BS EN 1434-4:2015

BSI Standards Publication

Heat meters

Part 4: Pattern approval tests

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National foreword

This British Standard is the UK implementation of EN 1434-4:2015. It supersedes BS EN 1434-4:2007 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee CPI/30, Measurement of fluid flow in closed conduits.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2015

ISBN 978 0 580 84659 5

ICS 17.200.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2015.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1434-4

November 2015

ICS 17.200.10

Supersedes EN 1434-4:2007

English Version

Heat meters - Part 4: Pattern approval tests

Compteurs d'énergie thermique - Partie 4: Essais en vue de l'approbation de modèle

Wärmezähler - Teil 4: Prüfungen für die Bauartzulassung

This European Standard was approved by CEN on 5 September 2015.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 1434-4:2015 E

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European foreword

This document (EN 1434-4:2015) has been prepared by Technical Committee CEN/TC 176 “Heat meters”, the secretariat of which is held by SIS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2016, and conflicting national standards shall be withdrawn at the latest by May 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1434-4:2007.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

EN 1434, *Heat meters* consists of the following parts:

— *Part 1: General requirements*

— *Part 2: Constructional requirements*

— *Part 3: Data exchange and interfaces*[1)]

— *Part 4: Pattern approval tests*

— *Part 5: Initial verification tests*

— *Part 6: Installation, commissioning, operational monitoring and maintenance*

In comparison to EN 1434-4:2007, the following changes have been made:

— metrological requirements for smart metering applications are added;

— additional functionalities for smart metering applications are added;

— cooling meters are added;

— influences of sensors are added;

— tests for cooling applications and for fast response meters are added;

— test for additional functionalities for smart metering applications, e.g. internal clock, external digital signal, absolute temperature are added;

— calculator with single temperature sensor are added;

1) EN 1434-3 is maintained by CEN/TC 294.

— test for communication interfaces, endurance test for flow sensors and accelerated durability test are added;

— electromagnetic field caused by digital radio equipment;

— static magnetic field;

— test procedure for temperature sensor pairs with pockets and without pockets.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies pattern approval tests for heat meters. Heat meters are instruments intended for measuring the energy which in a heat-exchange circuit is absorbed (cooling) or given up (heating) by a liquid called the heat-conveying liquid. The heat meter indicates the quantity of heat in legal units.

Electrical safety requirements are not covered by this European Standard.

Pressure safety requirements are not covered by this European Standard.

Surface mounted temperature sensors are not covered by this European Standard.

This standard covers meters for closed systems only, where the differential pressure over the thermal load is limited.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1434-1:2015, *Heat meters — Part 1: General requirements*

EN 55022, *Information technology equipment — Radio disturbance characteristics — Limits and methods of measurement (CISPR 22:2008)*

EN 60068-2-1, *Environmental testing — Part 2-1: Tests - Test A: Cold (IEC 60068-2-1)*

EN 60068-2-2, *Environmental testing — Part 2-2: Tests - Test B: Dry heat (IEC 60068-2-2)*

EN 60068-2-30, *Environmental testing — Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle) (IEC 60068-2-30)*

EN 60751:2008, *Industrial platinum resistance thermometers and platinum temperature sensors (IEC 60751:2008)*

EN 61000-4-2, *Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test (IEC 61000-4-2)*

EN 61000-4-3, *Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques — Radiated, radio-frequency, electromagnetic field immunity test (IEC 61000-4-3)*

EN 61000-4-4, *Electromagnetic compatibility (EMC) — Part 4-4: Testing and measurement techniques — Electrical fast transient/burst immunity test (IEC 61000-4-4)*

EN 61000-4-5, *Electromagnetic compatibility (EMC) — Part 4-5: Testing and measurement techniques — Section 5: Surge immunity test (IEC 61000-4-5) (IEC 61000-4-5)*

EN 61000-4-6:2014, *Electromagnetic compatibility (EMC) — Part 4-6: Testing and measurement techniques — Immunity to conducted disturbances, induced by radio-frequency fields (IEC 61000-4-6:2013)*

EN 61000-4-8, *Electromagnetic compatibility (EMC) — Part 4-8: Testing and measurement techniques — Power frequency magnetic field immunity test (IEC 61000-4-8)*

EN 61000-4-11, *Electromagnetic compatibility (EMC) — Part 4-11: Testing and measurement techniques — Voltage dips, short interruptions and voltage variations immunity tests (IEC 61000-4-11)*

EN ISO 4064-2, *Water meters for cold potable water and hot water — Part 2: Test methods (ISO 4064-2)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1434-1:2015 apply.

4 General

The procedure shall ascertain that the pattern conforms to the metrological requirements of this European Standard. In addition to the checking of the documentation (Clause 7) and the comparison of the pattern with the metrological requirements of this European Standard, the tests in Clause 6 shall be performed.

It is recommended to use a checklist as in Annex B to report in a standardized way the result of the comparison between the patterns under approval with the essential requirements of this European Standard.

5 Requirements

Under normal operating conditions, the error of heat meters or their sub-assemblies shall not exceed the maximum permissible error, MPE specified in EN 1434-1.

When heat meters or their sub-assemblies are exposed to disturbances, significant faults shall not occur.

6 Specification of operating conditions

6.1 Rated operating conditions

The rated operating conditions are those given in Table 1.

Table 1 — Rated operating conditions

Environmental class	**A**	**B**	**C**
Ambient temperature in °C	+5 to +55	−25 to +55	+5 to +55
Relative humidity in %	< 93		
Mains supply voltage in V	195 V to 253 V		
Mains frequency	f_{nom} ± 2 %		
Battery voltage	The voltage of a battery in service under normal conditions		
Remote AC supply voltage	12 V to 36 V		
Remote DC supply voltage	12 V to 42 V		
Local external DC supply voltage	as specified by manufacturer		

6.2 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

Basic mounting orientation

The actual temperature and relative humidity within the specified range shall not vary by more than ± 2,5 K 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.

6.3 Reference values for the measurand, RVM

6.3.1 General

For heating/cooling meters the RVM shall be based on the values for the heating range.

6.3.2 Reference values for the measurand, RVM

Table 2 — Reference values for heating and cooling

	Heating applications	**Cooling applications**
Range of temperature difference:	(40 ± 2) K	(10 ± 2) K
Range of flow rate:	(0,7 to 0,75) q_p in m^3/h	(0,7 to 0,75) q_p in m^3/h
Outlet temperature:	(50 ± 5) °C	(15 ± 5) °C

The conditions, mentioned in Table 2, are reference values for a complete heat meter. Reference values for sub-assemblies are the relevant parts of the conditions mentioned in Table 2.

Flow rate simulation for the flow sensor electronics is allowed, but testing with water is always preferred. The temperature of the liquid in the flow sensor shall be kept at (50 ± 5) °C or at ambient temperature. The power and signal wires shall be connected. The flow sensor including flow sensor electronics shall be operated at zero flow rate (without low flow cut off device).

7 Tests and measurements

7.1 General

Unless otherwise stated in the test specification, the test requirements apply irrespective of the heat meter's environmental class. See EN 1434-1:2015, Clause 10.

All measurements shall be carried out under the installation conditions stipulated by the manufacturer for his type of meter (e.g. straight sections of piping upstream and downstream of the meter). For all tests the heat conveying liquid shall be water, unless otherwise specified. The performance test shall be carried out with the specified liquid and the type approval certificate shall include the specification of the liquid to be used for initial verification.

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 at all tests.

If the error determined lies outside the MPE, the test shall be repeated twice unless otherwise stated. The test is satisfactory declared 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:

For each meter model the test in 7.4, 7.18 and 7.19 can be carried out on a limited number of sizes according to an evaluation by the testing laboratory. This evaluation shall be included in the type testing report.

The test in 7.8 shall be carried out only for those sizes of a type for which the highest wear is expected.

For dimensions > DN 200, 7.19 shall be carried out at θ_{min}.

For each meter model the following tests shall be carried out on one size only: 7.5, 7.6, 7.7, 7.9, 7.10, 7.11, 7.12, 7.13, 7.14, 7.15, 7.16, 7.17, 7.20, 7.21 and 7.23.

Tests of additional energy registers for smart metering functionalities:

The accuracy of thermal energy accumulation into the additionally and independently energy registers shall be tested by energy performance tests according to 7.4.

NOTE In applications of smart metering, one or both single sensors of the pair are used as additional single sensor.

Additional tests for control quantities, the internal clock, external digital signal, single temperature sensors, calculators and calculators with single sensors shall be done according to requirements in EN 1434-1:2015, 5.10. It shall be tested that the specific MPE according to EN 1434-1:2015, 5.10.5 for tolerance quantities, used for threshold activation of additional energy accumulations will be met.

The absence of software-interaction between all energy registers shall be proved in accordance with the WELMEC Guide “7.2 Software”, respective latest edition. This shall be done for both directions of energy flow, in cases of delivered and absorbed energy (heat and cooling meter).

Each additional register under test shall be activated by the corresponding control quantity. It shall be ascertained that the specific activated register content on display is corresponding to the changes of control quantity, as expected and by at least one totalizer energy increment.

By metrological tests the accuracy of generating and processing, the accumulated energy values in dependency on the parameterisation of the corresponding control parameters shall be tested. By checking of the switch-on/off parameters, it shall be ascertained that the control quantity and the values thereof are indicated on display properly. The information on the display shall not deviate from the real measurement with respect to measurement conditions.

