# TEST PROCEDURES FOR
# PATTERN APPROVAL
## AND THE VERIFICATION OF WATER METER

Presented by

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MEDEA Training on Pattern Approval and Verification of Water Meters – OIML R49

Physikalisch-Technische Bundesanstalt Braunschweig und Berlin

NATIONAL METROLOGY INSTITUTE OF MALAYSIA

SIRIM

# Presentation Outline

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## OVERVIEW: TYPE EVALUATION TESTS

# FOR WATER METERS

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# WATER METER CALIBRATION FACILITY

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# PERFORMANCE TESTS FOR ALL TYPE WATER METER

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| No. | Test | Sub-clause | No. of Meters |
|---|---|---|---|
| 1 | Static pressure | 7.3 | All |
| 2 | Error (of indication) | 7.4 | All |
| 3 | Absence of flow | 8.17 | ≥ 1 |
| 4 | Water temperature | 7.5 | ≥ 1 |
| 5 | Overload water temperature | 7.6 | ≥ 1 |
| 6 | Water pressure | 7.7 | ≥ 1 |
| 7 | Reverse flow | 7.8 | ≥ 1 |
| 8 | Pressure loss | 7.9 | ≥ 1 |
| 9 | Flow disturbance | 7.10 | ≥ 1 |
| 10 | Discontinuous flow durability test at $Q_3$ (≤ 16 m$^3$/h) / $Q \geq 2Q_{x2}$ | 7.11.2 | ≥ 1 ieao |
| 11 | Continuous flow durability test at $Q_3$ ($Q_3$ > 16 m$^3$/h) | 7.11.3 | ≥ 1 ieao |
| 12 | Continuous flow durability test at $Q_4$ | 7.11.3 | ≥ 1 ieao |
| 13 | Continuous flow durability test at 0.9 $Q_{x1}$ | 7.11.3 | ≥ 1 ieao |
| 14 | Magnetic field testing | 8.16 | ≥ 1 |

ieao: in each applicable orientation

# LAB BASIC SAFETY GUIDELINES

- ✓ Perform only those testing authorized by the instructor. Never do anything in the testing laboratory. Carefully follow ALL instructions, written and oral. Unauthorized testing are prohibited.
- ✓ Shoes must completely cover the foot. Sandals are NOT allowed.
- ✓ If any Test Bench equipment is malfunctioning, making strange noises from the pumps, sparking, smoking, smells "funny," from the control panel, get an instructor or staff immediately. It is imperative that the instructor or staff knows of any equipment problems.
- ✓ All accidents, no matter how minor, should be reported to the staff member supervising the laboratory immediately.

- × Please don't yell, scream, or make any sudden loud noises that could startle others who are concentrating on their work.
- × Do not use any equipment unless you are trained and approved as a user by your instructor or staff. Ask questions if you are unsure of how to operate something.
- × Don't eat, drink, or smoke.

# NUMBER OF SAMPLES

- ✓ Minimum number of meters to be tested for all meter types:

| Meter Designation, $Q_3$ [m³/h] | Minimum Number of Meters |
|---|---|
| $Q_3 \leq 160$ | 3 |
| $160 < Q_3 \leq 1\,600$ | 2 |
| $1\,600 < Q_3$ | 1 |

- ✓ excluding the tests required for meters with electronic devices (**5** samples)

***Table 6 OIML R49-1:2013 7.2.2***

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## CALIBRATION STANDARDS &

# INSTRUMENTS

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# INSTRUMENTS

- ✓ test rig
- ✓ water supply (tank, pump)
- ✓ pipework
- ✓ calibrated reference (tank, balance, meter)
- ✓ pressure sensor
- ✓ temperature sensor
- ✓ stopwatch

# INSTRUMENTS – Platform Balance


# INSTRUMENTS – Pump


# INSTRUMENTS – Temperature Sensor

# INSTRUMENTS –Pressure Sensor

# TRACEABILITY CHART

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## SI Units

kg | K | s | Pa

**National Standard of Mass**
Heavy Mass Laboratory, NMIM

**National Standard of Temperature**
Radiation Thermometry Laboratory, NMIM

**National Standard of Time**
Time & Frequency Laboratory, NMIM

**National Standard of Pressure**
Low Pressure Laboratory, NMIM

PLATFORM BALANCE

TEMPERATURE SENSOR

STOPWATCH

PRESSURE SENSOR

## WATER FLOW CALIBRATION SYSTEM

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CALIBRATION

# PROCEDURES

## DETERMINATION OF INTRINSIC ERRORS TEST

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# DETERMINATION OF INTRINSIC ERRORS (OF INDICATION) TEST

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OBJECTIVE

- ✓ To determine the intrinsic errors (of indication) of a water meter and the effects of the meter orientation on the error (of indication).

- ✓ The method specified here for determining the meter errors (of indication) is the so – called "**COLLECTION**" method, in which the quantity of water passed through a water meter is collected in one or more collecting vessels and the quantity determined volumetrically or by weighing.

