range:	86 kPa to 106 kPa [0.86 bar to 1.06 bar]
Power supply voltage (mains AC):	Nominal voltage (U_{nom}) $\pm 5\%$
Power supply frequency:	Nominal frequency (f_{nom}) $\pm 2\%$
Power supply voltage (battery):	A voltage V in the range $U_{bmin} \leq V \leq U_{bmax}$

REFERENCE CONDITIONS

During each test:

- The temperature shall not vary by more than 5 °C
- The relative humidity shall not vary by more than 10 %

PERFORMANCE TESTS

General Requirements

Water:

- Shall be used for all tests
- Shall be public potable water or equivalent
- Water shall be free of substances that can damage the meter
- Shall not contain bubbles

Test Equipment:

- Shall be designed, constructed and used to ensure that reference conditions are met
- Shall be subjected to periodic inter-comparisons between test rigs in accordance with OIML International Document D7

PERFORMANCE TESTS

General Requirements (cont.)

Group Testing:

- Meters can be tested either individually or in groups
- When meters are tested in series, the pressure at the exit of each meter shall be sufficient to prevent cavitation

Location:

- The environment (test facility) chosen for meter tests shall be in accordance with the principles elaborated in OIML publication G 13 *Planning of metrology and testing laboratories*
- Shall be free from disturbing influences (for example, ambient temperature, vibration)

PERFORMANCE TESTS

General Requirements (cont.)



**In-Series Test
Badger Meter
USA**

PERFORMANCE TESTS

Tests Applicable to All Meters:

- Static pressure
- Intrinsic Error (of indication) and Meter Orientation
- Water temperature
- Water pressure
- Flow reversal
- Pressure loss
- Flow disturbance
- Discontinuous flow endurance
- Continuous flow endurance test

STATIC PRESSURE TEST

Object of the test:

- To verify that the water meter can withstand the specified hydraulic test pressure for the specified time without leakage or damage.

STATIC PRESSURE TEST

Test procedure (In-line meters):

- Caution to only increase and decrease the pressure gradually without pressure surges.
- Increase the hydraulic pressure to 1.6 times the maximum admissible pressure (MAP) of the meter, hold it for 15 minutes.
- Examine the meters for physical damage, for external leaks and for leaks into the indicating device.
- Increase the hydraulic pressure to twice the MAP, hold for 1min.
- Examine the meters for physical damage and leaks
- Complete test report 5.1 in R 49-3.
[oiml r49-3 Static pressure test.doc](#)

STATIC PRESSURE TEST

Acceptance criteria:

- There shall be no leakage from the meter or leakage into the indicating device, or physical damage

STATIC PRESSURE TEST



**Badger Meter
USA**

INTRINSIC ERROR (of indication) TEST

Object of the test:

- To determine the intrinsic errors (of indication) of the water meter.

INTRINSIC ERROR (of indication) TEST

Test procedures:

- Use the following flowrates to determine the intrinsic errors (of indication) of the water meter:
 - between Q_1 and $1.1 Q_1$
 - between $0.5 (Q_1 + Q_2)$ and $0.55 (Q_1 + Q_2)$ (only for $Q_2/Q_1 > 1.6$)
 - between Q_2 and $1.1 Q_2$
 - between $0.33 (Q_2 + Q_3)$ and $0.37 (Q_2 + Q_3)$
 - between $0.67 (Q_2 + Q_3)$ and $0.74 (Q_2 + Q_3)$
 - between $0.9 Q_3$ and Q_3
 - between $0.95 Q_4$ and Q_4

and for combination meters:

 - between $0.85 Q_{x1}$ and $0.95 Q_{x1}$
 - between $1.05 Q_{x2}$ and $1.15 Q_{x2}$

- the error at each flowrate is measured twice:

INTRINSIC ERROR (of indication) TEST

Test procedures (cont.):

- During a test hold all other influence factors at reference conditions
- Measure the errors (of indication) at other flowrates if the shape of the error curve indicates that the mpe may be exceeded
- Calculate the relative error (of indication) for each flowrate
- Complete test report R 49-3, 5.3.
[oiml r49-3 intrinsic error.doc](#)

