INTERNATIONAL
RECOMMENDATION

# OIML R 75-2

Edition 2002 (E)

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## Heat meters
## Part 2: Type approval tests and initial verification tests

Compteurs d'énergie thermique
Partie 2: Essais d'approbation de type et essais de vérification primitive

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OIML R 75-2 Edition 2002 (E)

ORGANISATION INTERNATIONALE
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INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

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# Foreword

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States.

The two main categories of OIML publications are:

- **International Recommendations (OIML R)**, which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity; the OIML Member States shall implement these Recommendations to the greatest possible extent;

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Cooperative agreements are established between OIML and certain institutions, such as ISO and IEC, with the objective of avoiding contradictory requirements; consequently, manufacturers and users of measuring instruments, test laboratories, etc. may apply simultaneously OIML publications and those of other institutions.

International Recommendations and International Documents are published in French (F) and English (E) and are subject to periodic revision.

This publication - reference OIML R 75-2 Edition 2002 - was developed by the OIML Technical Committee TC 11 *Instruments for measuring temperature and associated quantities* on the basis of Parts 4 and 5 of the European Standard EN 1434 (1997), the relevant paragraphs of which have been reproduced with the agreement of the European Committee for Standardization (CEN). This publication was approved for final publication by the International Committee of Legal Metrology in 2001 and will be submitted to the International Conference of Legal Metrology in 2004 for final sanction.

OIML Recommendation R 75 includes three parts: Part 1 (*General requirements*) and Part 2 (*Type approval tests and initial verification tests*) which have been issued in 2002 as separate publications, and Part 3 (*Test report format*) which is expected to be approved and issued at a later stage. It supercedes the former edition dated 1988.

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# Heat meters

# Part 2: Type approval tests and initial verification tests

## 1 Scope

Heat meters which comply with the general requirements of R 75-1 and which are submitted for type approval and/or initial verification shall comply with the specified tests in this Recommendation. Initial verification is intended to ensure that instruments which are put into service shall have specified metrological characteristics within the limits of the maximum permissible errors, and shall function properly.

*Note:* For terms and their definitions, refer to R 75-1.

## 2 References

**OIML R 49-2 (2002)**
*Water meters intended for the metering of cold potable water. Part 2: Test methods.*

**IEC 60068-2-2 (1974-01)**
Amendments IEC 60068-2-2-am1(1993-02) and IEC 60068-2-2-am2(1994-05). *Environmental testing. Part 2: Tests. Test B: Dry heat.* International Electrotechnical Commission, Geneva.

**IEC 60068-2-1 (1990-05)**
Amendments IEC 60068-2-1-am1(1993-02) and IEC 60068-2-1-am2(1994-06). *Environmental testing. Part 2: Tests. Test A: Cold.* International Electrotechnical Commission, Geneva.

**IEC 60751 (1995-07)**
Amendments IEC 60751-am1(1986-01) and IEC 60751-am2(1995-07). *Industrial platinum resistance thermometer sensors.* International Electrotechnical Commission, Geneva.

**IEC 60068-2-30 (1980-01)**
Amendment IEC 60068-2-30-am1(1985-08). *Environmental testing. Part 2: Tests. Test Db and guidance: Damp heat, cyclic (12+12-hour cycle).* International Electrotechnical Commission, Geneva.

**IEC 61000-4-11 (1994-06)**
Amendment IEC 61000-4-11-am1(2000-11). *Electromagnetic compatibility (EMC). Part 4: Testing and measurement techniques. Section 11: Voltage dips, short interruptions and voltage variation immunity tests.* International Electrotechnical Commission, Geneva.

**IEC 61000-4-4 (1995-01)**
Amendments IEC 61000-4-4-am1(2000-11) and IEC 61000-4-4-am2(2001-07). *Electromagnetic compatibility (EMC). Part 4: Testing and measurement techniques. Section 4: Electrical fast transient/burst immunity tests. Basic EMC publication.* International Electrotechnical Commission, Geneva.

**IEC 61000-4-5 (2001-04)**
**Ed. 1.1 Consolidated Edition**
Amendment IEC 61000-4-5-am1(2001-11). *Electromagnetic compatibility (EMC). Part 4: Testing and measurement techniques. Section 5: Surge immunity test.* International Electrotechnical Commission, Geneva.

**IEC 61000-4-3 (1995-02)**
Amendments IEC 61000-4-3-am1(1998-06) and IEC 61000-4-3-am2(2000-11). *Electromagnetic compatibility (EMC). Part 4: Testing and measurement techniques. Section 3: Radiated, radio-frequency, electromagnetic field immunity test.* International Electrotechnical Commission, Geneva.

**IEC 60870-5-1 (1990-02)**
*Telecontrol equipment and systems. Part 5: Transmission protocols. Section 1: Transmission frame formats.* International Electrotechnical Commission, Geneva.

**IEC 61107 (1996-03)**
*Data exchange for meter reading, tariff and local control - Direct local data exchange.* International Electrotechnical Commission, Geneva.

**IEC 61000-4-2 (2001-04)**
**Ed. 1.2 Consolidated Edition**
Amendment IEC 61000-4-2-am1(2000-11).
*Electromagnetic compatibility (EMC). Part 4: Testing and measurement techniques. Section 2: Electrostatic discharge immunity test*. International Electrotechnical Commission, Geneva.

**IEC/TR 61000-2-7 (1998-01)**
*Electromagnetic compatibility (EMC). Part 2: Environment. Section 7: Low frequency magnetic fields in various environments*. International Electrotechnical Commission, Geneva.

## 3 General

The type approval procedure shall ascertain that the instrument type conforms to the metrological requirements of R 75-1. In addition to the checking of the documentation (clause 8) and the comparison of the type with the metrological requirements of R 75-1, the tests in clause 6 shall be performed. When testing the heat meter as a combined instrument, the flow sensor, the temperature sensor pair, the calculator or a combination of these shall each be tested separately.

Initial verification of a measuring instrument consists of a series of tests and visual examinations carried out to determine whether an instrument manufactured to replicate a given type conforms to that type and to regulations, and that its metrological characteristics lie within the limits of the maximum permissible errors. If the instrument passes all tests and examinations, it is given legal character by its acceptance as evidenced by stamping and/or issue of a certificate of verification. Initial verification is divided into metrological, technical and administrative phases. When verifying the heat meter as a combined instrument, the flow sensor, the temperature sensor pair, the calculator or a combination of these shall each be verified separately.

Unless otherwise stated in the type approval certificate, the verification shall be carried out in accordance with this Recommendation, the provisions of which also apply to the subsequent verification of heat meters.