7.2 Test programme

Samples of a heat meter, or its sub-assemblies, submitted for pattern 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 3.

The test sequence and the number of items used shall be either as described in Table 3 or as agreed between the manufacturer and the testing laboratory (assuming four samples, numbered by the testing laboratory).

Only one influence quantity shall be applied at a time.

If the meter 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.

Table 3 — Test programme for heat meters and their sub-assemblies

Test	Subclause	Exposure	Temperature sensor pair	Flow sensor	Calculating device	Complete meter	Item number
		Influence factors					
MPE	7.4	Performance test	X	X	X	X	2
MPE	7.5	Dry heat		X[a]	X	X	2
MPE	7.6	Cold		X[a]	X	X	2
MPE	7.7	Static deviations in supply voltage		X[a]	X	X	2
		Disturbances					
NSFa	7.8	Durability	X	X		X	4
NSF	7.9.1 7.9.2	Damp heat, cyclic Damp heat, steady-state	X X[c]	X[a] X[c]	X	X X	1 1
NSF	7.10	Short time reduction in supply voltage		X	X	X	3
NSFa	7.11	Electrical transients		X[a,b]	X[b]	X	3
NSFd	7.12	Electromagne tic field		X[a,b]	X[b]	X	3
NSFd	7.13	Electromagne tic field – digital radio equipment		X[a,b]	X[b]	X	3
NSFd	7.14	Radio frequency, amplitude modulated		X[a,b]	X[b]	X	3
NSFa	7.15	Electrostatic discharge		X[a]	X	X	3
NSFd	7.16	Static magnetic field		X	X	X	3
NSFd	7.17	Mains frequency magnetic field		X[a]	X	X	3
NSFa	7.18	Internal pressure		X		X	1
	7.19	Pressure loss		X		X	1
	7.20	Electromagne tic emission		X[a]	X[b]	X	3

Test	Subclause	Exposure	Temperature sensor pair	Flow sensor	Calculating device	Complete meter	Item number
	7.21	24 hrs interruption			X	X	3
NSFd	7.22	Flow disturbances		X		X	1
NSFa	7.23	Vibration/ mechanical shock	X	X	X	X	2

MPE Maximum permissible error according to EN 1434-1:2015, Clause 9.

NSFd No signification fault shall occur during the test.

NSFa No signification 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.

[c] For cooling for meters / sub-assemblies with at least IP 65.

For heating/cooling meters the tests in 7.4 shall cover both functions, the tests in 7.6 and 7.9 shall be carried out using the cooling function, but all other tests shall be carried out using the heating function. (For RVM values see 6.3.)

7.3 Uncertainty of test equipment and influences of EUT

Standards, instruments and methods used in pattern approval tests shall suit the purpose, be traceable to more precise standards and be part of a reliable calibration programme.

The uncertainties associated with these standards, methods and measuring instruments shall always be known. They shall be calculated with a coverage factor of 2 corresponding to a coverage probability of 95 %.

The expanded uncertainties shall either:

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

or

b) if the uncertainty is higher than 1/5 of MPE, the value of the difference between uncertainty and 1/5 MPE shall be subtracted from MPE, to calculate a new reduced MPE.

The use of a) is recommended.

Uncertainty influences (combination of resolution and repeatability) coming from equipment under test shall not be more than 30 % for the flow sensor, 20 % for the calculator and 60 % for the temperature sensor pair of the MPE of each sub-assembly.

7.4 Performance tests

7.4.1 General

The initial intrinsic error shall be determined at least at the conditions stated in 7.4.2, 7.4.3, 7.4.4 and 7.4.5.

7.4.2 Flow sensor

7.4.2.1 General

All performance tests shall be carried out three times.

For a meter model with more than one specified mounting orientation, the performance testing shall be performed in the orientation, where the higher influences are expected.

Tests of flow sensors shall be done above minimum operation pressure specified by the manufacturer with examination of absence of cavitation.

It shall be tested, that the volume and energy registers for billing purposes will not decrement in the case of reverse flow rate.

7.4.2.2 Flow rates

Flow rates:

$q_{1}{}^{0}_{-10}\%$, $q_2 \pm 5\%$, $q_3 \pm 5\%$, $q_4 \pm 5\%$ 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

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

The test flow rate 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.

Table 4 — Water temperatures

	Applications		
	Heating	**Cooling**	
Test points	All	All	
a	θ_{min} to θ_{min} + 5) °C (but not less than 10 °C)	(15 ± 5) °C	
b	(50 ± 5) °C	(5 ± 1) °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, testing at water temperature a) only, is considered sufficient 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.

7.4.2.3 Electromagnetic type flow sensors

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

If the manufacturer 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 certificate.

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 manufacturer, be used for the above mentioned low conductivity test and noted in the certificate.

7.4.2.4 Fast response meters

For fast response meters the transient behaviour of the flow sensors of size $q_p \leq 2{,}5$ m³/h shall be investigated by measuring the total quantity of water delivered in 10 to 15 cycles, consisting of 10 s period at a flow rate of q_s and 30 s period at zero flow rate.

The duration of start and stop shall be (1 ± 0,2) s.

The water temperature shall be as a) in 7.4.2.2.

The error shall not exceed the MPE.

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

7.4.3 Calculator

7.4.3.1 Heating and cooling applications

The calculator shall be tested at the following simulated temperatures:

Table 5 — Testing temperatures for heating applications

Temperature °C	Temperature difference K
a) $\theta_{outlet} = \left(\theta_{\min}{}^{+5}_{0}\right)$	$\Delta\Theta_{\min}$, 5, 20, $\Delta\Theta_{RVM}$
b) $\theta_{outlet} = \left(\theta_{RVM} \pm 5\right)$	$\Delta\Theta_{\min}$, 5, 20, $\Delta\Theta_{RVM}$, $\Delta\Theta_{\max}$ [a]
c) $\theta_{inlet} = \left(\theta_{\max}{}^{0}_{-5}\right)$	20, $\Delta\Theta_{RVM}$, $\Delta\Theta_{\max}$

[a] The level corresponding to $\Delta\Theta_{\max}$ shall be reduced if needed to be within $\theta_{\max}$.

Table 6 — Testing temperatures for cooling applications

Temperature °C	Temperature difference K
a) $\theta_{inlet} = \left(\theta_{\min}{}^{+5}_{0}\right)$	$\Delta\Theta_{\min}$, 5, $\Delta\Theta_{RVM}$, $\Delta\Theta_{\max}$
b) $\theta_{inlet} = \left(15 \pm 5\right)$	$\Delta\Theta_{\min}$
c) $\theta_{outlet} = \left(\theta_{\max}{}^{0}_{-5}\right)$	$\Delta\Theta_{RVM}$, $\Delta\Theta_{\max}$

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.

Additional test for bifunctional meters for change-over systems between heating and cooling:

An example for the switching over from heating to cooling register and reversed is given in EN 1434-1:2015, Figure 1.

It shall be tested that

— heating energy shall only be recorded at $\Delta\theta > \Delta\theta_{hc}$ and at $\theta_{inlet} > \theta_{hc}$;

— cooling energy shall only be recorded at $\Delta\theta < -\Delta\theta_{hc}$ and at $\theta_{inlet} < \theta_{hc}$;

— no heating and cooling energies shall be recorded between $-\Delta\theta_{hc}$ and $\Delta\theta_{hc}$.

The general test in this clause shall be performed both for the heating and the cooling function using the correct heat coefficient (depending on installation of the flow sensor in higher respectively lower temperature).

7.4.3.2 Additional functionalities for smart metering applications

7.4.3.2.1 Internal clock as control quantity

It shall be shown that the deviation from the official legal time during the whole estimated durability period does not exceed the optional values given in EN 1434-1:2015, 5.10.5.1, means less than 1 h/year or less than 6 min or less than 7 s, by verifying the accuracy for setting the legal time or calculated evidence of deviation by the characteristics of the crystal frequency depending on e.g. temperature and time.

By test for the accuracy of periodic interval registers for billing periods (e.g. hourly, daily, weekly or monthly registers), it shall be shown that the time deviation is not more than 1 % of the regarded period.

This correct function of time as control quantity shall be tested at least three points of time within an appropriate period (e.g. 24 h), at a defined date.

7.4.3.2.2 External digital signal as control quantity

By tests of each additional register depending on the specific digital trigger signal (switching on/off), the correct activation of the specific additional accumulation register shall be proved.

7.4.3.2.3 Absolute temperature as control quantity

7.4.3.2.3.1 Single temperature sensor

The compliance with the permissible error of the temperature sensor of ± 0,7 K compared to the performance curve according to EN 60751, including the signal cables thereof, shall be tested for each temperature sensor at three typical temperature points for field applications (e.g. 10 °C; 30 °C; 50 °C).

7.4.3.2.3.2 Calculator

The compliance with the permissible error on temperature indication of the inlet and outlet temperatures compared to the correct value of the absolute temperature of ± 0,3 K shall be tested.

This test shall be examined in relation to the value of the threshold temperature Θ_S used for activating the specific additional accumulation register at the range of

$$\Theta_s - 5\,\mathrm{K} \leq \Theta_s \leq \Theta_s + 5\,\mathrm{K}$$

by double-sided approaches (increasing and decreasing) in increments of 0,25 °C via the parameterized control temperature, the proper on/off-switching function of the respective additional accumulation register shall be proved.