INTRINSIC ERROR (of indication) TEST

- **Acceptance criteria:**
 - Errors (of indication) shall not exceed the applicable mpe for each test run. [Class 2 MPE.ppt](#)
 - If the error observed on one or more meters is greater than the maximum permissible error at one flowrate only the test at that flowrate shall be repeated. [flowratesOIML 49-2.ppt](#)
 - The test shall be declared satisfactory if two out of the three results lie within the maximum permissible error and the arithmetic mean of the results for the three tests at that flowrate is less than or equal to the maximum permissible error.
 - If all the relative errors (of indication) of the water meter have the same sign, at least one of the errors shall not exceed one half of the maximum permissible error.
 - In all cases this requirement shall be applied equitably with respect to the water supplier and the consumer

ORIENTATION

(of water meters)

- If the meters are marked 'H' mount the connecting pipework with the flow axis in the horizontal plane during the test.
- If the meters are marked 'V' mount the connecting pipework with the flow axis in the vertical plane during the test.
- If the meters are not marked 'H' or 'V',
 - at least one meter from the sample shall be mounted with the flow axis vertical, with flow direction from bottom to top
 - at least one meter from the sample shall be mounted with the flow axis vertical, with flow direction from top to bottom
 - at least one meter from the sample shall be mounted with the flow axis at an intermediate angle to the vertical and horizontal
- the remaining meters from the sample shall be mounted with the flow axis horizontal.

ORIENTATION (of water meters)



**Badger Meter
USA**

ORIENTATION (of water meters)



WRc-NSF
Wales, UK

ORIENTATION

(of water meters)

- Where the meters have an indicating device which is integral with the body of the meter, at least one of the horizontally mounted meters shall be oriented with the indicating device positioned at the side and the remaining meters shall be oriented with the indicating device positioned at the top.
- The tolerance on the position of the flow axis for all meters, whether horizontal, vertically or at an intermediate angle, shall be $\pm 5^\circ$.

ORIENTATION (of water meters)



Badger Meter
USA

WATER TEMPERATURE TEST

Object of the test:

- To measure the effects of water temperature on the errors (of indication) of the meter.

WATER TEMPERATURE TEST

Test procedure:

- Measure the error (of indication) of at least one meter at the flowrate Q_2 with the inlet temperatures held at $10\text{ °C} \pm 5\text{ °C}$. All other influence factors maintained at reference conditions.
- Measure the error (of indication) of at least one meter at the flowrate Q_2 with the inlet temperatures held at the maximum admissible temperature (MAT) (Table 1, R 49-1) of the meter with a tolerance of $+0\text{ °C}$, -5 °C and all other influence factors maintained at reference conditions.
- Calculate the relative error (of indication) for each inlet water temperature in accordance with Annex B.
- Complete test report R 49-3, 5.4.

WATER TEMPERATURE TEST

Acceptance criteria:

- The relative error (of indication) of the meter shall not exceed the applicable maximum permissible error (mpe).
- Class 2, T30 meter @ Q2, $mpe = \pm 2\%$

WATER PRESSURE TEST

Object of the test:

- To measure the effects of internal water pressure on the errors (of indication) of the meter.

WATER PRESSURE TEST

Test procedure:

- Measure the error (of indication) of at least one meter at a flowrate of Q_2 with the inlet pressure held firstly at 0.03 MPa (0.3 bar) $\pm 5\%$ and then at the maximum admissible pressure (MAP) (+ 0, - 10 %).
- During each test, all other influence factors shall be maintained at reference conditions.
- Calculate the relative error (of indication) for each inlet water pressure.
- Complete test report R 49-3, 5.5.

WATER PRESSURE TEST

Acceptance criteria:

- The relative error (of indication) of the meter shall not exceed the applicable maximum permissible error (mpe).
- Class 2, T30 meter @ Q2, $mpe = \pm 2\%$

FLOW REVERSAL TEST

Object of the test

- To verify that the meter satisfies the requirement of 3.2.6 in R 49-1 when flow reversals occur.
[reverse flow OIML R 49-1.ppt](#)

FLOW REVERSAL TEST

Test procedure

- **Meters designed to measure reverse flow**
 - Measure the error (of indication) of at least one meter at each of the following reverse flowrates:
 - Between Q_1 and $1.1 Q_1$
 - Between Q_2 and $1.1 Q_2$
 - Between $0.9 Q_3$ and Q_3
 - All other influence factors shall be maintained at reference conditions.
 - Calculate the relative error (of indication) for each flowrate.
 - Complete test report R 49-3, 5.6.1.