***OIML49-2:2013 7.4.1***

***OIML R49-2:2013 7.4.2.1***

# ERRORS OF TEST COMMENCEMENT

Standing-Start-and-Finish

- ✓ Tests with readings taken with the meter at rest
- ✓ Flow is established by opening a valve, situated downstream of the meter, and it is stopped by closure of this valve. The meter is read when the registration is stationary

Flying-Start-and-Finish

- ✓ Tests with readings taken under stable flow conditions and diversion of flow
- ✓ The measurement is carried out when flow conditions have stabilized.
- ✓ The meter is read while in motion.

***OIML R49-2:2013 7.4.2.2.5***

# PREPARATION – PRECAUTIONS

- ✓ Check that the operation of the test rig is such that, during a test, the actual volume of water that flows through the meter(s) is equal to that measured by the reference device.
- ✓ Check that the pipe (e.g. the swan-neck in the outlet pipe) is filled to the same datum level at the beginning and at the end of the test.
- ✓ Bleed all air from the interconnecting pipework and the meter(s).
- ✓ Take all precautions necessary to avoid the effects of vibration and shock.

***OIML R49-2:2013 7.4.2.2.3***

# RATED OPERATING CONDITIONS

| | |
|---|---|
| Flow Rate Range | $Q_1$ to $Q_3$ inclusive |
| Ambient Temperature Range | + 5 °C to + 55 °C |
| Water Temperature Range | Table 1 |
| Ambient Relative Humidity | 0 % to 100 %<br>0 % to 93 % (remote) |
| Pressure Range<br>(DN < 500 mm) | 0.03 MPa to at least 1 MPa |
| Pressure Range<br>(DN ≥ 500 mm) | 0.03 MPa to at least 0.6 MPa |

***OIML R49-1:2013 6.4***

# MAJOR FACTORS AFFECTING THE MEASUREMENT OF ERRORS

- ✓ Supply pressure
- ✓ Flow rate
- ✓ Temperature
- ✓ Orientation of water meter(s)
  - ✓ H: Horizontal
  - ✓ V: Vertical
  - ✓ Unmarked:

    V / H / 45º

# TEST PROCEDURE

a) Determine the intrinsic errors (of indication) of a water meter (in the measurement of the actual volume), for at least the following flow rates, the error at each flow rate being measured 3 times for 1), 2) and 5) and twice for other ranges:

1) $Q_1$ to 1.1 $Q_1$;
2) $Q_2$ to 1.1 $Q_2$;
3) 0.33 × ($Q_2$ + $Q_3$) to 0.37 × ($Q_2$ + $Q_3$);
4) 0.67 × ($Q_2$ + $Q_3$) to 0.74 × ($Q_2$ + $Q_3$);
5) 0.9 $Q_3$ to $Q_3$;
6) 0.95 $Q_4$ to $Q_4$;

and for combination meters:

7) 0.85 $Q_{x1}$ to 0.95 $Q_{x1}$;
8) 1.05 $Q_{x2}$ to 1.15 $Q_{x2}$

***OIML R49-2:2013 7.4.4***

# TEST PROCEDURE

b) Test the water meter without its supplementary devices attached (if any).

c) During a test, hold all other influence factors at reference conditions.

d) Measure the errors (of indication) at other flow rates if the shape of the error curve indicates that the MPE may be exceeded.

e) Calculate the relative error (of indication) for each flow rate in accordance with Annex B.