## 4 Requirements

Under rated operating conditions, the errors of heat meters or their sub-assemblies shall not exceed the maximum permissible error, MPE, specified in R 75-1. When heat meters or their sub-assemblies are exposed to disturbances, significant faults shall not occur.

## 5 Specification of operating conditions

### 5.1 Rated operating conditions

The rated operating conditions are those given in Table 1.

### 5.2 Reference conditions

- Range of ambient temperature: + 15 °C to + 35 °C
- Range of relative humidity: 25 % to 75 %
- Range of ambient air pressure: 86 kPa to 106 kPa

The actual temperature and relative humidity within the specified range shall not vary by more than ± 2.5 °C and ± 5 percentage points respectively during the period of one measurement.

The reference conditions for a sub-assembly shall be the conditions under which it would operate if it was a part of a combined heat meter.

Table 1 Rated operating conditions

| | | Environmental class | | |
|---|---|---|---|---|
| | | A | B | C |
| Ambient temperature | °C | + 5 to + 55 | – 25 to + 55 | + 5 to + 55 |
| Relative humidity | % | < 93 | | |
| Mains supply voltage | V | $V_{nom}{}^{+10}_{-15}$ % | | |
| Mains frequency | Hz | $f_{nom}$ ± 2 % | | |
| External low voltage (< 50 V) | AC V | $V_{nom}{}^{+50}_{-50}$ % | | |
| | DC V | $V_{nom}{}^{+75}_{-50}$ % | | |
| Battery voltage | | The voltage of a battery in service under normal conditions | | |

### 5.3 Reference values for the measurand, RVM

*5.3.1 Reference values for the measurand, RVM, for $q_p \leq 3.5$ m³/h*

- Range of temperature difference:
  (40 ± 2) K, or $\Delta\Theta_{max}$ $^{0}_{-2}$ K
  if $\Delta\Theta_{max}$ is less than 40 K
- Range of flow rate:
  (0.7 to 0.75) $q_p$ in m³/h
- Return temperature:
  (50 ± 5) °C or the upper limit of the return temperature, if the limit is less than 50 °C.

The conditions mentioned above are reference values for a complete heat meter. Reference values for sub-assemblies are the relevant parts of the above mentioned condition

*5.3.2 Reference values for the measurand, RVM, for $q_p > 3.5$ m³/h*

Flow rate simulation of the flow sensor electronics is allowed, but testing with water is always preferred and is carried out in accordance with 5.3.1.

If flow rate simulation is used, the following RVM values apply:

- Range of temperature difference:
  (40 ± 2) K, or $\Delta\Theta_{max}$ $^{0}_{-2}$ K
  if $\Delta\Theta_{max}$ is less than 40 K
- Water temperature in flow sensor:
  (50 ± 5) °C or ambient
- Range of flow rate:
  (0.7 to 0.75) $q_p$ in m³/h.

The power supply to and the signal wires from the flow sensor shall be connected.

The flow sensor including flow sensor electronics shall be operated at zero flow rate (without low flow cut-off device).

## 6 Type approval tests and measurements

### 6.1 General

Unless otherwise stated in the test specification, the test requirements apply irrespective of the heat meter's environmental class (see clause 10 of R 75-1).

All measurements shall be carried out under the installation conditions (e.g. straight sections of piping upstream and downstream of the meter) stipulated by the supplier for his type of meter. For all tests, the heat-conveying liquid shall be water unless otherwise specified.

If a temperature sensor can be installed in the flow sensor, this shall be done during the performance tests of the flow sensor. Where a filter or strainer is an integral part of the flow sensor, it shall be included in all the tests.

If the error determined lies outside the MPE, the test shall be repeated twice unless otherwise stated.

The test is then declared satisfactory if both:

- the arithmetic mean of the result of the three tests; and
- at least two of the test results are within or at the MPE.

Depending on the flow sensor size, the tests and measurements to be carried out are described below.

The tests in 6.4 and 6.16 shall be carried out on all sizes.

The test in 6.8 shall be carried out only for those sizes of a type for which the highest wear is expected.

The tests in 6.17 shall be carried out for all sizes. For DN > 200 it shall be carried out at $\Theta_{min}$.

For each meter model, the following tests shall be carried out on one size only: 6.5, 6.6, 6.7, 6.9, 6.10, 6.11, 6.12, 6.13, 6.14, and 6.15.

### 6.2 Test program

Samples of a heat meter, or its sub-assemblies, submitted for type approval, shall be subject to tests to verify their conformity with clause 4. Unless otherwise stated, the tests shall be carried out at reference conditions and the samples shall be exposed to the influence factors or disturbances specified for the respective tests, as stated in Table 2.

The test sequence and the number of items used shall be either as described in Table 2 or as agreed between the supplier and the testing laboratory (assuming three samples, numbered by the testing laboratory).

Only one influence quantity shall be applied at a time.

If the equipment under test (complete, combined or sub-assemblies) has test outputs for quantity of water, temperature difference and/or energy, these outputs can be used to test such parameters.

### 6.3 Expanded uncertainty of test equipment (for type approval and initial verification tests)

Standards, instruments and methods used in type approval tests or in initial verification tests shall suit the purpose, be traceable to international standards or to national standards traceable to international standards and be part of a reliable calibration program.

Table 2 Test program for heat meters and their sub-assemblies

| Test | Subclause | Exposure | Temperature sensor pair | Flow sensor | Calculator | Complete meter | Number of sample*) |
|---|---|---|---|---|---|---|---|
| | | ***Influence factors*** | | | | | |
| MPE | 6.4 | Performance test | X | X | X | X | 2 |
| MPE | 6.5 | Dry heat | | X (a) | X | X | 2 |
| MPE | 6.6 | Cold | | X (a) | X | X | 2 |
| MPE | 6.7 | Static deviations in supply voltage | | X (a) | X | X | 2 |
| | | ***Disturbances*** | | | | | |
| NSFa | 6.8 | Durability | X | X | | X | 2 |
| NSFd | 6.9 | Damp heat, cyclic | | X (a) | X | X | 1 |
| NSFd | 6.10 | Short time reduction in supply voltage | | X (a) | X | X | 3 |
| NSFa | 6.11 | Electrical transients | | X (a) (b) | X(b) | X | 3 |
| NSFd | 6.12 | Electromagnetic field | | X (a) (b) | X(b) | X | 3 |
| NSFa | 6.13 | Electrostatic discharge | | X(a) | X | X | 3 |
| NSFd | 6.14 | Static magnetic field | | X | X | X | 3 |
| NSFd | 6.15 | Electromagnetic field at mains frequency | | X(a) | X | X | 3 |
| NSFa | 6.16 | Internal pressure | | X | | X | 1 |
| | 6.17 | Pressure loss | | X | | X | 1 |

MPE - Maximum permissible error according to clause 9 of R 75-1
NSFd - No significant fault shall occur during the test
NSFa - No significant fault shall occur after the test
X - Test to be performed
a - Only for flow sensors with electronic devices
b - This test shall be done with connected cables
*) - Recommended

The uncertainties associated with these standards, methods and measuring instruments shall always be known. They shall either:

a) not exceed 1/5 of the maximum permissible errors of the heat meter or the sub-assemblies (recommended provision), or

b) be subtracted from the maximum permissible errors of the heat meter or the sub-assemblies to obtain a new MPE (provision to be only when $\Delta\Theta \leq 3$ K).