FLOW REVERSAL TEST

Test procedure (cont.):

- **Meters not designed to measure reverse flow**
 - Subject the meter to a reverse flow of $0.9 Q_3$ for 1 minute.
 - Measure the error (of indication) of at least one meter at each of the following reverse flowrates:
 - Between Q_1 and $1.1 Q_1$
 - Between Q_2 and $1.1 Q_2$
 - Between $0.9 Q_3$ and Q_3
 - All other influence factors shall be maintained at reference conditions.
 - Calculate the relative error (of indication) for each flowrate.
 - Complete test report R 49-3, 5.6.1.

FLOW REVERSAL TEST

Test procedure (cont.):

- **Meters which prevent reverse flow**
 - Subject the meter to the maximum admissible pressure in the reverse flow direction for 1 minute.
 - Measure the error (of indication) of at least one meter at each of the following reverse flowrates:
 - Between Q_1 and $1.1 Q_1$
 - Between Q_2 and $1.1 Q_2$
 - Between $0.9 Q_3$ and Q_3
 - All other influence factors shall be maintained at reference conditions.
 - Calculate the relative error (of indication) for each flowrate.
 - Complete test report R 49-3, 5.6.1.

FLOW REVERSAL TEST

Acceptance criteria:

- The relative error (of indication) of the meter shall not exceed the applicable maximum permissible error (mpe).
- Class 2, T30 meter

Flow Rate	MPE
Between Q_1 and $1.1 Q_1$	$\pm 5\%$
Between Q_2 and $1.1 Q_2$	$\pm 2\%$
Between $0.9 Q_3$ and Q_3	$\pm 2\%$

PRESSURE LOSS TEST

Object of the test:

- To determine the maximum pressure loss through the water meter at any flowrate between Q_1 and Q_3 . To verify the maximum pressure loss is less than 0.063 MPa (0.63 bar).

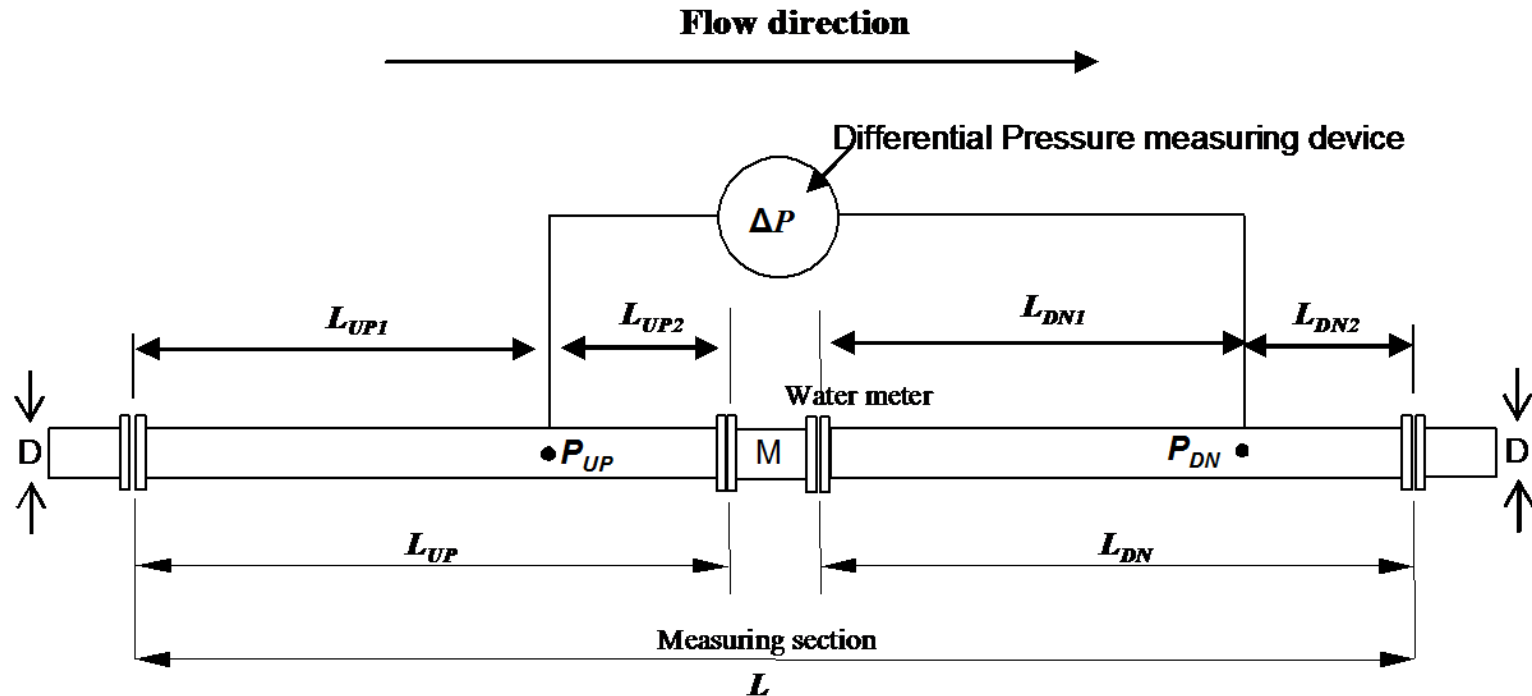
[pressure loss definition OIML R 49-1.ppt](#)