f) Complete the test report

***OIML R49-2:2013 7.4.4***

# MARKS AND INSCRIPTIONS FOR A METER WITHOUT ELECTRONIC DEVICE



BRAND : Delta MTR
Q3 = 4 $m^3$/ hr
Ratio = R160
DN20

BRAND : DP MTR
Q3 = 2.5 $m^3$/ hr
Ratio = R400
DN15

***OIML R49-1:2013 6.6***

# MARKS AND INSCRIPTIONS FOR A METER WITHOUT ELECTRONIC DEVICE


BRAND : GLMJ2
Q3 = 2.5 $m^3$/ hr
Ratio = R80
DN15


BRAND : DP MTR
Q3 = 4 $m^3$/ hr
Ratio = R200
DN20

***OIML R49-1:2013 6.6***

# MARKS AND INSCRIPTIONS FOR A METER WITHOUT ELECTRONIC DEVICE


BRAND : DIEHL Metering
Q3 = 4 $m^3$/ hr
Ratio = R160
DN20

***OIML R49-1:2013 6.6***

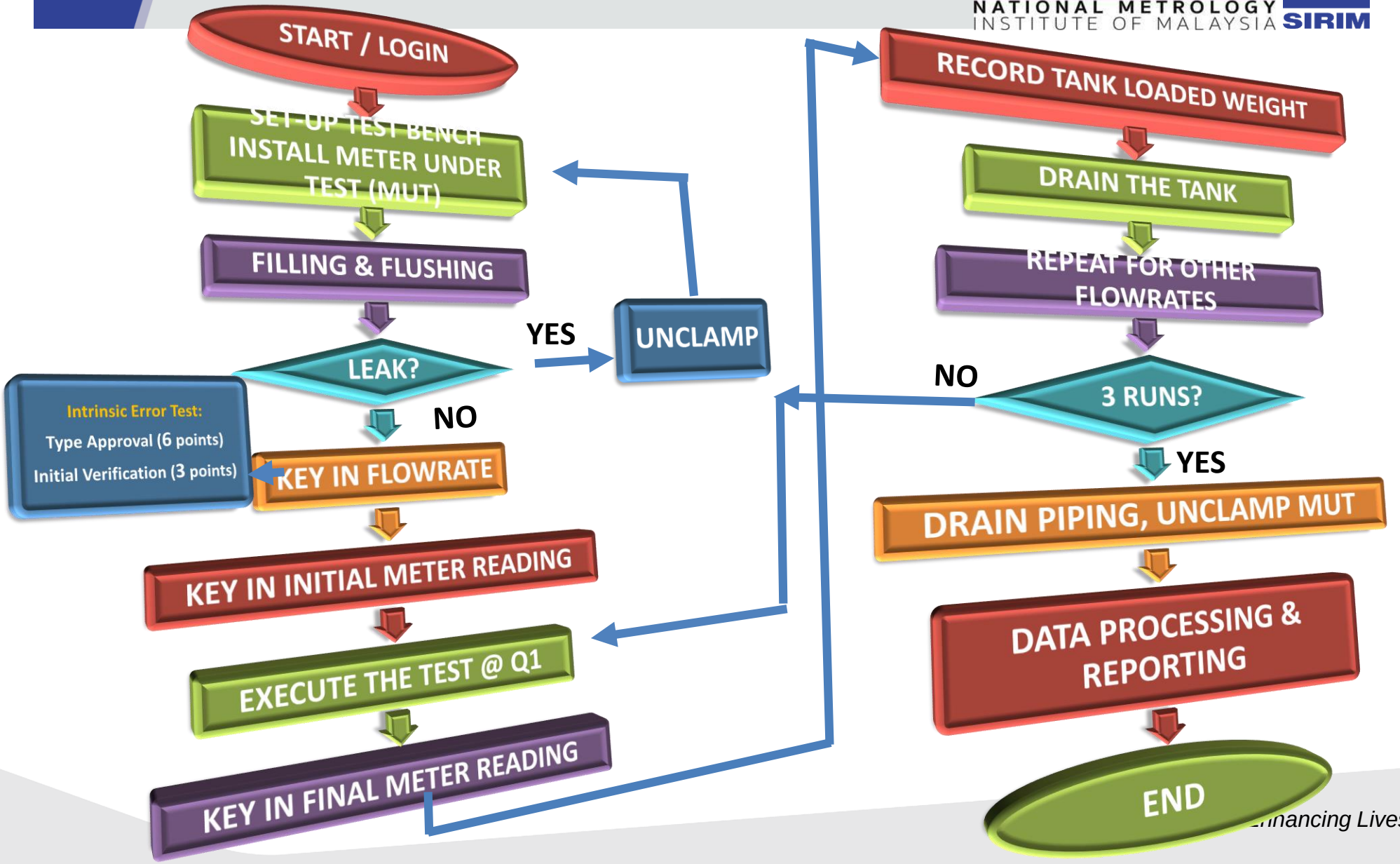
# Calculate Value of Flowrate $Q_1$, $Q_2$, $Q_3$ and $Q_4$

**Constant Value :**

The ratio $Q_2 / Q_1$ shall be 1.6
The ratio $Q_4 / Q_3$ shall be 1.25

***OIML R49-1:2013 4.1***

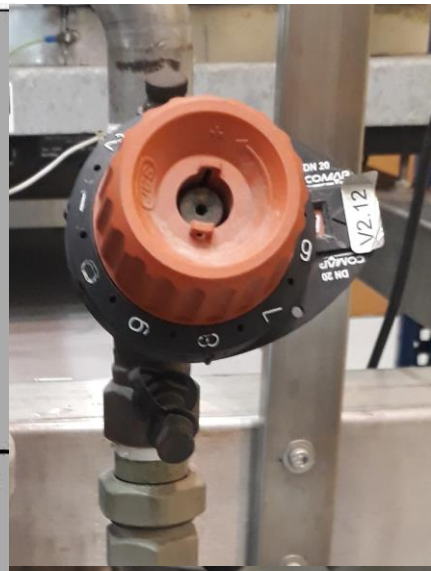
# ACCURACY TEST FLOW CHART



# TEST PROCEDURE

- ✓ Calculate the flow rate $Q_1$, $Q_2$ and $Q_4$ from $Q_3$
- ✓ Key in the flow rate
- ✓ Key in initial meter reading $V_i$ (i)
- ✓ Execute the test at flow rate $Q_1$
- ✓ Key in final meter reading $V_i$ (f)

$$V_i = V_i(\mathrm{f}) - V_i(\mathrm{i})$$

# TEST PROCEDURE

- ✓ Record the final mass of water in the collection tank ($V_a$)
- ✓ Drain the collection tank
- ✓ Repeat the test for flow rate $Q_2$, $Q_3$ and $Q_4$
- ✓ Repeat for three (3) consecutive runs
- ✓ Drain piping and unclamp meters
- ✓ Calculate the error using the data
- ✓ Generate report