7.4.3.2.3.3 Calculator with single temperature sensor

The compliance with the permissible error on temperature indication of the inlet and outlet temperatures compared to the correct value of the absolute temperature of ± 1,0 K shall be tested. The test shall be examined in accordance with 7.4.3.2.3.2.

NOTE In applications of smart metering, one or both single sensors of the pair are used as additional single sensor.

7.4.3.2.3.4 Communication interface

Communication interfaces (e.g. electronic, optical, radio or other technical interface) shall be tested that the meter data correspond to the LCD contents.

7.4.4 Temperature sensors

7.4.4.1 Qualifying immersion depth

It shall be verified in a thermostatic bath with a temperature of (85 ± 5) °C at an ambient temperature of (23 ± 2) °C, that a deeper immersion than the qualifying immersion depth changes the resistance value by an amount corresponding to < 0,1 K.

7.4.4.2 Thermal response time

The temperature sensors shall be tested according to EN 60751:2008. For sensors designed to be mounted in pockets the test should be made with pockets using the set up defined in Annex A. The response time shall not exceed the manufacturer's specification.

7.4.4.3 General testing

The temperature sensors of a pair shall be tested without their pockets at three temperature levels given in Table 7:

Table 7 — Temperature levels

Test points	Test temperature range	
θ_1	θ_{min} to (θ_{min} + 10 K)	
θ_2	$\frac{\theta_1 + \theta_3}{2} \pm 5\,\mathrm{K}$	
θ_3	$\theta_{max} \leq 150°C$	(θ_{max} – 10 K) to θ_{max}
	$\theta_{max} > 150°C$	(θ_{max} – 20 K) to θ_{max} , but in any case more than 140 °C

The immersion depth of the sensor under test shall be 90 % to 99 % of the total length.

The determined resistance values shall be used in a system of three equations to calculate the three constants of the temperature/resistance equation of EN 60751 and a curve shall be drawn through the three test points. Thereby the characteristic curve for the temperature sensor is known.

The "ideal" curve using the standard constants of EN 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 outlet temperatures above 80 °C, only temperature differences over 10 K shall be taken into account.

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.

The error determined as described above shall be within the limits stated in EN 1434-1:2015, 9.2.2.2.

7.4.4.4 Testing of the influence of pockets

The manufacturer shall deliver a special temperature sensor pair with pockets, described as follows:

— One sensor (the dedicated inlet temperature sensor) with pocket, selected or manufactured that the gap between pocket and sensor is the maximum gap according to the manufacturer's specification.

— One sensor (the dedicated outlet temperature sensor) with pocket, selected or manufactured that the gap between pocket and sensor is the minimum gap according to the manufacturer's specification.

Only the shortest pocket length in a family shall be tested, provided that thread, material, etc. are identical for all pockets in the family.

The test is carried out in two stages as follows:

a) The two temperature sensors are tested without pockets according to 7.4.4.3.

b) The two temperature sensors are then mounted in the pockets as described above and retested according to 7.4.4.3.

The calculated difference between the results obtained with and without pockets shall be within 1/2 of the limits stated in EN 1434-1:2015, 9.2.2.2.

To get the best reproducibility it is strongly recommended that the tests with and without pockets are both carried out following the procedure in Annex A.

7.4.5 Combined sub-assemblies or complete meter

The relevant tests for flow rate (7.4.2), temperatures and temperature differences (7.4.3) shall be carried out.

7.5 Dry heat

7.5.1 General

The heat meters or their sub-assemblies shall be exposed to dry heat under the following test conditions with help of a climatic chamber:

Reference to standard:	EN 60068-2-2, Part 2-2: Tests, Test Bd: Dry heat
Temperature:	(55 ± 2) °C
Duration:	2 h

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

The rate of change of temperature shall not exceed 1K/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 of 7.5.2, 7.5.3 and 7.5.4 shall be carried out without exceeding the MPE.

7.5.2 Calculator

Simulated temperatures:	θ_{min} and θ_{RVM}
Simulated rate:	The flow rate producing the maximum input signal acceptable by the calculator

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

7.5.3 Flow sensor

Water temperature:	(50 ± 5) °C for heating applications and (15 ± 5) °C for cooling applications

Flow rates

a) (1 to 1,2) q_i;

b) (0,7 to 0,75) q_p .

7.5.4 Combined sub-assemblies or complete meter

The relevant tests as described (see Table 3) for calculator and flow sensor shall be carried out.

7.6 Cold

7.6.1 General

The heat meters or their sub-assemblies shall be exposed to cold air under the test conditions in Table 8.

Reference to standard: EN 60068-2-1

Test Ad: Cold, for heat dissipating heat meter or the sub-assemblies with gradual change of temperature.

Table 8 — Test conditions

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

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

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 of 7.6.2, 7.6.3 and 7.6.4 shall be carried out without exceeding the MPE.

7.6.2 Calculator

Simulated temperatures: θ_{min} and θ_{RVM}

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

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

7.6.3 Flow sensor

Water temperature: (50 ± 5) °C for heating applications and (15 ± 5) °C for cooling applications

Flow rates

a) (1 to 1,2) q_i;

b) (0,7 to 0,75) q_p.

7.6.4 Combined sub-assemblies or complete meter

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

7.7 Static deviations in supply voltage

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), c), d), e) and f) below

Duration: as needed for determination of RVM conditions

The duration of each test, which shall be at normal 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_{n1} (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}

$$U = \left(U_{n2} + U_{n1}\right) / 2$$

c) 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 manufacturer at an ambient temperature of 20 °C.

d) Remote AC supply voltage

U_{max} = 36 V

U_{min} = 12 V

e) Remote DC supply voltage

U_{max} = 42 V

U_{min} = 12 V

f) Local external DC supply voltage

U_{max} as specified by the manufacturer.

U_{min} as specified by the manufacturer.

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

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

7.8 Durability test

7.8.1 General

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

7.8.2 Flow sensor

7.8.2.1 General

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.

For a meter with more than one specified mounting orientation all tests shall be performed at the orientation where the higher influences are expected.

NOTE Experience shows that there might be a specific influence on the sensor's durability by particles in the energy-conveying liquid.

If desired by the manufacturer, the durability tests may be carried out with e.g. test water containing more than 400 µg/kg of Magnetite particles specified in chemical type and particle size and a pH value of 9,5 ± 1 (Electromagnetic type flow sensors shall be tested with water having an electrical conductivity higher than 200 µS/cm). The test water analysis shall then be reported in the type approval report.

7.8.2.2 Basic test

The test procedure is based on a continuous series of one hundred cycles at three different flow rates, each cycle lasting 24 h. The high load phase lasts 18 h; the flow rate shall be 16 h 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 h. The four transition intervals between the different loads shall be approx. one quarter of an hour each. The flow versus time is shown in Figure 1.

Tolerances:

(1,5 × q_i) ± 5 % q_p ± 5 % $q_{s}{}_{-5}^{\ 0}$ %

The basic wear test shall be carried out at the upper limit of the temperature range.

After the test the error of indication shall be determined at the flow rates stated in 7.4.2 (for the flow sensor) at:

For heating applications

(50 ± 5) °C or at $\left(\theta_{max}{}_{-5}^{\ 0}\right)$ °C if $\theta_{max} < 50$ °C.

For cooling applications

(15 ± 5) °C

No significant error shall occur.

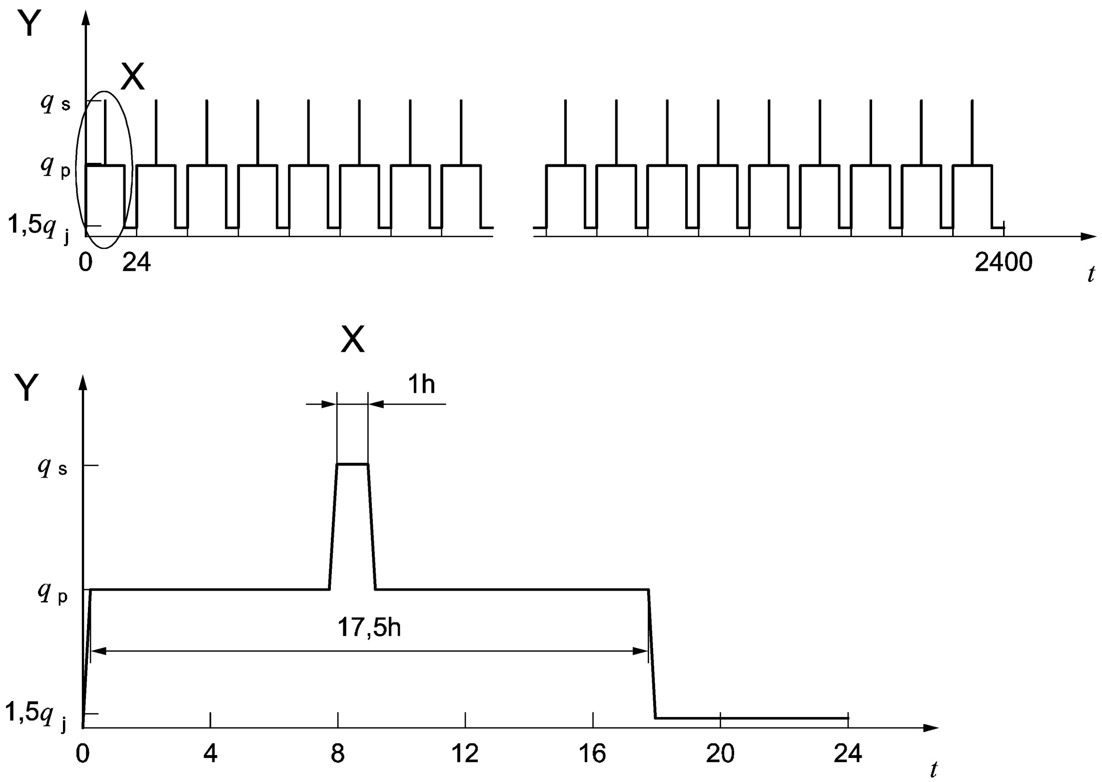


Figure 1 — Basic wear test cycles with magnification of the first cycle

The 100 continuous load changes are estimated for a durability period of 5 years. The durability period is scalable by its number of load cycles. Water quality is explained according to CEN/TR 16911.