PRESSURE LOSS TEST

Test procedure:

- Meter is placed in test rig
- Vary flow between Q_1 and Q_3 and monitor differential pressure
- Find the flowrate (Q_t) showing the largest pressure loss
- Record Q_t , maximum pressure loss, and water temperature. Normally will be found to be equal to Q_3
- The static pressure downstream of the meter under test shall be at least 100 kPa to avoid cavitation or air release
- Complete test report R 49-3, 5.7

PRESSURE LOSS TEST



P_{UP} and P_{DN} are planes of the pressure tapplings M is the water meter

Minimum Pipe lengths: L_{UP} and $L_{DN} \geq 15D$ L_{UP1} and $L_{DN1} \geq 10D$ L_{UP2} and $L_{DN2} \geq 5D$

Fig 1: Pressure loss test; Layout of measuring section

PRESSURE LOSS TEST

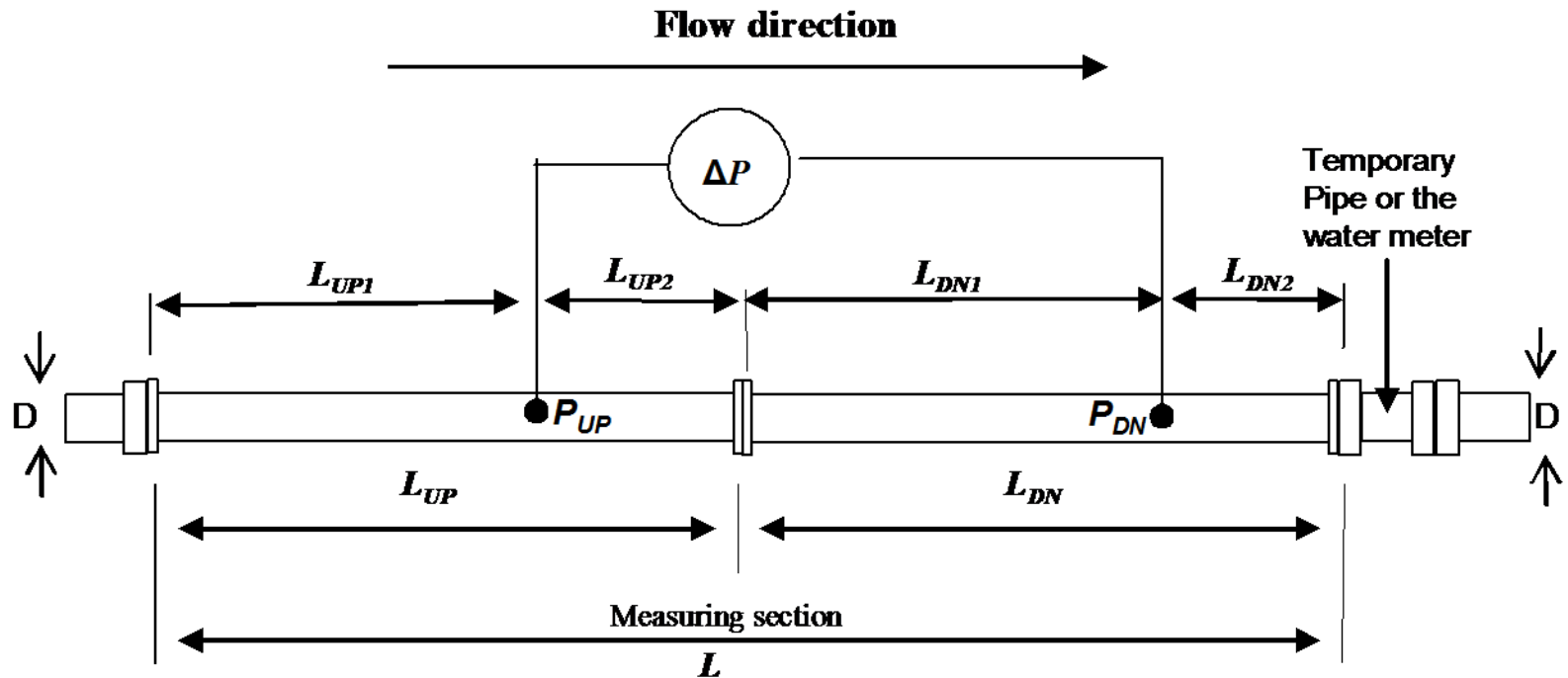


Fig 2: Pressure loss test; Pipe pressure loss

PRESSURE LOSS TEST

Calculation of the actual ΔP of a water meter

- Calculate the pressure loss (ΔP_t) of the water meter at (Q_t)
 - $\Delta P_t = \Delta P_{m+p} - \Delta P_p$
 - ΔP_{m+p} is the measured pressure loss at Q_t with the meter in place
 - ΔP_p is the pressure loss measured without the meter at Q_t
- If the measured flowrate either during the test or during the determination of the pipe pressure loss is not equal to the selected test flowrate, the measured pressure loss can be corrected to that expected at Q_t by reference to the square law formula. [pressure loss correction.doc](#)

PRESSURE LOSS TEST

Acceptance criteria:

- The pressure loss of the meter shall not exceed 0.063 MPa (0.63 bar) at any flowrate between Q_1 and Q_3 inclusive.

FLOW DISTURBANCE TEST

Object of the test:

- To verify that the meter complies with the requirements of 5.3.4 in R 49-1
- The effects on the error (of indication) of a water meter, of the presence of specified, common types of disturbed flow upstream and downstream of the meter are measured.

FLOW DISTURBANCE TEST

Test procedure:

- Use a Types 1, 2 and 3 flow disturbance device

Flow Disturber	Disturbance
Type 1	left-handed (sinistrorsal) swirl
Type 2	right-handed (dextrosal) swirl
Type 3	asymmetric velocity profile

- Determine the error (of indication) of the meter at a flowrate between $0.9 Q_3$ and Q_3 , for each of the installation conditions shown in Annex C.