## 6.4 Performance test

The initial intrinsic error shall be determined at least at the conditions stated in 6.4.1, 6.4.2, 6.4.3 and 6.4.4.

### *6.4.1 Flow sensor*

All performance tests shall be carried out three times, at the flow rates according to 6.4.1.1.

#### *6.4.1.1 General*

Flow rates:

$q_1$ $^{0}_{-10}$ %, $q_2$ ± 5 %, $q_3$ ± 5 %, $q_4$ ± 5 %, et $q_5$ $^{+10}_{0}$ %

where

$q_1 = q_s$ and $q_5 = q_i$, $q_1/q_2 = q_2/q_3 = q_3/q_4 = q_4/q_5 = K$

where

$$K = \sqrt[4]{\frac{q_s}{q_i}}$$

The point nearest to 0.7 $q_p$ to 0.75 $q_p$ shall be changed to be within 0.7 $q_p$ to 0.75 $q_p$ in order to obtain one point within RVM conditions.

Water temperatures:

a) $\Theta_{min}$ to ($\Theta_{min}$ + 5) °C (but not less than 10 °C);

b) (50 ± 5) °C;

c) (85 ± 5) °C.

The water temperature at the heat meter shall not vary by more than 2 K during a measurement.

For flow sensors larger than DN 250, the test may be carried out only at temperature a) if the following conditions are satisfied:

- the test results for smaller flow sensors of the same model are inside MPE for all water temperatures;
- documentary evidence is given that technological similarity exists between the models tested and the larger sizes applied for.

#### *6.4.1.2 Electromagnetic type flow sensors*

Electromagnetic type flow sensors shall be tested with water having an electrical conductivity higher than 200 µS/cm.

If the supplier has stated a lower permitted conductivity, tests shall also be performed at that conductivity at the flow rates $q_1$ and $q_5$, and at the water temperature a). The conductivity shall be noted in the type test report.

If the electronic part of the flow sensor is separated from the sensor head, the type and the maximum length of the connecting cable to the electrodes shall be stated by the supplier and be used for the above mentioned low conductivity test and noted in the type test report.

#### *6.4.1.3 Fast response meters*

For fast response meters, the transient behavior of the flow sensors of size $q_p \leq 2.5$ m$^3$/h shall be investigated by measuring the total quantity of water delivered in at least 10 cycles, each consisting of a 10 s period at a flow rate of $q_s$ and a 30 s period at zero flow rate.

The total quantity of water measured shall be at least twice the quantity used for the test at $q_s$ in 6.4.1.1.

The duration of start and stop shall be (1 ± 0.2) s.

The water temperature shall be as a) in 6.4.1.1.

The error shall not exceed the MPE.

For a complete or combined meter, the water temperature specified above is the return temperature. The temperature difference shall be the maximum obtainable, but shall not exceed 42 K.

*6.4.2 Calculator*

The calculator shall be tested at the following simulated temperatures:

| Temperature | Temperature difference |
|---|---|
| a) $\Theta_{return} = (\Theta_{min}\ ^{+5}_{0})$ °C | $\Delta\Theta_{min}$, 5, 20, $\Delta\Theta_{RVM,}$ $\Delta\Theta_{max}$ K |
| b) $\Theta_{return} = (\Theta_{RVM} \pm 5)$ °C | $\Delta\Theta_{min}$, 5, 20, $\Delta\Theta_{RVM}$ K |
| c) $\Theta_{flow} = (\Theta_{max}\ ^{0}_{-5})$ °C | 20, $\Delta\Theta_{RVM}$, $\Delta\Theta_{max}$ K |

The maximum temperature for these tests shall not exceed $\Theta_{max}$.

Tolerances:

- for all temperature differences: ± 20 %
- except for $\Delta\Theta_{min}$: $^{+20}_{0}$ % and $\Delta\Theta_{max}$: $^{0}_{-20}$ %.

For all test points, the simulated flow rate shall not create a signal exceeding the maximum signal acceptable by the calculator.

*6.4.3 Temperature sensors*

*6.4.3.1 Minimum immersion depth*

The value of the specified minimum immersion depth (see subclause 4.16 of R 75-1) shall be verified.

*6.4.3.2 Thermal response time*

The temperature sensors shall be tested according to IEC 60751; pockets shall be excluded. The response time shall not exceed the supplier's specification.

For sensors intended to be installed in pockets the test shall also be done with the pocket if the tolerated gap between the sensor and the pocket is more than 0.125 mm or the immersion depth of the pocket is less than 70 mm.

*6.4.3.3 General testing*

The temperature sensors of a pair shall be tested without their pockets at least at three temperature levels from the following scale:

(5 ± 5) °C, (40 ± 5) °C, (70 ± 5) °C, (90 ± 5) °C, (130 ± 5) °C, (160 ± 10) °C

chosen to optimize the spread of temperature over the temperature range specified by the manufacturer.

For sensors intended to be installed in pockets, the test shall also be carried out with a pocket if the maximum tolerated gap between the sensor and the pocket is more than 0.125 mm or the immersion depth of the pocket is less than 70 mm. The result shall be within the MPE and not deviate from the value determined without the pocket by more than 1/3 MPE.

The resistance values obtained on test shall be used in a system of three equations to calculate the three constants of the temperature/resistance equation of IEC 60751. Thereby the characteristic curve for the temperature sensor is known. The "ideal" curve using the standard constants of IEC 60751 shall be generated. To give the error at any temperature, the "ideal" curve shall be subtracted from the characteristic curve for each temperature sensor.

As a further step, the worst case error of the pair shall be determined over the temperature range and over the temperature difference range specified for the temperature sensors. For return temperatures above 80 °C, only temperature differences over 10 K shall be taken into account.

The error determined as described above shall be within the limits stated in subclause 9.2.2.2 of R 75-1.

If the temperature sensor pair and calculator form an inseparable sub-assembly, or a complete meter is to be approved, the test conditions for the sub-assembly or complete meter shall apply.

*6.4.4 Combined sub-assemblies or complete instruments*

The relevant tests for flow rate (6.4.1), temperatures and temperature differences (6.4.2 and /or 6.4.3) shall be carried out.