$$V_a = \frac{Mass}{\rho_{dw}(t)}$$

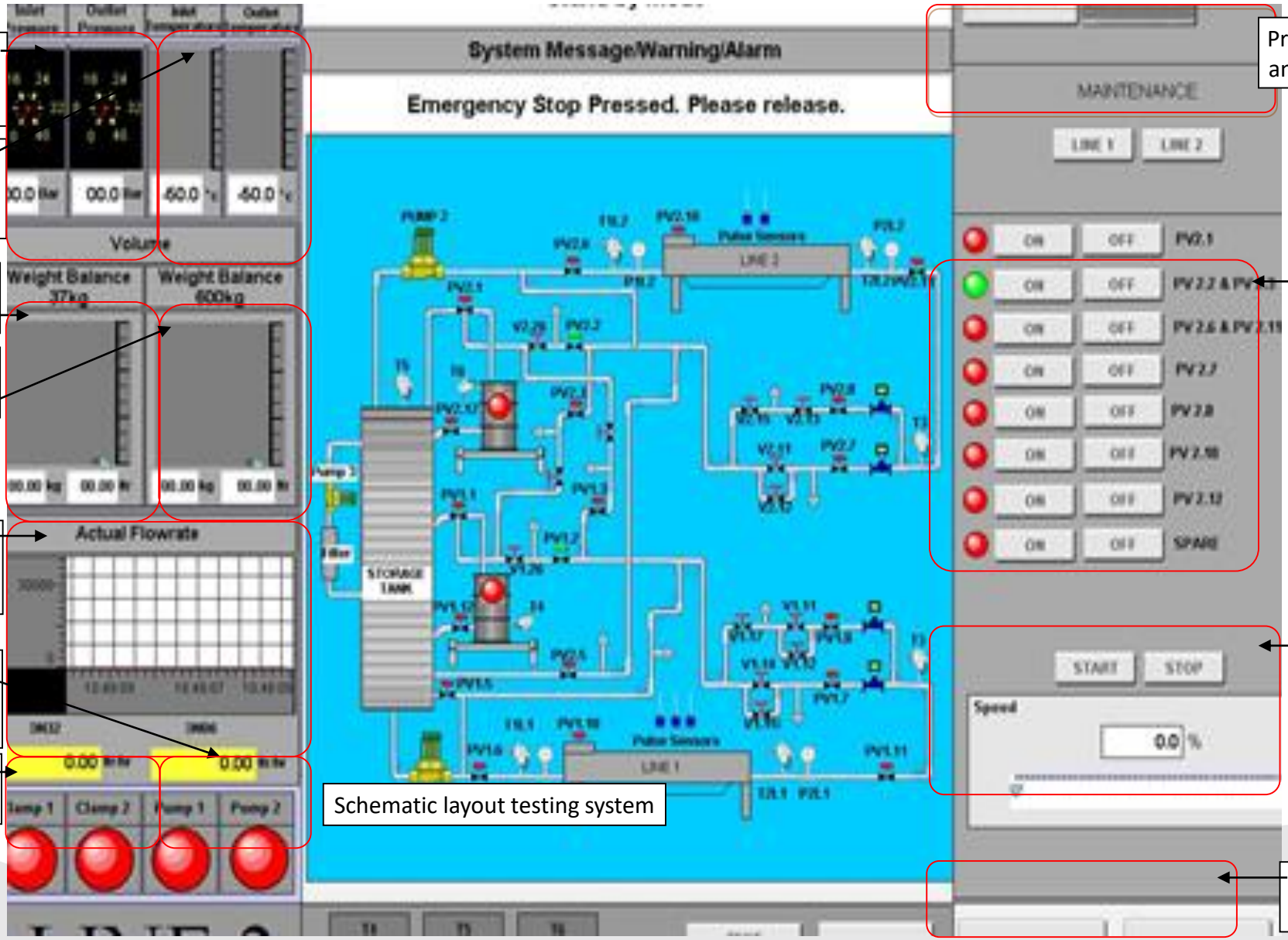
# CALCULATION

$$\rho_{dw}(t) = a_0 \frac{(1 + a_1\theta + a_2\theta^2 + a_3\theta^3)}{(1 + a_4\theta + a_5\theta^2)}$$

$$E_m = \frac{V_i - V_a}{V_a} \text{ x } 100\ \%$$

$V_i$ – Volume determined by the meter [litre]
$V_a$ – Actual volume
$\rho_{dw}(t)$ – Density of water at temperature $\boldsymbol{t}$, in $\mathrm{kg/m^3}$
$Mass$ – Mass of water in $\mathrm{kg}$