[ANNEX C.doc](#)
- During each test, all other influence factors shall be maintained at reference conditions.
- Complete test report R 49-3, 5.8.

FLOW DISTURBANCE TEST

Flow Disturber



Type 1

Type 2

Type 3

FLOW DISTURBANCE TEST

Test procedure:

- **Additional Requirements:**

[Additional Requirements FLOW.doc](#)

FLOW DISTURBANCE TEST

Acceptance criteria:

- The relative error (of indication) of the meter shall not exceed the applicable maximum permissible error for any of the flow disturbance tests.



ENDURANCE TEST

Endurance test:

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

Types:

- Discontinuous
- Continuous

Applications:

- Endurance Tests:

DISCONTINUOUS ENDURANCE TEST

Object of the test:

- To verify that the water meter is durable when subjected to cyclic flow conditions.
- This test is applied only to meters with $Q3 \leq 16 \text{ m}^3/\text{h}$.
- The meter is subjected to a specified number of starting and stopping flowrate cycles.
- Each cycle is of a short duration.
- The constant test flowrate phase of each cycle is kept at the specified flowrate (ex. $Q3$).

DISCONTINUOUS ENDURANCE TEST

Test procedure:

- **Flowrate cycle:**

A complete cycle comprises the following four phases:

- zero to the test flowrate (start-up)
- a period at constant test flowrate
- test flowrate to no flowrate (rundown)
- period at no flowrate.

DISCONTINUOUS ENDURANCE TEST

Test procedure:

- Before commencing the discontinuous endurance test, measure the errors (of indication) of the meter.
[error of indication test.doc](#)
- Run the meter(s) at the conditions shown below:

Meter Type	Test Q	Number Of Cycles	Duration Of Stops	Duration at Test Q	Duration of Start-up and Rundown
Q3 ≤ 16m ³ /hr	Q3	100,000	15 s	15 s	Min = 1 s
Combination	2 x Qx2 (increasing Q)	50,000	15 s	15 s	Min = 3 s Max = 6 s

DISCONTINUOUS ENDURANCE TEST

Test procedure cont:

- Following the discontinuous endurance test, measure the final errors (of indication).
- Calculate the final relative error (of indication) for each flowrate.
- For each flowrate, subtract the value of the intrinsic error (of indication) obtained before the test from the error (of indication) obtained after the test.
- Complete test report R 49-3, 5.9.1.