**6.5 Dry heat (Ref.: IEC 60068-2-2)**

The heat meters or their sub-assemblies shall be exposed to dry heat under the following test conditions:

- Temperature: (55 ± 2) °C
- Duration: 2 h

The duration of the test commences after the heat meter or the sub-assemblies has/have reached temperature stability.

The rate of change of temperature shall not exceed 1 K/min during heating up and cooling down.

The relative humidity of the test atmosphere shall not exceed 20 %.

After temperature stability of the heat meter or the sub-assemblies has been attained, the tests in 6.5.1, 6.5.2 and 6.5.3 shall be carried out without exceeding the MPE.

*6.5.1 Calculator*

Simulated return temperatures:
$\Theta_{min}$ and $\Theta_{RVM}$

Simulated flow rate:
The flow rate producing the maximum input signal acceptable by the calculator

Simulated temperature differences:
$\Delta\Theta_{min}$ and $\Delta\Theta_{RVM}$

*6.5.2 Flow sensor*

Water temperature:
(50 ± 5) °C

Flow rates:
a) (1 to 1.1) $q_i$ to be carried out only where $q_i \leq 3$ m$^3$/h

b) (0.7 to 0.75) $q_p$ if $q_p > 3.5$ m$^3$/h; the test shall be carried out according to 5.3.2.

*6.5.3 Combined sub-assemblies or complete instruments*

The relevant tests as described (see Table 2) for calculator and flow sensor shall be carried out.

### 6.6 Cold (Ref.: IEC 60068-2-1)

The heat meters or their sub-assemblies shall be exposed to cold air under the test conditions in Table 3.

The test commences after the heat meter or the sub-assemblies has/have reached temperature stability.

Table 3 Test conditions

| Environmental class | | A | B | C |
|---|---|---|---|---|
| Temperature | °C | 5 ± 3 | 25 ± 3 | 5 ± 3 |
| Duration | h | 2 | | |

The rate of change of temperature shall not exceed 1 K/min during heating up and cooling down.

After temperature stability of the heat meter or the sub-assemblies has been attained, the tests in 6.6.1, 6.6.2 and 6.6.3 shall be carried out without exceeding the MPE.

*6.6.1 Calculator*

Simulated return temperatures:
$\Theta_{min}$ and $\Theta_{RVM}$

Simulated flow rate:
The flow rate producing the maximum input signal acceptable by the calculator

Simulated temperature differences:
$\Delta\Theta_{min}$ and $\Delta\Theta_{RVM}$

*6.6.2 Flow sensor*

Water temperature:
(50 ± 5) °C

Flow rates:
a) (1 to 1.1) $q_i$ to be carried out only where $q_i \leq 3$ m$^3$/h

b) (0.7 to 0.75) $q_p$ if $q_p > 3.5$ m$^3$/h the test shall be carried out according to 5.3.2.

*6.6.3 Combined sub-assemblies or complete instruments*

The relevant tests as described for the calculator and flow sensor shall be carried out.

### 6.7 Static deviations in supply voltage and frequency

The heat meters or their sub-assemblies shall be subjected to static deviations from the rated supply voltage $U_n$ under the following test conditions:

Upper limit: $U_{max}$
Lower limit: $U_{min}$
Supply mode: Defined in a), b) and c) below
Duration: As needed for determination of RVM conditions

The duration of each test, which shall be at reference conditions, shall be sufficient to determine the error of the heat meter or the sub-assemblies.

Supply modes:

a) Electronic devices for mains operation and having a single rated voltage $U_n$:

$U_{max} = 1.1\ U_n$

$U_{min} = 0.85\ U_n$

$f = f_{nom}$

Variation of mains frequency if mains frequency is used for measuring purposes:

$f_{max} = 1.02\ f_{nom}$

$f_{min} = 0.98\ f_{nom}$

$U = U_n$

where $f_{nom}$ is the nominal frequency.

b) Electronic devices for mains operation and having a nominal range of voltage from $U_{nl}$ (the lower limit of the range) to $U_{n2}$ (the upper limit of the range):

$U_{max} = 1.1\ U_{n2}$

$U_{min} = 0.85\ U_{n1}$

$f = f_{nom}$

Variations of mains frequency if mains frequency is used for measurement purposes:

$f_{max} = 1.02\ f_{nom}$

$f_{min} = 0.98\ f_{nom}$

$$U = \frac{U_{n2} + U_{n1}}{2}$$

c) Electronic devices for external AC low voltage (< 50 V) operation and having a single rated voltage $U_n$:

$U_{max} = 1.5\ U_n$

$U_{min} = 0.5\ U_n$

$f = f_{nom}$

Variations of AC frequency if AC frequency is used for measurement purposes:

$f_{max} = 1.02\ f_{nom}$

$f_{min} = 0.98\ f_{nom}$

d) Electronic devices for external DC low voltage (< 50 V) operation and having a single rated voltage $U_n$:

$U_{max} = 1.75\ U_n$

$U_{min} = 0.50\ U_n$

e) Electronic devices for operation with batteries:

$U_{max} = U_{batt.max}$

$U_{min} = U_{batt.min}$

where $U_{batt.max}$ is the voltage of a new battery at no load and $U_{batt.min}$ is the lowest battery voltage of operation as specified by the meter supplier at an ambient temperature of 20 °C.

For each of the above supply modes, the errors shall be determined whilst the heat meter or the sub-assemblies are tested under the stated conditions.

Four test points for modes a) and b) at the limits and two test points for mode c), d) and e) at its limits are required. The errors obtained during the tests shall not exceed the MPE.

## 6.8 Durability test

In order to determine the durability of the heat meter, sub-assemblies of the heat meters shall be subject to accelerated wear tests in so far as such tests are reasonable for the type.

### *6.8.1 Flow sensor*

The durability test for flow sensors consists of a basic test for meters with normal lifetime and an additional endurance test which shall be carried out for flow sensors designed for long-life meters.