# ACCURACY TEST CONTROLLER




Line 1: Inlet/Outlet Pressure

Line 2: Inlet/Outlet Temperature

Weight bal. 37 kg

Weight bal. 600 kg

Mag. Meter Flowrate Indicator

Pump Selection Indicator

Clamping Indicator

Schematic layout testing system

Preparation menu and programming

Water Meter Data and Test Detail

Filling and Flushing

Clamping: Line 1/Line 2

# ACCURACY TEST CONTROLLER

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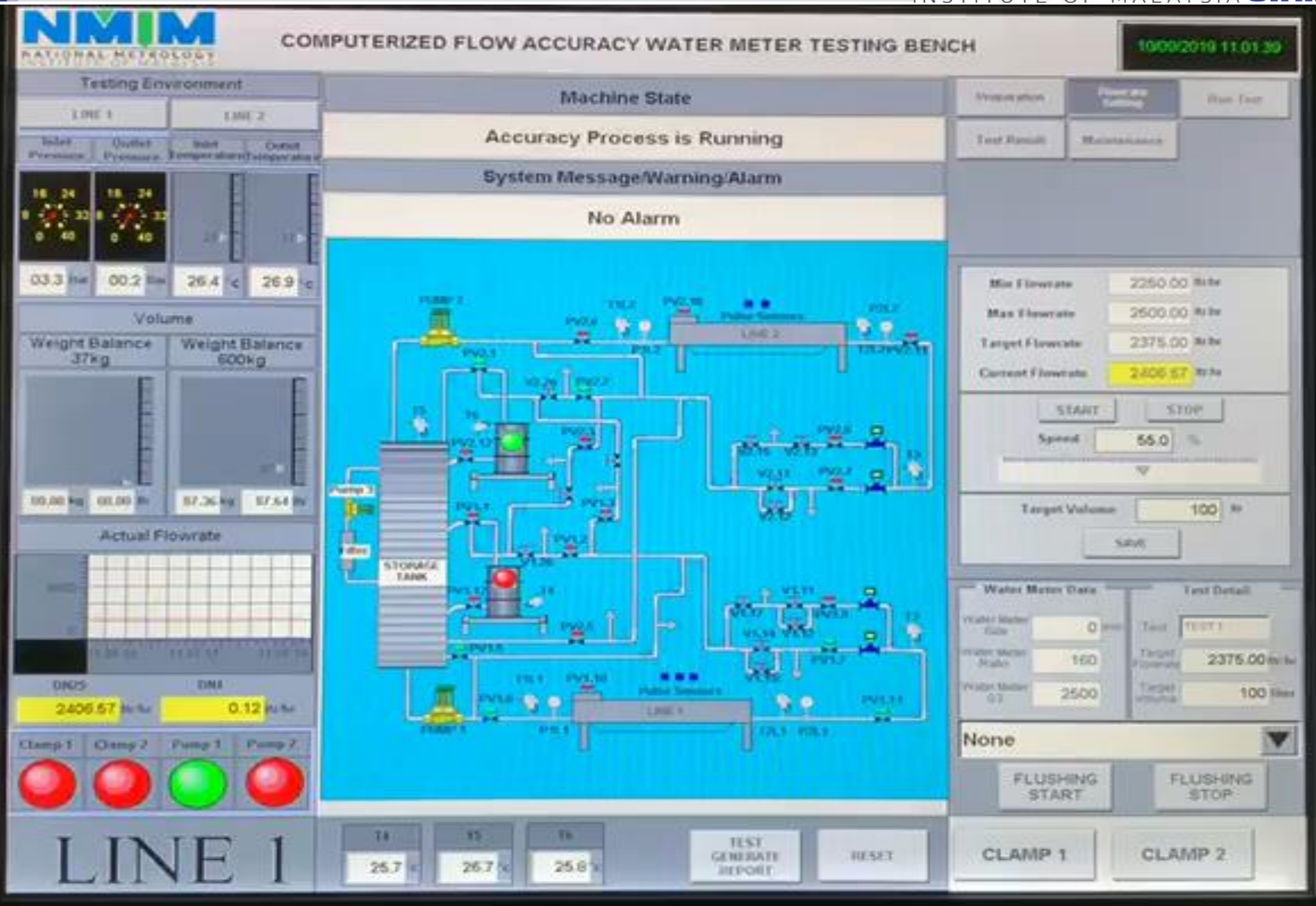

## ACCEPTANCE CRITERIA

- ✓ The relative errors (of indication) observed for each of the flow rates shall not exceed the Maximum Permissible Error (MPE). If the error observed on one or more meters is greater than the MPE at one flow rate only, then if only two results have been taken at that flow rate, the test at that flow rate shall be repeated; the test shall be declared satisfactory if two out of the three results at that flow rate lie within the MPE and the arithmetic mean of the results for the three tests at that flow rate lies within the MPE.

# ACCEPTANCE CRITERIA

- ✓ If all the relative errors (of indication) of a water meter have the same sign, at least one of the errors shall not exceed one-half of the MPE. In all cases, this requirement shall be applied equitably with respect to the water supplier and the consumer.

- ✓ The standard deviation for 7.4.4 a) 1), 2) and 5) shall not exceed one-third of the MPE.