DISCONTINUOUS ENDURANCE TEST

Test Conditions:

Test Condition	Tolerance
Flowrate	Not exceed 10% at test flowrate (Q3)
Test Timing	Each phase shall not exceed 10% Total test duration shall not exceed 5%
Number of cycles	Number of cycles stipulated (n) Number of cycles recorded (nr)n $n < nr \geq 1.01 n$
Discharged Volume	$\pm 5\%$ ($1/2 \times Q3 \times \text{total time}$)

DISCONTINUOUS ENDURANCE TEST

Acceptance criteria:

After the discontinuous endurance test:

- The variation in the error curve shall not exceed 3 % for flowrates in the lower zone ($Q1 \leq Q < Q2$), or 1.5 % for flowrates in the upper zone ($Q2 \leq Q \leq Q4$). For the purpose of determining these requirements the mean values of the errors (of indication) at each flowrate shall apply.

- For T30 meters, the curves shall not exceed a maximum error limit of:
 - ± 6 % for flowrates in the lower zone ($Q1 \leq Q < Q2$), and
 - ± 2.5 % for flowrates in the upper zone ($Q2 \leq Q \leq Q4$)

DISCONTINUOUS ENDURANCE TEST



WRc-NSF
Wales, UK

CONTINUOUS ENDURANCE TEST

Object of the test:

- To verify the durability of the water meter when subjected to continuous, permanent and overload flow conditions.
- The test consists of subjecting the meter to constant flowrate of $Q3$ or $Q4$ for a specified duration.

CONTINUOUS ENDURANCE TEST

Test procedure:

- Before commencing the discontinuous endurance test, measure the errors (of indication) of the meter.
[error of indication test.doc](#)
- Run the meter(s) at the conditions shown below:

Meter Type	Test Q	Duration at Test Q
$Q3 \leq 16\text{m}^3/\text{hr}$	Q4	100 hours
$Q3 > 16\text{m}^3/\text{hr}$	Q3	800 hours
$Q3 > 16\text{m}^3/\text{hr}$	Q4	200 hour

CONTINUOUS ENDURANCE TEST

Test procedure cont:

- Following the continuous endurance test, measure the final errors (of indication).
- Calculate the final relative error (of indication) for each flowrate.
- For each flowrate, subtract the value of the intrinsic error (of indication) obtained before the test from the error (of indication) obtained after the test.
- Complete test report R 49-3, 5.9.1.

CONTINUOUS ENDURANCE TEST

Acceptance criteria:

After the continuous endurance test:

- The variation in the error curve shall not exceed 3 % for flowrates in the lower zone ($Q1 \leq Q < Q2$), or 1.5 % for flowrates in the upper zone ($Q2 \leq Q \leq Q4$). For the purpose of determining these requirements the mean values of the errors (of indication) at each flowrate shall apply.
- For T30 meters, the curves shall not exceed a maximum error limit of:
 - ± 6 % for flowrates in the lower zone ($Q1 \leq Q < Q2$), and
 - ± 2.5 % for flowrates in the upper zone ($Q2 \leq Q \leq Q4$)