Basic test:

The test procedure is based on a continuous series of one hundred cycles at three different flow rates, each cycle lasting 24 hours (Figure 1). The high load phase

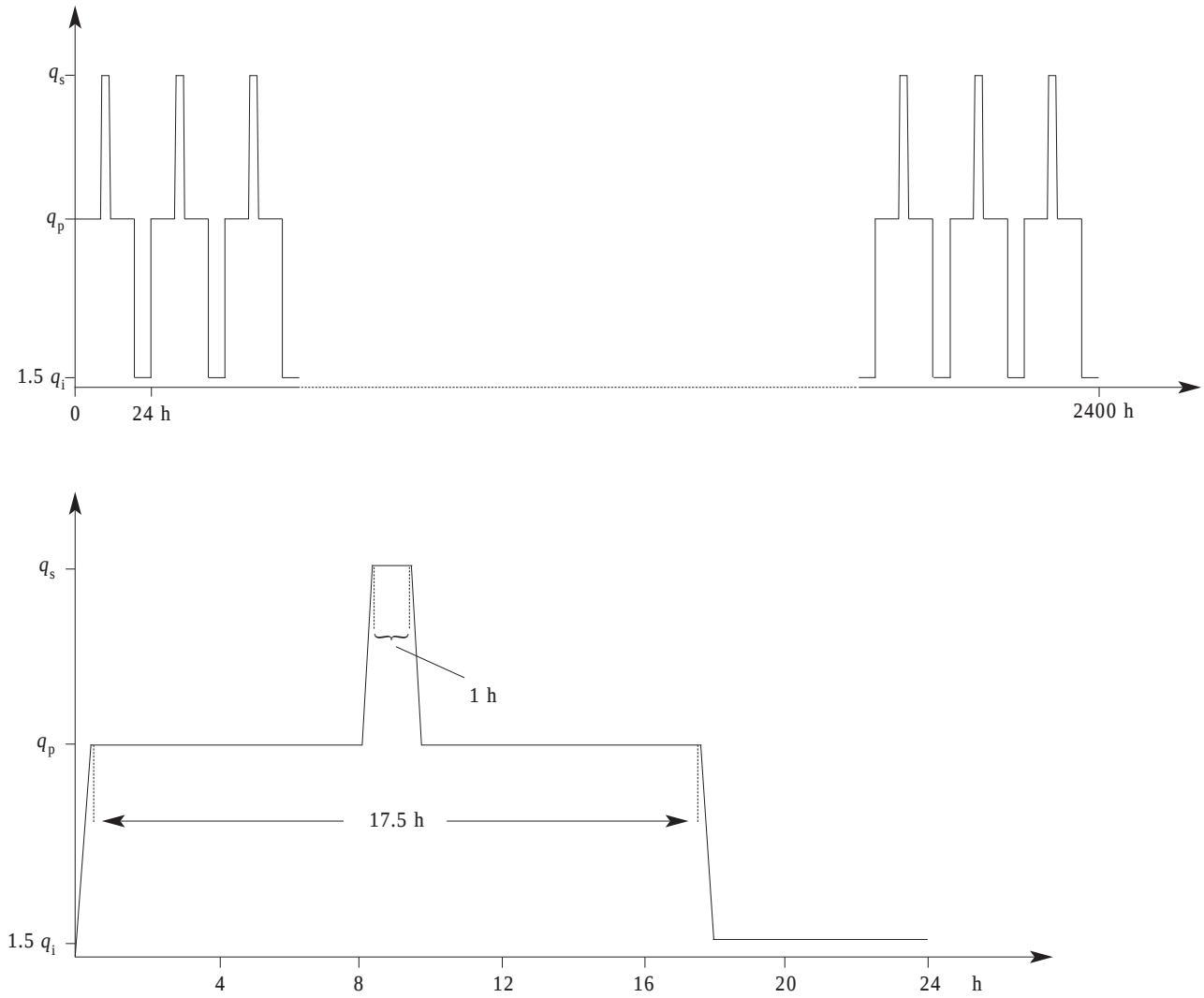


Figure 1 Basic wear test cycles (not to scale) with magnification of the first cycle

lasts 18 hours; the flow rate shall be 16 hours equal to $q_p$, plus one hour in which the flow rate is raised up to $q_s$. The high load phase shall be followed by a low load phase at 1.5 $q_i$ lasting 6 hours. The four transition intervals between the different loads shall be approximately one quarter of an hour each.

Tolerances:

(1.5 $q_i$) ± 5 % $q_p$ ± 5 % $q_s$ – 5 % to $q_s$

The basic wear test shall be carried out at the upper limit of the temperature of the heat conveying liquid which the flow sensor is required to withstand.

After the durability test, the error of indication shall be determined at the temperature of:

(50 ± 5) °C or at $\Theta_{max}$ to $\Theta_{max}$ – 5 °C if $\Theta_{max}$ < 50 °C and at the flow rates stated:

$q_{1\ -10}^{\ 0}$ %, $q_2$ ± 5 %, $q_3$ ± 5 %, $q_4$ ± 5 % and $q_5\ ^{+10}_{\ 0}$ %

where

$q_1 = q_s$ and $q_5 = q_i$, $q_1/q_2 = q_2/q_3 = q_3/q_4 = q_4/q_5 = K$

where $K = \sqrt[4]{\frac{q_s}{q_i}}$

No significant fault shall occur.

Additional test:

The additional durability test for long-life sensors shall have a duration of 300 hours at a flow rate equal to $q_s$

and at the upper limit of the temperature of the heat conveying liquid which the flow sensor is required to withstand.

Tolerance:

$q_s$ – 5 % to $q_s$

After the test the error of indication shall be determined at the flow rate stated in 6.8.1 for the flow sensor and at the temperature of (50 ± 5) °C or $(\Theta_{max\ -5}^{\ 0})$ °C if $\Theta_{max}$ < 50 °C.

No significant fault shall occur.

*6.8.2 Temperature sensors (Ref.: IEC 60751)*

The temperature sensor shall be brought slowly to its upper temperature limit, then exposed to air at room temperature and then brought slowly to its lower temperature limit. This procedure shall be repeated 10 times. At each limit the temperature sensor shall be immersed, at least to its declared immersion depth, and shall be maintained at the temperature for sufficient time to reach thermal equilibrium (according to IEC 60751).

The durability error shall be less than 0.1 °C.

After the temperature cycling, the insulation resistance of the temperature sensors as a sub-assembly shall be tested under the conditions according to 4.2.1 and 4.3.1 of IEC 60751.

The insulation resistance between the metal envelope of the sensor and each of the conductors connected to it shall be measured at reference conditions and using a test voltage of 100 V DC. The polarity of the voltage shall be reversed. The measured resistance shall in no cases be less than 100 MΩ.

The insulation resistance between the metal envelope of the sensor and each of the conductors connected to it shall be measured when the sensor is at its maximum temperature, using a test voltage not exceeding 10 V DC. The polarity of the voltage shall be reversed. The measured resistance shall in no case be less than 10 MΩ.

*6.8.3 Combined sub-assemblies or complete instruments*

The relevant tests for each sub-assembly shall be carried out.

Before and after the test, measurements shall be carried out as for each sub-assembly. One exception is the insulation resistance for temperature sensors. This measurement shall not be carried out when the temperature sensor is a part of the heat meter or the sub-assemblies.