7.8.2.3 Additional test

The additional endurance test for long-life flow sensors shall have a duration of 500 h at a continuous flow rate equal to qs and at the upper limit of the temperature range.

The additional test is estimated for an additional durability period of 5 years. The durability period is scalable by its number of hours. Water quality is explained according to CEN/TR 16911.

Tolerance:

$q_{s\,-5}^{\;\;0}$ %

After the test the error of indication shall be determined at the flow rates stated in 7.4.2 (for the flow sensor) at:

For heating applications

(50 ± 5) °C or at $\left(\theta_{\max\,-5}^{\;\;\;\;0}\right)$ °C if $\theta_{\max}$ < 50 °C.

For cooling applications

(15 ± 5) °C

No significant error shall occur.

7.8.2.4 Accelerated Durability test

To accelerate the test procedure the samples may be weared alternatively by 4 000 continuous load change cycles; flow sensors with moving mechanical parts with flow rate load changes shall be raised up from zero to q_s (at a temperature of 80 °C to 85 °C) and reversed, and flow sensors without moving mechanical parts with temperature load changes shall be raised up from (20 to 15) °C to (80 to 85) °C and reversed at the constant flow rate q_p. Each low load phase and each high load phase shall last 2,5 min.

The test shall be done with 6 samples of identical flow sensors for those sizes for which the highest wear is expected.

The 4 000 continuous load changes are estimated for a durability period of 5 years. The durability period is scalable by its number of load cycles up to 10 years.

7.8.3 Temperature sensors

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 to an immersion depth of 90 % to 99 % of the total length and shall be maintained at the temperature for sufficient time to reach thermal equilibrium (according to EN 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 following conditions:

Reference to standard: EN 60751:2008, 4.2.1 and 4.3.1.

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 VDC. The polarity of the voltage shall be reversed. The measured resistance shall in no case 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 VDC. The polarity of the voltage shall be reversed. The measured resistance shall in no case be less than 10 MΩ.

7.8.4 Combined sub-assemblies or complete meter

The relevant tests according to test 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.

7.9 Damp heat

7.9.1 Damp heat cyclic

The heat meters or their sub-assemblies shall be exposed to cyclic damp heat (condensing) under the conditions given in Table 9.

Reference to standard: EN 60068-2-30:2005, Test Db: test variant 1.

Table 9 — 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	6	2
Recovery period before proceeding to the next test	min. 1 h max. 2 h	min. 1 h max. 2 h	min. 1 h max. 2 h

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 % (±3 %) 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. The liquid temperature for cooling and heating/cooling meters shall be 15 °C or lower.

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. (see EN 60068-2-30:2005, Figure 3).

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.

7.9.2 Damp heat steady-state

Meters or sub-assemblies for cooling purpose with IP class 65 or higher (normally the hydraulic part of the flow sensor and the temperature sensors) shall also be exposed to “Damp heat, steady state” under the conditions below:

Reference to standard: EN 60068-2-78, Test Cab, “Damp heat, steady state”

The test specimen shall be operated with liquid at a temperature of 6 °C (±3°C) flowing through the flow sensor and the temperature sensors shall be mounted in the same pipe. Separate mounted calculators and flow sensor electronics shall not be included. Test conditions shall be 50 °C (±2 °C) and 95 % RH (±3 %) for a testing period of 96 h.

The test specimen shall be switched ON during the entire exposure and operate according to the conditions for RVM measurements, except that the liquid shall be 6 °C (±3 °C).

Intrinsic error determination on the flow sensor at these conditions shall be carried out before and after this test, at ambient conditions. No significant fault shall occur.

The temperature sensors shall be tested before and during the last 12 h of the testing period. The insulation resistance between the metal envelope of the sensor and each of the conductors connected to it shall be measured using a test voltage not exceeding 100 VDC. The polarity of the voltage shall be reversed. The measured resistance shall in no case be less than 100 MΩ.

7.10 Short time mains voltage reduction

NOTE 1 This clause is valid only for electronic devices or instruments for mains and low voltage AC supply operation.

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

Reference to standard: EN 61000-4-11, Voltage dips, short interruptions and voltage variations immunity test.

The test levels shall be voltage dips of 100 % in 10 half cycles.

NOTE 2 With 50 Hz mains this means interruptions of 100 ms.

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.

7.11 Electrical transients

7.11.1 Fast transients (bursts)

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 10.

Reference to standard: EN 61000-4-4

Table 10 — 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.

For power AC 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 11.

Reference to standard: EN 61000-4-4

Table 11 — 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		

Bursts are coupled to the terminals direct injection on line to ground.

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 $\Delta\Theta = \Delta\Theta_{RVM}$.

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.

7.11.2 Surge transients

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 12):

Reference to standard: EN 61000-4-5

Table 12 — 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 3 positive and 3 negative transients.

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

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

After the test it shall be examined that no information or any readings are 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 power AC lines the following applies:

The AC power line shall be subjected to electrical surge transients (see Table 13):

Reference to standard: EN 61000-4-5

Table 13 — Surge transients for AC power lines

Environmental classes	A, B and C
Test voltage - Line - ground	2,0 kV ± 10 %
Test voltage - Line - line	1,0 kV ± 10 %

The output impedance of the transient generator is 2 Ω. Each line shall be subjected to 3 positive and 3 negative transients.

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

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.

7.12 Electromagnetic field

The heat meter or the sub-assemblies calculator and flow sensor with electronics 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 14.

Reference to standard: EN 61000-4-3

Table 14 — 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 in two:

— 26 MHz to 200 MHz

— 201 MHz to 1 000 MHz

The preferred transmitting antennas are a bi-conical 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 as below 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 a RVM measurement and to respond.

The tests shall be carried out in steps, using the following frequencies in MHz:

26 40 60 80 100 120 144 150 160 180 200 250 350 400 435 500 600 700 800 934 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 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 3 requests.

NOTE Heat meters using the protocol according to EN 60870-5 answer with at least the minimum protocol, heat meters the protocol according to EN 62056-21 answer with an identification and a data message.

7.13 Electromagnetic field specifically caused by digital radio equipment

The complete heat meter and the sub-assemblies calculator and electronic flow sensor and its external cables of at least 1,2 m length shall be subjected to radiated RF fields of the frequencies 900 and 1 800 MHz under the conditions given in Table 15.

Reference to standard: EN 61000-4-3

Table 15 — Test conditions

Environmental class	**A**	**B**	**C**
Frequency	800 MHz to 960 MHz 1 850 MHz to 2 700 MHz		
Test level	10 V/m	10 V/m	30 V/m
Modulation	AM (1 kHz) 80 %		

The preferred transmitting antennas are a log-periodic antenna or a low-directional horn antenna.

The test shall be performed sequentially with the antenna polarized in two orthogonal positions.

The frequency ranges shall be stepped as below. 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 a RVM measurement and to respond.

The tests shall be carried out in steps, using the following frequencies in MHz:

800	850	900	950	1 750	1 850	1 950	2 400	2 700

Determination of the intrinsic error at RVM condition shall be 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 a standardised 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 3 requests.

NOTE Heat meters using the protocol according to EN 60870-5 answer with at least the minimum protocol, heat meters the protocol according to EN 62056-21 answer with an identification and a data message.

7.14 Radio frequency amplitude modulated

Each cable ports of a complete heat meter or the sub-assemblies calculator and electronic flow sensor shall be subjected to conducted RF voltage in the frequency range 0,15 MHz to 26 MHz under the conditions given in Table 16.

On temperature sensor cables which are terminated into an electrically isolated Platinum temperature sensing element (e.g. Pt 100 sensor in metal probe sheet) the injection shall be made using the EM-clamp described in EN 61000-4-6:2014, Annex A. The metal sheet of the temperature sensor shall be connected to a CDN of model M-1 (i.e. the metal sheet is connected to the ground plane via a 150 Ω impedance).

The injected current during the EM-clamp injection shall be monitored using a monitoring probe, as described in EN 61000-4-6. See Figures 2 and 3.