CONTINUOUS ENDURANCE TEST



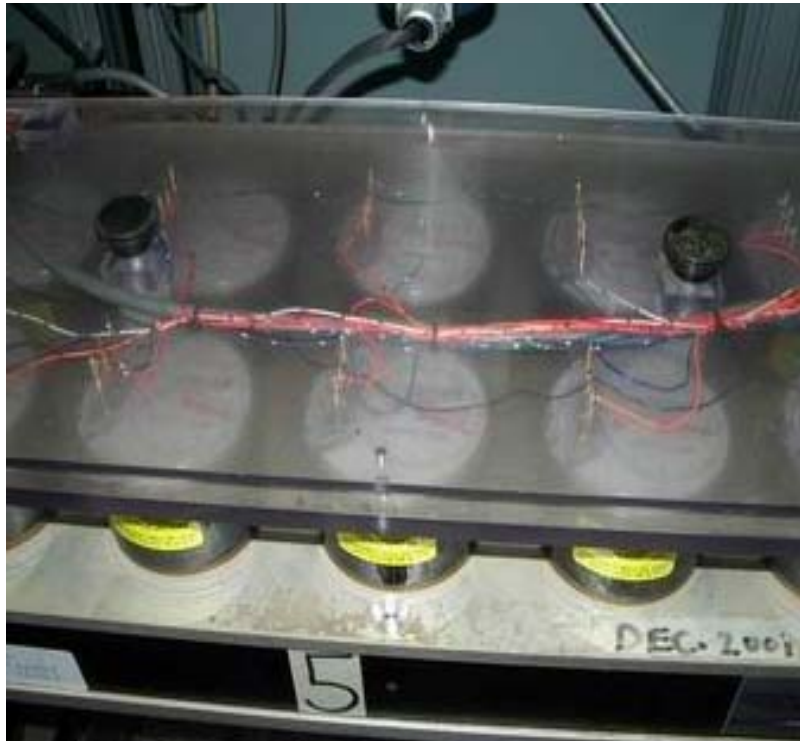
Badger Meter
USA

CONTINUOUS ENDURANCE TEST



Neptune TG
USA

CONTINUOUS ENDURANCE TEST



Neptune TG
USA

INFLUENCE QUANTITIES & DISTURBANCES TESTS

General Requirements:

- Section 7 defines the performance tests which are intended to verify that water meters perform and function as intended in a specified environment and under specified conditions.
- Tests only applies to electronic meters or meters incorporating electronic devices (one exception – see below).
- Static magnetic test also applies to meter with a magnetic drive

INFLUENCE QUANTITIES & DISTURBANCES TESTS

Tests:

- [Tests For Influence Quantities And Disturbances.doc](#)
- [Environmental classification.doc](#)

INFLUENCE QUANTITIES & DISTURBANCES TESTS

Dry Heat (non-condensing):

- [Dry heat.doc](#)

INFLUENCE QUANTITIES & DISTURBANCES TESTS

Dry Heat (non-condensing):

- [Dry heat.doc](#)

INFLUENCE QUANTITIES & DISTURBANCES TESTS



Environment Chamber – Dry Heat and Cold
Badger Meter
USA

INFLUENCE QUANTITIES & DISTURBANCES TESTS



Environment Chamber - Dry Heat and Cold
Badger Meter
USA

INFLUENCE QUANTITIES & DISTURBANCES TESTS

Cold:

- [cold.doc](#)

INFLUENCE QUANTITIES & DISTURBANCES TESTS

Damp Heat, Cyclic (condensing):

- [damp heat.doc](#)

INFLUENCE QUANTITIES & DISTURBANCES TESTS



Environment Chamber – Damp Heat
Badger Meter
USA

INFLUENCE QUANTITIES & DISTURBANCES TESTS



Environment Chamber – Damp Heat
Badger Meter
USA

INFLUENCE QUANTITIES & DISTURBANCES TESTS

Power Voltage Variation:

- [Power voltage variation.doc](#)

INFLUENCE QUANTITIES & DISTURBANCES TESTS



**Power Voltage Variation Device
Measurement Canada**

INFLUENCE QUANTITIES & DISTURBANCES TESTS

Short Time Power Reduction:

- [Short Time Power Reduction.doc](#)

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Bursts:

- [Bursts.doc](#)

INFLUENCE QUANTITIES & DISTURBANCES TESTS

EFT 500N5

ELECTRICAL FAST TRANSIENT GENERATOR



**Device used for Burst Test
and Short Time Power Reduction Test
NWML, UK**

INFLUENCE QUANTITIES & DISTURBANCES TESTS

Electrostatic Discharge:

- [Electrostatic discharge.doc](#)