# MPE CLASS 2 WATER METER

| FLOWRATE ZONE | TEMPERATURE RANGE | |
|---|---|---|
| Upper | 0.1 °C to 30 °C | > 30 °C |
| $Q_2 \leq Q \leq Q_4$ | ±2 % | ±3 % |
| Lower | All Range | |
| $Q_1 \leq Q < Q_2$ | ±5 % | |

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## CALIBRATION

# PROCEDURES

## DURABILITY TEST

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# DURABILITY TEST

- ✓ During durability tests, the rated operating conditions of the meter shall be met. Where a combination meter consists of individual meters that have been previously approved, only the discontinuous combination meters (additional test) (Table 1) is required. The test is required for forward flow and where appropriate for reverse flow.
- ✓ The orientation(s) of the meters under test shall be set with reference to the meter orientation(s) claimed by the manufacturer.
- ✓ The same meters shall be submitted to the discontinuous and continuous tests.

***OIML R49-2:2013 7.11***

# DURABILITY TEST

Table 1 Durability tests

| Temperature class | Permanent flow rate $Q_3$ $m^3/h$ | Test flow-rate | Test water tempera-ture $t_{test}$ °C ± 5 °C | Type of test | Number of interrupts | Time of pauses | Time of test at test flow rate | Duration of start-up and rundown |
|---|---|---|---|---|---|---|---|---|
| T30 and T50 | ≤ 16 | $Q_3$ | 20 | Dis-continuous | 100 000 | 15 s | 15 s | 0.15 $[Q_3]^a$ s with a minimum of 1 s |
| | | $Q_4$ | 20 | Continuous | — | — | 100 h | — |
| | > 16 | $Q_3$ | 20 | Continuous | — | — | 800 h | — |
| | | $Q_4$ | 20 | Continuous | — | — | 200 h | — |

***OIML R49-2:2013 7.11***

# DURABILITY TEST


***OIML R49-2:2013 7.11.3***

# DISCONTINUOUS FLOW TEST

OBJECTIVE

- ✓ To verify that a water meter is durable when subjected to cyclic flow conditions.
- ✓ This test is applied only to meters with $Q_3 \leq 16$ m$^3$/h and combination meters.
- ✓ The test consists of subjecting the meter to the specified number of starting and stopping flow rate cycles of short duration, the constant test flow rate phase of each cycle being kept at the prescribed flow rate throughout the duration of the test (see 7.11.2.3.2). For the convenience of laboratories, the test can be divided up into periods of at least 6 h.