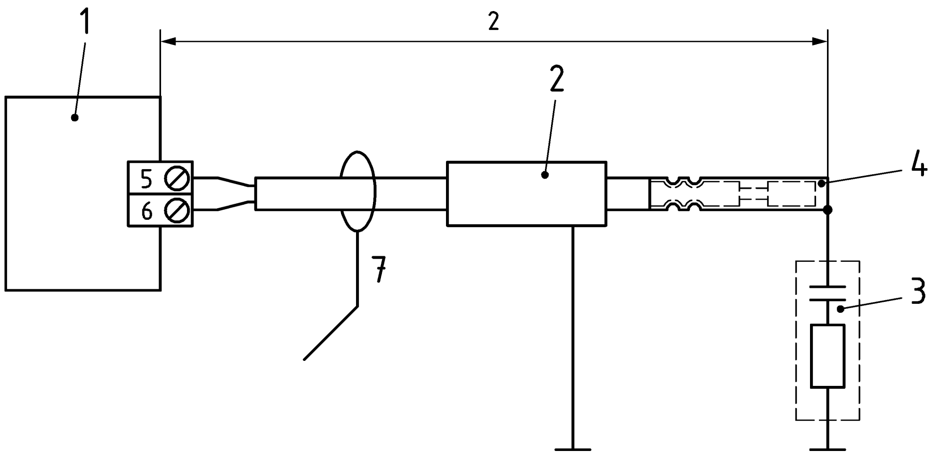


Figure 2 — Test set-up with precision resistor built-in to a metal cap

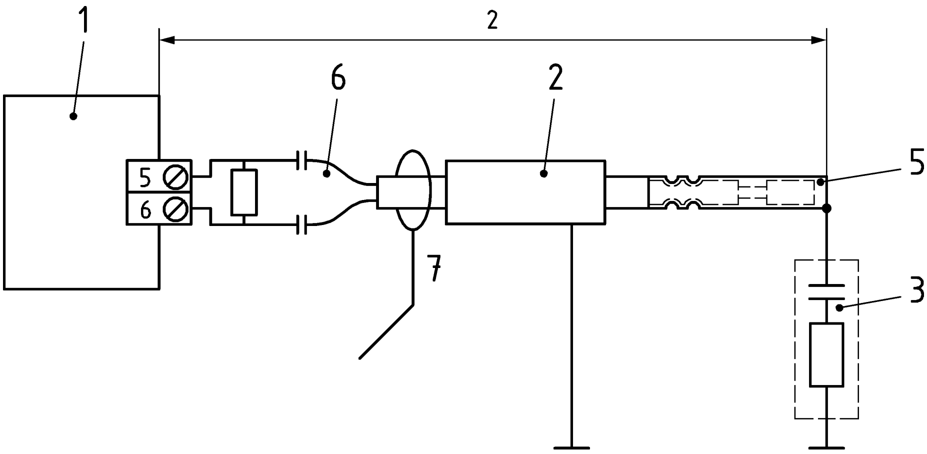


Figure 3 — Test set-up with precision resistor terminated to the sensor input

Key to Figures 2 and 3

1 EUT (in this example the flow pipe temperature of the heat meter calculator is exposed)

2 EM clamp (the EM current from the RF generator is coupled to the EUT via the EM clamp)

3 M1 CDN (representing 150 Ω common mode impedance to ground)

4 precision resistor in metal cap (Temperature simulator during the exposure)

5 temperature sensor in metal cap (simulates the capacitance between the sensor element and metal cap)

6 precision resistor with capacitive coupling (10 nF in each wire) to the temperature sensor

7 current measurement clamp (to measure the injected current)

The shown test set-up with 2 m cable length is representative for all cables with a specified length up to 25 m. For heat meters with a specified cable lengths longer than 25 m, the test set-up shall be made with injection via CDN-network.

The test shall also be performed on internal cable ports to be used with cables longer than 1,2 m within a complete meter.

The test shall not be performed on ports specified for use with cables shorter than 1,2 m or for temporary short time use.

Reference to standard: EN 61000-4-6

Table 16 — Test conditions

Environmental class	A	B	C
Frequency range	0,15 MHz to 26 MHz		
Test level	3 V	3 V	10 V
Modulation	AM (1 kHz) 80 %		

The frequency ranges shall be stepped as below 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.

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 a RVM measurement and to respond.

The tests shall be carried out in steps with the following carrier frequencies in MHz

0,15 0,23 0,34 0,5 0,8 1,1 1,7 2,5 3,8 7,0 14,0 21,0

Determination of the intrinsic error at RVM condition shall be 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 a standardised 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 3 requests.

NOTE Heat meters using the protocol according to EN 60870-5 answer with at least the minimum protocol, heat meters the protocol according to EN 62056-21 answer with an identification and a data message.

7.15 Electrostatic discharge

The heat meters or their parts with electronic devices shall receive a transfer of electro-static 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 17.

Reference to standard: EN 61000 4-2

Table 17 — 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, according to EN 61000-4-2. 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 a standardized data output, intrinsic error shall also be determined using this data output.

7.16 Static magnetic field (fraud protection)

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

A static 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, 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 (stationary or moving) of a static magnetic field will affect the correct functioning of the meter.

The indicating device of the heat meter shall be observed during testing at each of the identified test 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.

7.17 Mains frequency magnetic field

The heat meter shall be subjected to electromagnetic fields at mains frequency. The field strengths are given in Table 18.

Reference to standard: EN 61000-4-8

Table 18 — Field strength

Environmental class	A	B	C
Field strength at 50 Hz	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.

7.18 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) K less than the maximum admissible temperature,

or

— a hydraulic pressure equal to the maximum operating pressure, but at a temperature of 5 K above the maximum admissible temperature.

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.

7.19 Pressure loss

The test shall be carried out in accordance with EN ISO 4064-2 using the test equipment according to EN ISO 4064-2 with the flow rate set to 0,9 q_p up to q_p and the temperature set to (50 ± 5) °C or (15 ± 5) °C.

The presented result shall be recalculated at q_p with an uncertainty better than 5 % with a coverage factor of 2.

7.20 Electromagnetic emission

7.20.1 General

The conducted and radiated emission from the heat meter or the sub-assemblies shall meet the requirements in EN 55022.

The heat meter or the sub-assemblies shall be switched on during the test and operate at RVM conditions.

Reference to standard: EN 55022

The tests shall be done according to the Tables 19 to 21.

7.20.2 Conducted emission on power AC lines

Table 19 — Conducted emission on power AC lines

Frequency range – MHz	Limits - dBµV
0,15 to 0,5	66 to 56 quasi peak[a] 56 to 46 average[a]
0,5 to 5	56 quasi peak 46 average
5 to 30	60 quasi peak 50 average
[a] Limits decrease linearly with logarithmic frequency.	

7.20.3 Conducted emission on signal and DC power lines

The conducted emission is measured with a current probe on each cable.

Table 20 — Conducted emission on signal and power DC lines

Frequency range – MHz	Limits - dBµA
0,15 to 0,5	40 to 30 quasi peak[a] 30 to 20 average[a]
0,5 to 30	30 quasi peak 20 average
[a] Limits decrease linearly with logarithmic frequency	

7.20.4 Radiated emission

Table 21 — Radiated emission

Frequency range - MHz	Limits at 10 m - dBµV/m
30 to 230	30 quasi peak
230 to 1 000	37 quasi peak

7.21 24 h interruption in the mains power supply voltage

The calculator shall be exposed to the following sequence:

1) operate the calculator for 24 h at $\Delta\Theta_{max}$ and q_p;

2) operate the calculator for 24 h at $\Delta\Theta_{max}$ and zero flow;

3) note the reading on the display;

4) disconnect the mains power supply for 24 h;

5) re-connect the mains power supply;

6) note the reading on the display.

Requirements: the energy displayed before and after the mains power supply interruption shall not differ by more than the value of the least significant digit of the display.

7.22 Flow disturbances

The flow sensor (or the complete meter) shall be exposed to flow disturbances generated by a clock wise swirl disturbance generator as in EN ISO 4064-2. This shall be placed before the meter (or the specified flow conditioner package).

To state the difference in the performance of a flow sensor in an undisturbed flow compared to a disturbed flow, each test line of the calibration facilities shall have a fully developed velocity distribution.

This test is not required if all of the conditions under a) or b) below are fulfilled:

a):

— the ratio $q_p/q_i \leq 25$,

— and the accuracy class is 3,

— and q_i is specified at a pipe liquid speed > 0,04 m/s;

b):

— the ratio $q_p/q_i \leq 50$, and

— the accuracy class is 2 or 3, and

— q_i is specified at a pipe liquid speed > 0,02 m/s, and

— the standardized flow conditioning package as in Annex B of part 1 is specified.

Error determination at flow level q_4 and q_5 from 7.4.2.2 and at a temperature level of (50 ± 5) °C [or (15 ± 5) °C for cooling applications] shall be made without and with the disturbance and no significant faults shall occur.

NOTE For criteria for a fully developed flow profile, see Annex C.

7.23 Vibration/mechanical shock

The following influence quantities shall be considered in relation with mechanical environments:

— Vibration;

— Mechanical shock.

The complete meter or sub-assemblies shall be exposed to mechanical influence quantities as stated in EN 1434-1:2015, 10.5 (Mechanical classes M1 to M3).

NOTE 1 The exposure to mechanical influence quantities is described in OIML D11:2013, Clause 11.

NOTE 2 Application of the random vibration test is preferred in OIML Recommendations.

The sinusoidal test shall be applied only in those cases where the measuring instrument is exposed to be typically subjected to sinusoidal vibrations.

Guidance for the selection amongst both, the tests can be found in EN 60068-3-8 [2].

8 Documentation

The manufacturer shall submit two copies of the following documentation to the testing laboratory as well as the items to be tested - including one unit of the meter type tested for archival purposes (if requested by the testing laboratory):

- heat meter specification;
- technical description;
- statement of the self-heating effect of temperature sensors;
- qualifying immersion depth for temperature sensors;
- user's manual;
- installation instructions (EN 1434-1:2015, Clause 12);
- 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 lay out and operating instructions;
- initial functional check and instructions;
- test outputs, their use and their relationships to the parameters being measured.