### 6.9 Damp heat cyclic (Ref.: IEC 60068-2-30)

The heat meters or their sub-assemblies shall be exposed to cyclic damp heat (condensing) under the conditions given in Table 4.

The test consists of exposure to a cyclic temperature variation between the lower and the upper temperature, maintaining the relative humidity above 95 % during the temperature changes and low temperature phases, and at 93 % at the upper temperature phases. Condensation shall occur on the heat meter or the sub-assemblies during the temperature rise.

The heat meter or the sub-assemblies shall be switched on during the test and operate according to the conditions for RVM measurements.

Table 4 Test conditions

| Environmental class | A | B | C |
|---|---|---|---|
| Lower temperature | (25 ± 3) °C | (25 ± 3) °C | (25 ± 3) °C |
| Upper temperature | (40 ± 2) °C | (55 ± 2) °C | (55 ± 2) °C |
| Relative humidity | ≥ 93 % | ≥ 93 % | ≥ 93 % |
| Period of cycle | 12 h + 12 h | 12 h + 12 h | 12 h + 12 h |
| Number of cycles | 2 | 2 | 2 |
| Recovery period before proceeding to the next test | min. 1 h<br>max. 2 h | min. 1 h<br>max. 2 h | min. 1 h<br>max. 2 h |

Intrinsic error determinations at RVM conditions shall be carried out as follows:

- during the second cycle, starting 1 h after initiation of the increase of the temperature from the lower to the upper temperature;
- after recovery.

On completion of the damp heat cyclic test, comparison of intrinsic error test results at RVM conditions with initial intrinsic error test results shall show no significant fault.

### 6.10 Short time mains voltage reduction (Ref.: IEC 61000-4-11)

*Note:* This clause is valid only for electronic devices or instruments for mains or external AC low voltage operation.

The heat meter or the sub-assemblies shall be subjected to repetitive brief reductions in the supply voltage under the following test conditions.

The test levels are voltage dips of 100 % in 10 half-cycles.

Each individual voltage reduction shall be initiated, terminated and repeated at a zero crossing of the supply voltage. The interval of time between two successive reductions shall be (10 ± 1) s and 10 reductions shall be carried out.

Initial intrinsic error determinations at RVM conditions shall be made and the above test sequence started. Intrinsic error determinations shall be made and the measurement ended after (15 ± 1) min. With reference to the initial intrinsic error determination, no significant faults shall occur.

### 6.11 Electrical transients

#### *6.11.1 Fast transients (bursts) (Ref.: IEC 61000-4-4)*

For signal and DC lines the following applies:

Each cable, interconnecting sub-assemblies or external cables for permanent installation longer than 1.2 m, connected to the heat meters or their parts, shall be subjected to a repetitive series of electrical spikes during a fixed interval of time (i.e. electrical bursts) under the conditions given in Table 5.

Table 5 Test conditions

| | |
|---|---|
| Test voltage | 1.0 kV ± 10 % |
| Spike rise time | 5 ns |
| Spike duration | 50 ns |
| Spike repetition frequency | 5 kHz |
| Burst length | 15 ms |
| Burst period | 300 ms |
| Duration of test | 60 s for negative bursts and 60 s for positive bursts |

Bursts are coupled to the terminals only as common-mode interference with ground (earth) as reference.

Bursts are obtained by a transient generator having an output impedance of 50 Ω.

The spikes in bursts can have positive or negative polarity. The decay time is defined as the interval of time between the half-amplitude points of the transient.

The heat meter or the sub-assemblies shall be switched on during the test with a flow rate of zero and $\Delta\Theta = \Delta\Theta_{RVM}$.

Initial intrinsic error determination at RVM conditions shall be made.

Examination of the heat meter or the sub-assemblies after the tests shall show that no information or readings have changed due to the exposure, but the figure of the lowest significance of the readings for the water or heat quantity may alter by one unit at most.

After the tests, intrinsic error determinations at RVM conditions shall be carried out and no significant faults shall occur.

If the heat meter under test has a standardized data output, the intrinsic error determination shall also be made using this data output.

Table 6 Test conditions

| Environmental class | A | B | C |
|---|---|---|---|
| Test voltage | 2.0 kV ± 10 % | 2.0 kV ± 10 % | 4.0 kV ± 10 % |
| Spike rise time | 5 ns | 5 ns | 5 ns |
| Spike duration | 50 ns | 50 ns | 50 ns |
| Spike repetition frequency | 5 kHz | 5 kHz | 2.5 kHz |
| Burst length | 15 ms | 15 ms | 15 ms |
| Burst period | 300 ms | 300 ms | 300 ms |
| Duration of test | 60 s for negative bursts and 60 s for positive bursts | | |

For AC power lines the following applies:

Each cable connected to the heat meters or their parts shall be subjected to a repetitive series of electrical spikes during a fixed interval of time (i.e. electrical bursts) under the conditions given in Table 6.

Bursts are coupled to the terminals only as common mode interference with ground (earth) as reference.

Bursts are produced by a transient generator having an output impedance of 50 Ω.

The spikes in bursts can have positive or negative polarity. The decay time is defined as the interval of time between the half-amplitude points of the transient.

The heat meter or the sub-assemblies shall be switched on during the test with a flow rate of zero and $\Delta\Theta = \Delta\Theta_{RVM}$.

Before the test, an intrinsic error determination at RVM conditions shall be carried out.

Examination of the heat meter or the sub-assemblies after the tests shall show that no information or readings have changed due to the exposure, but the figure of the lowest significance of the readings for the water or heat quantity may alter by one unit at most.

After the tests, an intrinsic error determination at RVM conditions shall be carried out and no significant faults shall occur.

*6.11.2 Surge transients (Ref.: IEC 61000-4-5)*

For signal and DC lines the following applies:

Each cable longer than 10 m, interconnecting sub-assemblies or external cables for permanent installation, connected to the heat meters or their parts shall be subjected to electrical surge transients (see Table 7).

Table 7 Surge transients for signal and DC lines

| | |
|---|---|
| Test voltage, common mode | 0.5 kV |
| Test voltage, differential mode | 0.5 kV (only for external cables) |
| Rise time (open circuit) | 1.2 µs |
| Duration (open circuit) | 50 µs |
| Rise time (short circuit) | 8 µs |
| Duration (short circuit) | 20 µs |

When the surge transients are coupled to the signal lines, an impedance of 40 Ω shall be connected to the output of the surge generator. Each line shall be subjected to three positive and three negative transients.

The heat meter or the sub-assemblies shall be switched on during the test with a flow rate of zero and $\Delta\Theta = \Delta\Theta_{RVM}$.

Before the test, an intrinsic error determination at RVM conditions shall be carried out.