***OIML R49-2:2013 7.11.2***

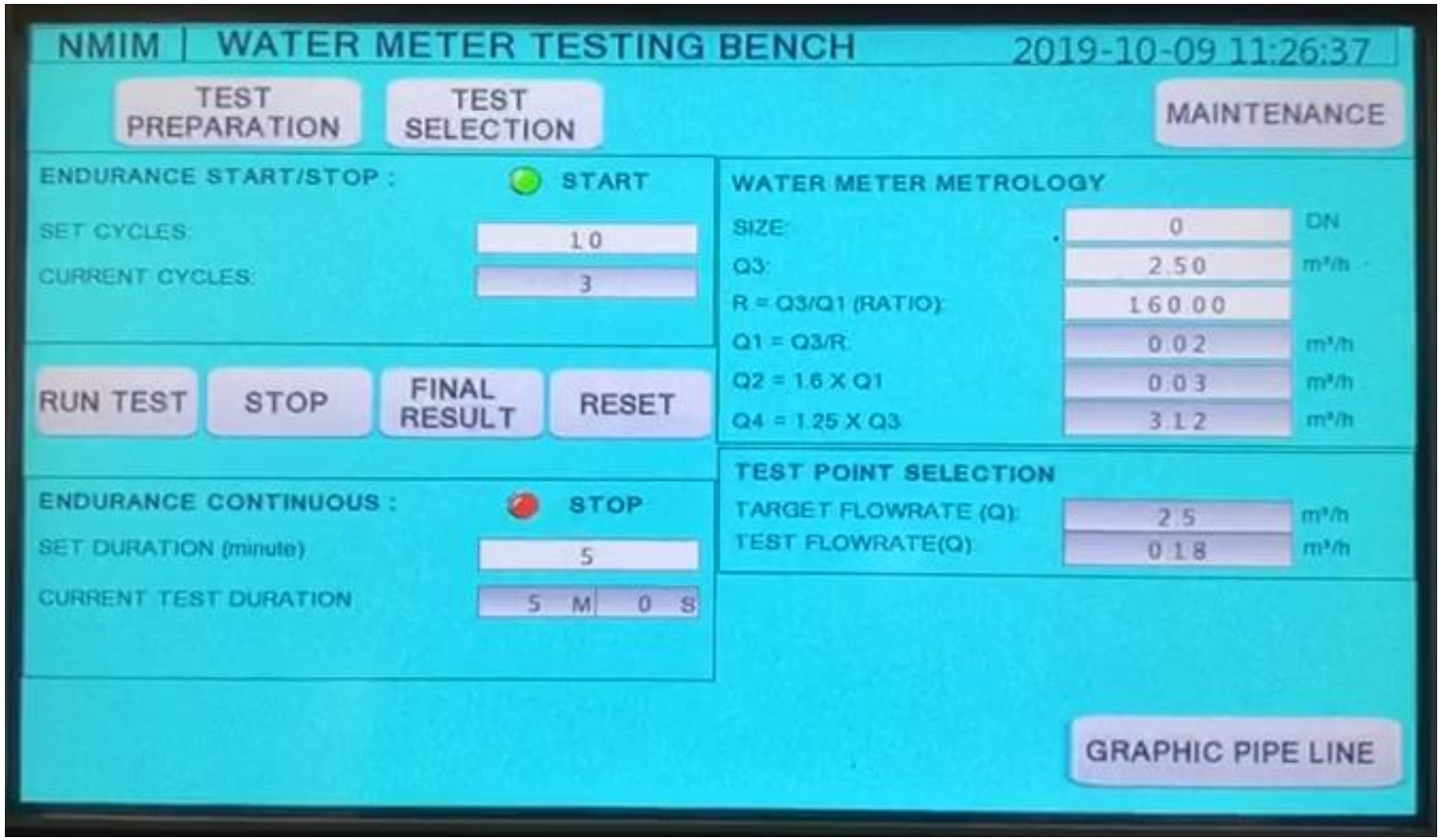
# TEST PROCEDURE - DISCONTINUOUS FLOW

- ✓ Set-up the test bench and install the meter under test (MUT).
- ✓ Establish a stable flow (FILL**)** through the pipeline and MUT until full and gradually increase the pump flow rate to FLUSH out any air bubble.

# TEST BENCH FOR DURABILITY

***OIML R49-2:2013 7.11***

# TEST PROCEDURE - DISCONTINUOUS FLOW




***OIML R49-2:2013 7.11.2***

# TEST PROCEDURE - DISCONTINUOUS FLOW

1. Measure the errors (of indication) of the meter(s) as specified in 7.4 and at the same flow rates as in 7.4.4.
2. Mount the meters either singly or in groups in the test rig in the same orientations as those used in determination of the intrinsic errors (of indication).
3. During the tests, maintain the meters within their rated operating conditions and with the pressure downstream of the meters high enough to prevent cavitation in the meters.
4. Adjust the flow rate to within the specified tolerances.

***OIML R49-2:2013 7.11.2.3***

# TEST PROCEDURE - DISCONTINUOUS FLOW

5. Run the meter(s) at the conditions shown in Table 1 (OIML R49-2).
6. Following the discontinuous durability test, measure the final errors (of indication) of the meters as specified in 7.4 and at the same flow rates as in 7.4.4.
7. Calculate the final relative error (of indication) for each flow rate in accordance with Annex B.
8. For each flow rate, subtract the value of the intrinsic error (of indication) obtained at step 1 from the error (of indication) obtained at step 7.
9. Complete the test report.

***OIML R49-2:2013 7.11.2.3***

# MPE CLASS 2 WATER METER AFTER DISCONTINUOUS TEST

| FLOWRATE ZONE | TEMPERATURE RANGE | |
|---|---|---|
| Upper | 0.1 °C to 30 °C | > 30 °C |
| $Q_2 \leq Q \leq Q_4$ | ±2.5 % | ±3.5 % |
| Lower | All Range | |
| $Q_1 \leq Q < Q_2$ | ±6 % | |

# VARIATION AFTER DISCONTINUOUS TEST

ACCEPTANCE CRITERIA

- ✓ Variation within MPE before and MPE after discontinuous test.
- ✓ The variation in the error curve shall not exceed:

| FLOWRATE ZONE | ERROR CURVE VARIATION |
|---|---|
| Upper | 1.5 % |
| $Q_2 \leq Q \leq Q_4$ | |
| Lower | 3 % |
| $Q_1 \leq Q < Q_2$ | |

- ✓ For the purpose of determining these requirements, the mean values of the errors (of indication) at each flow rate shall apply.