Annex A
(informative)

Testing procedure for temperature sensor pairs with pockets and without pockets

A.1 Test set-up

A.1.1 General

This is a recommended procedure to ensure the best reproducibility.

A.1.2 Requirements of a temperature bath

A.1.2.1 General

In order to obtain comparable results and to optimize the reproducibility it is necessary that the temperature bath meets following requirements, especially for testing of temperature probes / pockets.

A.1.2.2 Temperature distribution

a) Block calibrators shall not be used because of the lower temperature reproducibility.

b) For the qualification of the bath the following parameters shall be checked in the work area:

   1) The temporal distribution σ_{temp};

   2) The local distribution σ_{loc};

   3) The depth distribution σ_{deep}.

The **temporal distribution** is obtained from the half of the maximum temperature deviation during the measurement time. The observation time should be longer than the measurement time for the samples to recognize the total deviation in the work area (measured with a thermometer on different positions).

The **local distribution** is measured with two thermometers (sufficient long-term stability), whereby one thermometer is at a fixed position (temperature Θ_{FIX}) and with the second thermometer different positions (temperature Θ_i) are checked in the work area. For every variable position the difference $\Delta\Theta_{FIX,i}$ of the average of the temperature on this position Θ_i and the fixed position Θ_{FIX} is calculated (The measurement values at every position shall be distributed normally). The local distribution of the work area is calculated by difference of the maximum $\Delta\Theta_{FIX,i}$ and minimum $\Delta\Theta_{FIX,i}$ (I = 1 … N; N = number of investigated positions).

The **depth distribution** is also measured with two thermometers, beginning at the same immersion depth. Then the second thermometer is positioned at different immersion depths, beginning at 20 mm immersion depth, to determine the distribution in the limits of the work area. This value is only determined to recognize, if the bath has a good mixing.

The combined uncertainty ($\sqrt{\frac{\sigma_{temp}^2}{3}+\frac{\sigma_{loc}^2}{3}}$) of the temporal and local distribution shall be in the following limits:

— For temperature < 90 °C: $\Delta\Theta$ < 10 mK (k = 2);

— for temperature ≥ 90 °C: $\Delta\Theta$ < 12 mK (k = 2).

In the sensor test area the error of the depth distribution shall be lower than 20 mK. Normally this part is not considered, because the measurements of the thermometers and pocket are carried out at the same immersion depth.

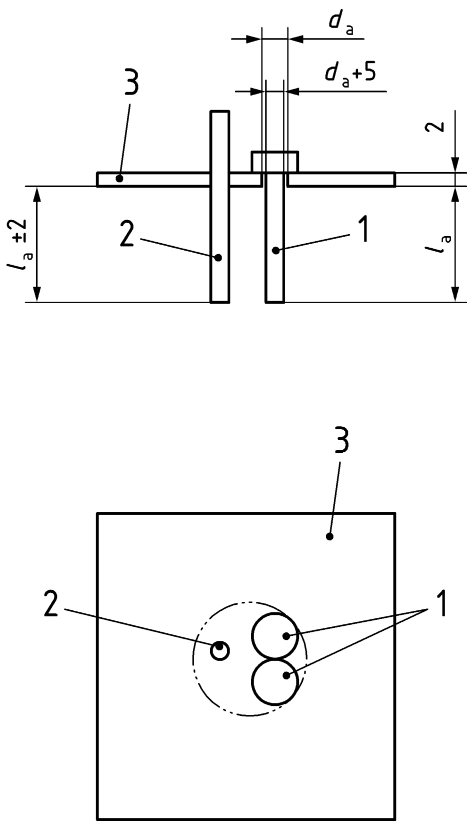
A.1.2.3 Liquid

Liquid shall be water up to 85 °C (temperatures above 85 °C should be avoided because of the vapour pressure of water) and glycerine above 85 °C and higher (silicone oil cannot be used, because the thermal characteristics are worse compared to glycerine and the heat dissipative error shall be increased).

Recommended ambient temperatures are (23 ± 1) °C for type testing and (23 ± 2) °C for initial verification.

No active ventilation shall be allowed near the bath during the measurements.

A.1.2.4 Test setup



Key

1 sensor pair / pockets under test (50 % of the pocket thread shall be over the metal lid)

2 reference sensor

3 metal lid (thickness 2 mm, stainless steel) not in thermal contact with the body of the bath (e.g. point fixing by plastic parts; no metal contact between the lid and the bath housing); but the bottom side of the lid shall be in contact with the liquid

Figure A.1 — Details of temperature bath

No thermal insulation shall be used over the metal lid.

The temperature probe and the pocket shall be installed with all installations-parts (e.g. screws, bushing, fixing adapters and with thermal insulation of ≥ 20 mm if the installation rule of the sensor has obligatory demand of insulation.)

A.2 Test sequence

At least 4 pairs shall be tested.

All measurements shall be carried out at a minimum of three different temperature levels.

The following demands for the test sequence for measurement at one temperature shall be fulfilled:

— The temperature sensor pair shall be submerged into the liquid, as indicated in Figure A.1 and the immersion depth corresponds to the immersion depth of the pocket;

— a measurement shall only be commenced after thermal stability has been achieved (including both liquid and self-heating generated by the measurement current);

— the measurements on the reference temperature sensor and the temperature sensor pair under test shall be carried out at the same time or repeated sequentially several times generating a mean value.

A.3 Calculations

a) The resistance values obtained during the complete test shall be used to calculate the three constants for the sensor under test in accordance with the temperature/resistance equation of EN 60751:

$$R\left(T\right)=R_0\times\left(1+A\times T+B\times T^2\right) \quad \text{(A.1)}$$

Thereby the characteristic for each sensor under test is determined.

b) The T error function based on the characteristic in a) and the characteristic based on the standard constants in EN 60751 shall be calculated for each sensor.

c) Based on the two T error functions in b) the errors (E_{pair}) between the two temperature sensors shall be calculated:

$$E_{\text{pair}}=f\left(\Delta\Theta_{\text{i}},\Delta\Theta_{\text{j}}\right) \quad \text{(A.2)}$$

where j is the index for the flow or the return temperature.

The worst case error in temperature difference of the temperature sensor pair under test (E_{pair}) shall be determined over the temperature range and over the temperature difference range specified for the pair. For return temperatures above 80 °C, only temperature differences of more than 10 K shall be taken into account.

Annex B
(informative)

Checklist for type approvals of heat meters according to EN 1434

Table B.1 — Checklist for type approvals of heat meters according to EN 1434

Clause of Part 1	Requirement	+	-	Remarks
	Notes:	X /	 X	The instrument has passed The instrument has failed Not applicable
6.1.2	The manufacturer of the heat meter shall declare any limitations with regard to installation of the heat meter and its orientation, with respect to the vertical.			
6.1.3	IP54 for heating applications and IP65 for cooling applications for equipment that is to be installed into pipework and IP52 for other enclosures.			
6.1.5	The maximum pressure loss at q_p shall not exceed 0,25 bar, except where the heat meter includes a flow controller or also acts as a pressure reducing device.			
6.2	Requirements outside the limiting values of the flow rate When the true value of the flow rate is less than a threshold value declared by the manufacturer, no registration is allowed. According to Part 1 Clause 6.2.			
	For flow rates greater than q_s, the behaviour of the meter, e.g. by producing spurious or zero signals, shall be declared. Flow rates greater than q_s shall not result in a positive error greater than 10 % of the actual flow rate.			
6.3.1	The quantity of heat shall be indicated in Joules, Watt-hours or in decimal multiples of those units. The name or symbol of the unit shall be indicated adjacent to the figures of the display.			
6.3.2	In the event of a failure or interruption of the external power supply (mains or external DC), the meter indication of energy shall remain accessible for a minimum of one year. The manufacturer shall specify how the indication of energy is handled in case of a failure or interruption in the external power supply (mains or external DC).			
6.3.3	The reading of the indication shall be sure, easy and unambiguous.			
6.3.4	The real or apparent height of the figures on the display for energy shall not be less than 4 mm.			
6.3.5	The figures indicating decimal fractions of a unit shall be separated from the others, either by a comma or by a point. In addition, the figures indicating decimal fractions of energy shall be clearly distinguishable from the others.			

Clause of Part 1	Requirement	+	-	Remarks
6.3.6	Where the display is of the roller-type, the advance of a figure of a particular significance shall be completed during the time, when the figure of next lower significance changes from 9 to 0. The roller carrying the figures of lowest significance may have a continuous movement, of which the visible displacement shall then be from bottom to top.			
6.3.7	The display indicating the quantity of heat shall be able to register, without overflow, a quantity of heat at least equal to the transfer of energy, which corresponds to a continuous operation for 3 000 h at the upper limit of the thermal power of the heat meter.			
	The quantity of heat, measured by a heat meter, operating at the upper limit of the thermal power for 1 h shall correspond to at least one digit of lowest significance of the display.			
6.4	Protection against fraud Heat meters shall have protective devices which can be sealed in such a way, that after sealing, both before and after the heat meter has been correctly installed, there is no possibility of dismantling, removing, or altering the heat meter or its adjustment devices without evident damage to the device(s) or seal(s).			
	Means shall also be provided for meters with external power supply, either to give protection against the meter being disconnected from the power supply, or to make it evident, that this has taken place. This requirement does not apply to meters with external power supply with automatic switchover to internal battery supply.			
6.5.1	AC mains operated heat meters or subassemblies shall have a rated voltage, U_n, of 230 V $^{+10\%}_{-15\%}$.			
6.5.2	Remote DC or AC operated heat meters or subassemblies shall have a rated voltage U_n of 24 V. The tolerance for DC shall be 12 V to 42 V and for AC 12 V to 36 V.			
	If the remote supply lines are also used for data transmission these values shall be maintained during any data transmission.			
6.5.3	Local external DC operated meters or subassemblies shall preferably have a rated voltage U_n of 6 V, 3,6 V or 3 V.			
7.2	Temperature difference The ratio of the upper and lower limits of the temperature difference shall not be less than 10, with the exception of heat meters intended for cooling circuits. The lower limit shall be stated by the manufacturer to be either 1, 2, 3, 5 or 10 K. The preferred lower limit is 3 K for heating applications.			
7.3	Flow rate The ratio of the permanent flow rate to the lower limit of the flow rate (q_p/q_i) shall be 10, 25, 50, 100 or 250.			