Examination of the heat meter or the sub-assemblies after the tests shall show that no information or

readings have changed due to the exposure, but the figure of the lowest significance of the readings for the water or heat quantity may alter by one unit at most.

After the test, an intrinsic error determination at RVM measurement shall be carried out and no significant faults shall occur.

For AC power lines the following applies:

The AC power line shall be subjected to electrical surge transients (see Table 8).

Table 8 Surge transients for AC power lines

| Environmental class | A, B and C |
|---|---|
| Test voltage - common mode | 2.0 kV ± 10 % |
| Test voltage - differential mode | 1.0 kV ± 10 % |

The output impedance of the transient generator is 2 Ω. Each line shall be subjected to three positive and three negative transients.

The heat meter or the sub-assemblies shall be switched on during the test with a flow rate of zero and $\Delta\Theta = \Delta\Theta_{RVM}$.

Before the test an intrinsic error determination at RVM conditions shall be carried out.

Examination of the heat meter or the sub-assemblies after the tests shall show that no information or readings have changed due to the exposure, but the figure of the lowest significance of the readings for the water or heat quantity may alter by one unit at most.

After the test an intrinsic error determination at RVM conditions shall be carried out and no significant faults shall occur.

### 6.12 Electromagnetic field (Ref.: IEC 61000-4-3, IEC 60870-5-1 and IEC 61107)

The heat meter and its external cables of at least 1.2 m length shall be subjected to radiated RF fields in the frequency range 26 MHz to 1 000 MHz under the conditions given in Table 9.

Table 9 Test conditions

| Environmental class | A | B | C |
|---|---|---|---|
| Frequency range | 26 MHz to 1 000 MHz | | |
| Test level | 3 V/m | 3 V/m | 10 V/m |
| Modulation | AM (1 kHz) 80 % | | |

The specified frequency range is divided into two:

- 26 MHz to 200 MHz;
- 201 MHz to 1 000 MHz.

The preferred transmitting antennas are a biconical antenna for the frequency range 26 MHz to 200 MHz and a log-periodic antenna for the frequency range 201 MHz to 1 000 MHz.

The frequency ranges shall be stepped using Table 10 and using the power levels established during the calibration process and with the signal 80 % amplitude modulated with a 1 kHz sine wave. The test shall be performed sequentially, with the antenna polarized in two orthogonal positions.

The dwell time at each frequency shall be not less than the time necessary for the heat meter or the sub-assemblies to carry out an RVM measurement and to respond.

The tests shall be carried out in steps, using Table 10.

Table 10 Carrier frequencies

| MHz | MHz | MHz |
|---|---|---|
| 26 | 150 | 435 |
| 40 | 160 | 500 |
| 60 | 180 | 600 |
| 80 | 200 | 700 |
| 100 | 250 | 800 |
| 120 | 350 | 934 |
| 144 | 400 | 1 000 |

Determination of the intrinsic error at RVM condition is commenced at the start of each exposure and terminated at the end of each exposure. No significant faults shall occur.

If the heat meter or the sub-assemblies has/have a standardized data output, the intrinsic error shall also be determined using this data output. During the test,

the master shall send requests at intervals of 30 s to the meter. The meter shall respond within three requests.

*Note:* Heat meters using the protocol in accordance with IEC 60870-5-1 answer with at least the minimum protocol; heat meters using the protocol in accordance with IEC 61107 answer with an identification and a data message.

### 6.13 Electrostatic discharge (Ref.: IEC 61000-4-2)

The heat meters or their parts with electronic devices shall receive a transfer of electrostatic charge from a body of different electrostatic potential directly to the surface of the heat meter or the sub-assemblies (i.e. electrostatic discharge) under the test conditions given in Table 11.

Table 11 Test conditions

| | |
|---|---|
| Discharge voltage | Air 8 kV - contact 4 kV |
| Discharge rate | Single shot |
| Number of single shots per discharge point | 10 |

The discharge may be applied to any surface of the heat meter normally accessible to the user.

The discharge electrode shall approach the heat meter until discharge occurs, if possible, and shall be removed before the next discharge. In addition to this, the contact discharges shall be made on all surfaces where air discharge has occurred. Furthermore, contact shall be made to the vertical coupling plane (VCP) and to the horizontal coupling plane (HCP), on which the heat meter is placed. The interval of time between successive discharges shall be more than 10 s.

The heat meter or the sub-assemblies shall be switched on during the test with a flow rate of zero and $\Delta\Theta = \Delta\Theta_{RVM}$.

Initial intrinsic error determinations at RVM conditions shall be made before and after the exposure and no significant fault shall occur.

Examination of the heat meter or the sub-assemblies after the tests shall show that no information or readings have changed due to the exposure, but the figure of the lowest significance of the readings for the water or heat quantity may alter by one unit at most.

If the heat meter or the sub-assemblies has/have a standardized data output, intrinsic error shall also be determined using this data output.

### 6.14 Static magnetic field (fraud protection)

The heat meter or the sub-assemblies shall be put into operation at the RVM condition.

A permanent magnet having a strength of 100 kA/m shall be placed into contact at several positions around the flow sensor body, calculator casing and indicating device of the heat meter throughout the period of the test.

Trial and error, a knowledge of the heat meter's type and construction and/or past experience may identify locations on the envelope of the heat meter where the action of a static magnetic field will affect the correct functioning of the meter.

The indicating device of the heat meter shall be observed at each of the positions of the magnet. The test shall continue for long enough to permit the heat meter error at RVM conditions to be determined.

During the test:

- no disruption, abrupt addition or subtraction, acceleration, deceleration in the rate of indication of the indicating device or other output signals shall be discernible;
- no significant faults shall occur.

*Note:* The permanent magnet from a large loudspeaker or that used in an aquarium cleaning kit has a strength of 100 kA/m.

### 6.15 Electromagnetic field at mains frequency (Ref.: IEC/TR 61000-2-7)

The heat meter shall be subjected to electromagnetic fields at mains frequency. The field strengths are given in Table 12.

Table 12 Field strength

| Environmental class | A | B | C |
|---|---|---|---|
| Field strength at nominal frequency | 60 A/m | 60 A/m | 100 A/m |

Initial intrinsic error determinations at RVM conditions shall be made. Intrinsic error determinations are commenced at the start of the exposure and terminated at the end of exposure. With reference to the initial intrinsic error determination, no significant fault shall occur.

### 6.16 Internal pressure

Depending on the materials of construction of the flow sensor, the flow sensor shall withstand, without leakage or damage, either:

- a hydraulic pressure of 1.5 times the maximum working pressure at a water temperature of (10 ± 5) °C less than the upper temperature limit;
- a hydraulic pressure equal to the maximum operating pressure, but at a temperature of 5 °C above the upper temperature limit.