INFLUENCE QUANTITIES & DISTURBANCES TESTS



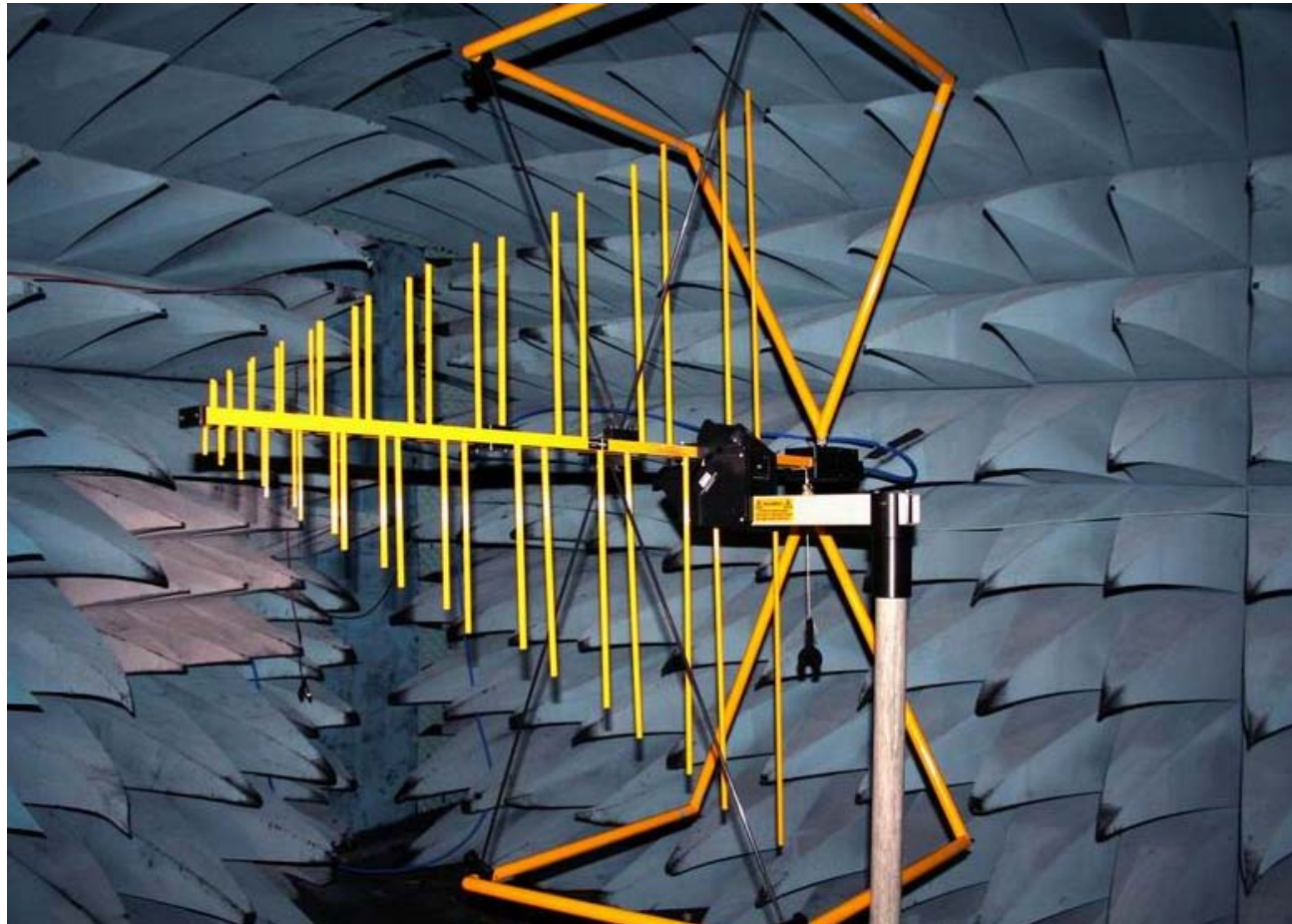
Static Gun
NWML, UK

INFLUENCE QUANTITIES & DISTURBANCES TESTS

Electromagnetic Susceptibility:

- [Electromagnetic susceptibility.doc](#)

INFLUENCE QUANTITIES & DISTURBANCES TESTS



**Anechoic Chamber
NWML, UK**

INFLUENCE QUANTITIES & DISTURBANCES TESTS



**Anechoic Chamber
NWML, UK**

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Static Magnetic Field Test:

- [static magnetic field.doc](#)

INFLUENCE QUANTITIES & DISTURBANCES TESTS



**Static Magnetic Field Test
South African Bureau of Standards**

INFLUENCE QUANTITIES & DISTURBANCES TESTS



**Static Magnetic Field Test
South African Bureau of Standards**

TEST PROGRAM FOR TYPE APPROVAL

Number of Samples Required:

- All water meters (see table below)
- Electronic meters - additional five meters submitted but only one is tested

Meter Designation m ³ /hr	Minimum Number of Water Meters to be Tested
$Q3 \leq 160$	3
$160 < Q3 \leq 1600$	2
$1600 < Q3$	1

TEST PROGRAM FOR TYPE APPROVAL

Family of Water Meters:

- When a family of water meters is submitted for type approval, the criteria in Annex D shall be applied by the approving authority in deciding if the meters conform to the definition of 'a family' and in selecting which meter sizes are to be tested.

[ANNEX D.doc](#)



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OIML R 49-2

Water meters intended for the metering of cold potable
water and hot water meters

TEST METHODS



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Questions or Comments