Clause of Part 1	Requirement	+	-	Remarks
11.1	Heat meter specification The manufacturer shall make available data sheets containing at least the following information:	/	/	
11.2	Flow sensor • Manufacturer • Type identification • Accuracy class; may differ depending on mounting orientation and on type of liquid • Environmental classification • Limits of flow rate (q_i, q_p and q_s). Different sets of q_i and q_s may be given depending on mounting orientation and type of liquid • Maximum admissible working pressure (PS in bar) • Nominal pressure (PN) • Maximum pressure loss (pressure loss at q_p) • Maximum admissible temperature • Limits of temperature (θ_{min} and θ_{max}). An additional set of limits for the cooling range may be specified for heating/cooling meters. • Nominal meter factor (litres/pulse or corresponding factor for normal and test output) • Installation requirements including installation pipe lengths, etc. • Basic mounting orientation and other specified orientations. • Physical dimensions (length, height, width, weight, thread/flange specification) • Pulse output device class (see EN 1434-2:2015, 7.1.3) • Output signal for testing (type/levels) • Performance at flow rates greater than q_s • Low flow threshold value • Liquid if other than water • Response time - for fast response meters • Mains power supply requirements - voltage, frequency • Battery power supply requirements - battery voltage, type, life-time • Nominal voltage level for external power supply • Current used (average and peak) at external power supply • Energy used per year at external power supply • Cabling requirement at external power supply (max. cable length and possible requirement for shielded or twisted cable) • Voltage limit at which the meter switches automatically from external power supply to internal battery • Time limit at which the meter switches automatically from external power supply to internal battery • P_{min}			

Clause of Part 1	Requirement	+	-	Remarks
11.3	Temperature sensor pair • Manufacturer • Type identification • Limits of temperature (θ_{min} and θ_{max}). An additional set of limits for the cooling range may be specified for heating/cooling meters. • Limits of temperature difference ($\Delta\Theta_{min}$ and $\Delta\Theta_{max}$). An additional set of limits for the cooling range may be specified for heating/cooling meters. • Maximum admissible working pressure for direct mounted sensors (PS in bar) • Maximum admissible temperature • Wiring of sensors (e.g. four or two wire) • Principle of operation • Maximum RMS value of sensor current • Physical dimensions • Installation requirements (e.g. for pocket mounting) • Maximum liquid velocity for sensor over 200 mm length • Total resistance of a 2-wire cable • Output signal for rated operation (type/levels) • Response time			
11.4	Calculator • Manufacturer • Type identification • Environmental classification • Maximum value of thermal power • Limits of temperature (θ_{min} and θ_{max}). An additional set of limits for the cooling range may be specified for heating/cooling meters. • Limits of temperature difference ($\Delta\Theta_{min}$ and $\Delta\Theta_{max}$). An additional set of limits for the cooling range may be specified for heating/cooling meters. • The conditions for switching between heating and cooling metering if applicable • Display unit options (MJ, kWh) • Dynamic behaviour (see EN 1434-2:2015, 5.4) • Other functions in addition to heat indication • Installation requirements including wiring of temperature sensors, indicating if screened cables are necessary or not • Physical dimensions • Mains power supply requirements - voltage, frequency • Battery power supply requirements - battery voltage, type, lifetime • Nominal voltage level for external power supply • Current used (average and peak) at external power supply			

Clause of Part 1	Requirement	+	-	Remarks
	• Energy used per year at external power supply • Cabling requirement at external power supply (max. cable length and possible requirement for shielded or twisted cable) • Voltage limit at which the meter switches automatically from external power supply to internal battery • Time limit at which the meter switches automatically from external power supply to internal battery • Handling of energy indication by external power failure (see 6.3.2) • Pulse input device class (see EN 1434-2:2015, 7.1.5) • Required input signal from temperature sensors • RMS value of temperature sensor current • Maximum permissible flow sensor signal (pulse rate) • Output signal for normal operation (type/levels) • Pulse output device class (see EN 1434-2:2015, 7.13) • Output signal for testing (type/levels) • Liquid if other than water • If the flow sensor shall be operated at the high or low temperature level			
11.5	Complete meters • Manufacturer • Type identification • Accuracy class ; may differ depending on mounting orientation and on type of liquid • Environmental classification • Display unit options (MJ, kWh) • Other functions in addition to heat indication • Maximum value of thermal power • Limits of flow rate (q_i, q_p and q_s). Different sets of q_i and q_s may be given depending on mounting orientation and type of liquid • Low flow threshold value • Maximum admissible working pressure for flow sensor (PS in bar) • Nominal pressure (PN) • Maximum pressure loss of flow sensor (pressure loss at q_p) • Maximum admissible temperature • Limits of temperature (θ_{min} and θ_{max}) of the flow sensor / temperature sensor pair. An additional set of limits for the cooling range may be specified for heating/cooling meters • Limits of temperature difference ($\Delta\Theta_{min}$ and $\Delta\Theta_{max}$). An additional set of limits for the cooling range may be specified for heating/cooling meters • The conditions for switching between heating and cooling metering if applicable • Installation requirements, including installation			

Clause of Part 1	Requirement	+	-	Remarks
	pipe lengths etc. • Basic mounting orientation and other specified orientations • Physical dimensions (length, height, width, weight, thread/flange specification) • Mains power supply requirements - voltage, frequency • Battery power supply requirements - battery voltage, type, lifetime • Handling of energy indication by external power failure (see 6.3.2). • Output signal for normal operation (type/levels) • Pulse output device class (see of EN 1434-2:2015, 7.1.3). • Output display/signal for testing (type/levels) • Performance at flow rates greater than q_s • Liquid if other than water • Dynamic behaviour (see of EN 1434-2:2015, 5.4). • Response time for the temperature sensor pair • If the meter shall be installed at the high or low temperature level • Response time - for fast response meters • Nominal voltage level for external power supply • Current used (average and peak) at external power supply • Energy used per year at external power supply • Cabling requirement at external power supply (max. cable length and possible requirement for shielded or twisted cable) • Voltage limit at which the meter switches automatically from external power supply to internal battery • Time limit at which the meter switches automatically from external power supply to internal battery • P_{min}			
12	Information to be delivered with the meter or sub-assemblies Installation instructions under the following headings shall include at least the following information	/	/	
12 a)	Flow sensor: • Flushing the system before installation • Install in inlet or outlet as stated on calculator • Minimum installation pipe length upstream and downstream • Orientation limitations • Need for flow straightener • Requirement for protection from risk of damage by shock and vibration • Requirement to avoid installation stresses from pipes and fittings			
12 b)	Temperature sensor pair			

Clause of Part 1	Requirement	+	-	Remarks
	• Possible need for symmetrical installation in the same pipe size • Use of pockets or fittings for temperature sensor • Use of thermal insulation for pipe and sensor heads			
12 c)	Calculator (and flow meter electronics) • Free distance around the meter • Distance between meter and other equipment • Need for adaptor plate to fit standardized holes			
12 d)	Wiring • Need for earth connection • Maximum cable lengths • Required separation between signal and power cables • Requirements for mechanical support • Requirements for electrical screening			
12 e)	Other • Initial function check and operating instructions • Installation security sealing			

Clause of Part 2	Requirement	+	-	Remarks
4	Temperature sensors	/	/	
4.2.2	Materials of temperature probe sheath and pocket The temperature pocket and the protective sheath of direct mounted probes shall be of a material that is adequately strong and resistant to corrosion and has the requisite thermal conductivity.			
4.2.3.4/6	Dimensions of probes, e.g. Figures 1, 2 respective 3			
4.3.3	Signal leads For signal leads, leads with strands can be used, or in the case of head probes, solid wires. The lead ends shall be precisely trimmed, if strands are used (e.g. by lead end sleeves). Solder-coating of the lead ends to prevent splicing is not permissible.			
	A soldered joint to connect the temperature probe signal lead to the calculator is only permitted in the case of non-interchangeable temperature probes.			
	For screened cables for temperature sensors there shall be no connection between the screen and the protecting sheet.			
4.3.4	Temperature sensors for the 2-wire method The length and cross sectional area of signal leads of paired resistance sensors of separable sub-assemblies shall be equal and shall be within the values given in Table 2.			
4.3.5	Temperature sensors for the 4-wire method The connections shall be clearly identifiable so that they cannot be confused.			
	A cross-section of 0,5 mm^2 is recommended for head sensors and a minimum cross-section of 0,14 mm^2 for cable sensors.			
5	Flow sensor	/	/	
5.2	Sizes and dimensions For each flow sensor size there is a corresponding value of the permanent flow rate q_p and a set of lengths as given in Tables 3 and 4.			
	Dimensions for the threaded end connections are specified in Table 4. Threads shall comply with EN ISO 228-1.			
	Flanged end connections shall comply with ISO 7005-1, ISO 7005-2 and ISO 7005-3 (as appropriate) for a nominal pressure corresponding to that of the flow sensor.			
5.3	Test signal output For test purposes, it is required that either high resolution pulses using an adaptor according to Annex B shall be provided, or data from a serial interface, as described in EN 1434-3, using an adapter (if necessary) shall be employed. The discrimination of these test outputs shall be such, that in a test at q_i, the measurement error resulting from the number of pulses is not greater than 0,8 %, and the test period of 1 h for sizes q_p.< 10 m^3/h or 1,5 h for $q_p \geq 10$ m^3/h, is			