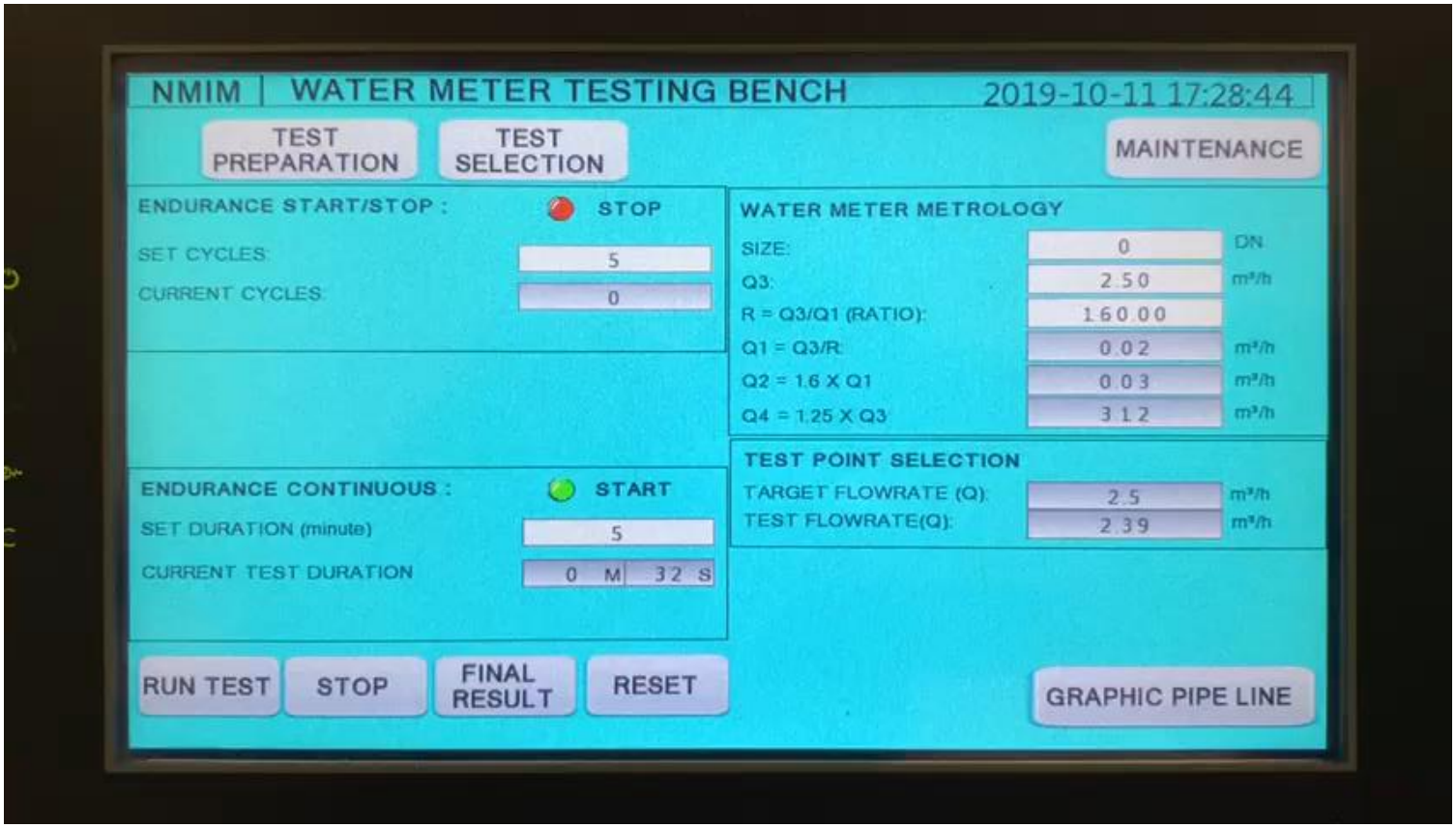
***OIML R49-2:2013 7.11.2.4.2***

OBJECTIVE

- ✓ To verify the durability of a water meter when subjected to continuous, permanent, and overload flow conditions.
- ✓ The test consists of subjecting the meter to constant flow rate of $Q_3$ or $Q_4$ for a specified duration. In addition, where the small meter of a combination meter has not been pre-approved, the combination meter shall be subjected to a continuous flow test as shown in Table 1. For the convenience of laboratories, the test can be divided up into periods of at least 6 h.

***OIML R49-2:2013 7.11.3***

# TEST PROCEDURE - CONTINUOUS FLOW




***OIML R49-2:2013 7.11.3***

# TEST PROCEDURE - CONTINUOUS FLOW

1. Measure the errors (of indication) of the meter(s) as specified in 7.4 and at the same flow rates as in 7.4.4.
2. Mount the meters either singly or in groups in the test rig in the same orientations as those used in determination of the intrinsic errors (of indication).
3. Run the meter(s) at the conditions shown in Table 1 (OIML R49-2).
4. Throughout the durability tests, the meter(s) shall be held within their rated operating conditions and the pressure at the outlet of each meter shall be high enough to prevent cavitation.

***OIML R49-2:2013 7.11.3.3***

# TEST PROCEDURE - CONTINUOUS FLOW

5. After the continuous durability test(s), measure the errors (of indication) of the meter(s) as specified in 7.4 and at the same flow rates
6. Calculate the relative error (of indication) for each flow rate in accordance with Annex B.
7. For each flow rate, subtract the value of the intrinsic error (of indication) obtained at step 1 of 7.11.2.3.1 from the error (of indication) obtained at step 7.
8. Complete the test report.

***OIML R49-2:2013 7.11.3.3***

# MPE CLASS 2 WATER METER AFTER CONTINUOUS TEST

| FLOWRATE ZONE | TEMPERATURE RANGE | |
|---|---|---|
| Upper | 0.1 °C to 30 °C | > 30 °C |
| $Q_2 \leq Q \leq Q_4$ | ±2.5 % | ±3.5 % |
| Lower | All Range | |
| $Q_1 \leq Q < Q_2$ | ±6 % | |

# VARIATION AFTER CONTINUOUS TEST

ACCEPTANCE CRITERIA

- ✓ Variation within MPE before continuous and MPE after continuous test.
- ✓ The variation in the error curve shall not exceed:

| FLOWRATE ZONE | ERROR CURVE VARIATION |
|---|---|
| Upper | 1.5 % |
| $Q_2 \leq Q \leq Q_4$ | |
| Lower | 3 % |
| $Q_1 \leq Q < Q_2$ | |

- ✓ For the purpose of determining these requirements, the mean values of the errors (of indication) at each flow rate shall apply.

***OIML R49-2:2013 7.11.3.4.2***