The duration of the test shall be 0.5 h.

Initial intrinsic error determinations at RVM conditions shall be made. Intrinsic error determinations shall be made after the pressure test. With reference to the initial intrinsic error determination, no significant fault shall occur.

### 6.17 Pressure loss

The test shall be carried out in accordance with subclause 6.7 of OIML R 49-2 with the flow rate set to (0.9 to 1.0) $q_p$ and the temperature set to (50 ± 5) °C.

## 7 Initial verification tests

For the requirements for the uncertainty of test equipment see 6.3.

If the error determined lies outside the MPE, the test shall be repeated twice. The test is then declared satisfactory if both:

- the arithmetic mean of the result of the three tests; and
- at least two of the test results are within or at the MPE.

### 7.1 Flow sensor

The verification of the flow sensor shall be carried out within each of the following flow rate ranges at a water temperature of (50 ± 5) °C:

a) $q_i \le q \le 1.1\ q_i$

b) $0.1\ q_p \le q \le 0.11\ q_p$

c) $0.9\ q_p \le q \le 1.0\ q_p$

If the type approval certificate so provides, the verification may be carried out with cold water in accordance with the procedures laid down in the certificate.

When testing the flow sensors, the guidelines in the type approval certificate shall be followed (e.g. requirements for water conductivity, water temperature, straight inlet/outlet pipes, etc.).

### 7.2 Temperature sensor pair

#### *7.2.1 Error in temperature difference*

The individual temperature sensors of the temperature sensor pair shall be tested, without their pockets, in the same temperature bath, at temperatures within each of the three temperature ranges in Table 13.

Table 13 Test temperature ranges

| No. | For $\Theta_{min}$ | Test temperature range |
|---|---|---|
| 1 | < 20 °C | $\Theta_{min}$ to ($\Theta_{min}$ + 10) °C |
| | ≥ 20 °C | 35 °C to 45 °C |
| 2 | all $\Theta_{min}$ | 75 °C to 85 °C |
| 3 | all $\Theta_{min}$ | ($\Theta_{max}$ – 30) °C to $\Theta_{max}$ |
| *Note:* If specified in the type approval certificate, variations in the temperature ranges and the number of temperatures are permissible. | | |

The immersion depth of the temperature sensors shall not be less than their minimum immersion depth.

The resistance values obtained on test shall be used in a system of three equations to calculate the three constants of the temperature/resistance equation of IEC 60751. Thereby the characteristic curve for the temperature sensor is known.

The "ideal" curve using the standard constants of IEC 60751 shall be generated. To give the error at any temperature, the "ideal" curve shall be subtracted from the characteristic curve for each temperature sensor.

As a further step, the worst case error of the temperature sensor pair shall be determined over the temperature range and over the temperature difference range specified for the sensors.

For return temperatures above 80 °C, only temperature differences over 10 K shall be taken into account.

The error determined as described above shall be within the limits stated in subclause 9.2.2.2 of R 75-1.

When measuring resistance, the current shall be such that the power dissipation does not exceed 0.1 mW RMS.

*7.2.2 Insulation resistance*

The resistance between each terminal and the sheath shall be measured with a DC test voltage between 10 V and 100 V, under ambient conditions between 15 °C and 35 °C and at a relative humidity not exceeding 80 %. The polarity of the test current shall be reversed. In all cases the resistance shall not be less than 100 MΩ.

### 7.3 Calculator

The calculator shall be tested, at least within each of the following temperature difference ranges:

a) $\Delta\Theta_{min} \leq \Delta\Theta \leq 1.2\ \Delta\Theta_{min}$

b) $10\ K \leq \Delta\Theta \leq 20\ K$

c) $\Delta\Theta_{max} - 5\ K \leq \Delta\Theta \leq \Delta\Theta_{max}$

The simulated flow rate signal shall not exceed the maximum acceptable by the calculator.

The return temperature shall be in the temperature range between 40 °C and 70 °C, if $\Theta_{max}$ is not exceeded.

To enable rapid testing of the calculator, it is customary to bypass the indicating device of the heat meter. However, for at least one test, the meter's indicating device shall be included.

### 7.4 Calculator and temperature sensor pair

The sub-assembly of calculator and temperature sensor pair shall be tested using the temperature ranges of 7.2 and the temperature difference ranges of 7.3.

Additionally, a final test of the sub-assembly is necessary, with the temperature sensor pair immersed in two temperature-regulated baths. The temperature difference of the baths shall be between 3 K and 4 K. The simulated flow rate shall not create a signal exceeding the maximum signal acceptable by the calculator.

If the calculator and temperature sensor pair are tested as an inseparable sub-assembly, it shall be tested in accordance with 7.3.

### 7.5 Combined instrument

The flow sensor, the temperature sensor pair and the calculator shall each be tested separately, in accordance with 7.1 to 7.3.

### 7.6 Complete instrument

The verification of the complete meter shall be carried out at least within each of the following ranges:

a) $\Delta\Theta_{min} \leq \Delta\Theta \leq 1.2\ \Delta\Theta_{min}$ and $0.9\ q_p \leq q \leq q_p$

b) $10\ K \leq \Delta\Theta \leq 20\ K$ and $0.2\ q_p \leq q \leq 0.22\ q_p$

c) $\Delta\Theta_{max} - 5\ K \leq \Delta\Theta \leq \Delta\Theta_{max}$ and $q_i \leq q \leq 1.1\ q_i$

## 8 Documentation

### 8.1 Documentation for type approval

The supplier shall submit two copies of the following documentation to the testing laboratory as well as the

items to be tested - including an archival unit of the meter type tested (if requested by the testing laboratory):

- Heat meter specification
- Technical description
- Statement of the self-heating effect of temperature sensors
- Minimum immersion depth for temperature sensors
- User's manual
- Installation instructions (clause 12 of R 75-1)
- Installation and security sealing plan
- Mechanical drawings
- Material specifications
- Electrical circuit diagrams
- Components list
- Specification for materials in bearings, gaskets, etc.
- Software description
- List of programmable constants
- Software flow chart
- Panel layout and operating instructions
- Initial functional check and instructions
- Test outputs, their use and their relationships to the parameters being measured

### 8.2 Documentation for initial verification

The supplier shall make available data sheets with at least the following information:

- Heat meter specification
- Sensors specification
- Type and specification of the battery
- Assembly instruction
- Installation instruction
- Security sealing plan
- Initial functional check and operating instruction
- Test outputs, their use and their relationship to parameters being measured
- Test conditions for initial verification
- Additional qualifying information supplied with the type approval certificate (e.g. additional recommended test conditions)

## *Notes*

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