Clause of Part 2	Requirement	+	-	Remarks
	not exceeded.			
	The nominal relationship between the signal emitted and the quantity measured shall be declared by the manufacturer.			
6	Calculator	/	/	
6.1	The casing of calculators intended for domestic use and wall mounting shall have maximum dimensions given in Figure 8. If the casing is large enough, the centre distances for the mounting holes shall be as in Figure 8. If the casing is smaller, an adapter plate shall be available.			
6.2.2	Terminals for signal leads The numbers specified shall be used for the inscriptions on the terminals provided. The terminals shall meet the following requirements: a) maximum cable cross-section 1,5 mm^2; b) distance between terminals 5 mm; c) suitable for stranded wire; d) the contact resistance for a two-wire Pt 100 transition between the terminal and the wire shall be ≤ 5 mΩ. The change in contact resistance with time shall be < 5 mΩ.			
6.2.3	Terminals for connection to the mains supply The numbers specified shall be used for the inscriptions on the terminals provided. Two or, preferably, three terminals shall be provided, which shall be suitable for stranded wire up to a cross-section of 2,5 mm^2. Cables with permanently fitted connections may also be used.			
6.3	Batteries If a heat meter has interchangeable batteries, they shall be replaceable without damaging verification markings. The life time of the batteries shall be declared by the manufacturer.			
6.5	Test signal output A high resolution energy signal is required for testing purposes. The resolution shall be sufficiently high so that at a test at the lower limit of temperature difference and/or flow rate, the additional error caused by the resolution of the energy signal can be shown to be insignificant. The nominal relationship between the high resolution signal and the energy reading shall be stated by the manufacturer.			
7	Complete meters The requirements given in Clauses 3 to 5 shall be applied where relevant.			
8	Interfaces between sub-assemblies The component values used verifies that the parameters in Tables 7 and 8 are fulfilled.			
9	Marking and security seals	/	/	
9.1.2	Temperature sensor pairs The following information shall appear in legible and			

Clause of Part 2	Requirement	+	-	Remarks
	indelible characters on the head or a separate security sealed plate: a) name of the manufacturer, or his trade mark; b) type - incl. Pt-designation (e.g. Pt 100), year of manufacture and serial number; c) limits of the temperature range (θ_{min} and θ_{max}). An additional set of limits for the cooling range may be specified for heating/cooling meters; d) limits of temperature differences ($\Delta\Theta_{min}$ and $\Delta\Theta_{max}$); An additional set of limits for the cooling range may be specified for heating/cooling meters; e) maximum admissible working pressure; f) if needed, identification of inlet and outlet temperature sensors.			
9.1.4	Flow sensor The following information shall appear in legible and indelible characters on the sensor or a security sealed plate: a) name of the manufacturer, or his trade mark; b) type, year of manufacture, serial number; c) meter factor; d) limits of temperature (θ_{min} and θ_{max}); An additional set of limits for the cooling range may be specified for heating/cooling meters; e) limits of flow rate (q_i, q_p and q_s) Different sets of q_i and q_s may be given depending on mounting orientation and type of liquid; f) one or two arrows to indicate the direction of the flow; g) the maximum admissible working pressure, PS in bar; h) nominal pressure, PN; i) the accuracy class; may differ depending on mounting orientation and on type of liquid; j) environmental class; k) heat conveying liquid if other than water; l) voltage level for external power supply.			
9.1.5	Calculator The following information shall appear in legible and indelible characters on the casing or a security sealed plate: a) name of the manufacturer, or his trade mark; b) type, year of manufacture, serial number; c) type of temperature sensors (e.g. Pt 100, Pt 500); d) limits of the temperature (θ_{min} and θ_{max}). An additional set of limits for the cooling range may be specified for heating/cooling meters; e) limits of temperature differences ($\Delta\Theta_{min}$ and $\Delta\Theta_{max}$). An additional set of limits for the cooling range may be specified for heating/cooling meters; f) meter factor for the flow sensor; g) flow sensor to be operated at the inlet or outlet temperature;			

Clause of Part 2	Requirement	+	-	Remarks
	h) environmental class; i) heat conveying liquid if other than water; j) voltage level for external power supply.			
9.1.6	Complete meter The following information shall appear in legible and indelible characters: a) name of the manufacturer, or his trade mark; b) type, year of manufacture and serial number; c) limits of the temperature (θ_{min} and θ_{max}). An additional set of limits for the cooling range may be specified for heating/cooling meters; d) limits of temperature differences ($\Delta\Theta_{min}$ and $\Delta\Theta_{max}$). An additional set of limits for the cooling range may be specified for heating/cooling meters; e) the limiting values of the flow rate (q_i, q_p and q_s) Different sets of q_i and q_s may be given depending on mounting orientation and type of liquid; f) meter to be installed in the inlet or outlet; g) one or more arrows to indicate the direction of the flow; h) the maximum admissible working pressure, PS in bar; i) nominal pressure, PN; j) the accuracy class; may differ depending on mounting orientation and on type of liquid; k) environmental class; l) heat conveying liquid if other than water; m) Voltage level for external power supply.			
9.2	Sites for marking Sites shall be provided for marks (e.g. legal status marks)			
9.3	Security seals see Part 1, 6.4	/	/	

Clause of Part 4	**Test description**	**+**	**-**	**Remarks**
	Temperature sensors	/	/	
7.4.4.1	Qualifying immersion depth			
7.4.4.2	Thermal response time			
7.4.4.4	Influence of pockets			
7.4.4.3	General testing			
7.8	Durability			
7.9.1	Damp heat, cyclic			
7.9.2 c)	Damp heat, steady-state			
	Flow sensor	/	/	
7.4.2.1	Performance test			
7.4.2.3	Test for electromagnetic type w. specified conductivity < 200 µS/cm			
7.4.2.4	Test for fast response meters			
7.5.3 a)	Dry heat			
7.6.3 a)	Cold			
7.7 a)	Static deviations in supply voltage			
7.8.2.2	Durability; basic test			
7.8.2.3	Durability; additional test			
7.9.1 a)	Damp heat, cyclic			
7.9.2 c)	Damp heat, steady-state			
7.10 a)	Short time reduction in supply voltage			
7.11.1 a)	Fast transients (burst)			
7.11.2 a)	Surge transients			
7.12 a)	Electromagnetic field			
7.13 a)	Electromagnetic field specifically caused by digital radio equipment			
7.14 a)	Radio frequency amplitude modulated			
7.15 a)	Electrostatic discharge			
7.16	Static magnetic field			
7.17 a)	Mains frequency magnetic field immunity test			
7.18	Internal pressure			
7.19	Pressure loss			
7.20.2 a)	Conducted emission on power AC lines			
7.20.3 a)	Conducted emission on signal and DC power lines			
7.20.4 a)	Radiated emission			
7.21 a)	24 h interruption in supply voltage			

Clause of Part 4	Test description	+	-	Remarks
7.22	Flow disturbances			
a)	Only for flow sensors with electronic devices			
	Calculator	/	/	
7.4.3	Performance test			
7.5.2	Dry heat			
7.6.2	Cold			
7.7	Static deviations in supply voltage			
7.9.1	Damp heat, cyclic			
7.10	Short time reduction in supply voltage			
7.11.1	Fast transients (burst)			
7.11.2	Surge transients			
7.12	Electromagnetic field			
7.13	Electromagnetic field specifically caused by digital radio equipment			
7.14	Radio frequency amplitude modulated			
7.15	Electrostatic discharge			
7.16	Static magnetic field			
7.17	Electromagnetic field at mains frequency			
7.20.2	Conducted emission on power AC lines			
7.20.3	Conducted emission on signal and DC power lines			
7.20.4	Radiated emission			
7.21	24 h interruption in supply voltage			
	Complete meter	/	/	
7.4.5	Performance test	/	/	
7.4.2.2	Flow rate test			
7.4.2.3	Test for electromagnetic type w. specified conductivity < 200 µS/cm			
7.4.2.4	Test for fast response meters			
7.4.3	Temperature and temperature different test			
7.5.4	Dry heat			
7.6.4	Cold			
7.7	Static deviations in supply voltage			
7.8.4	Durability			
7.9.1	Damp heat, cyclic			
7.9.2 c)	Damp heat, steady-state			
7.10	Short time reduction in supply voltage			
7.11.1	Fast transients (burst)			

Clause of Part 4	**Test description**	**+**	**-**	**Remarks**
7.11.2	Surge transients			
7.12	Electromagnetic field			
7.13	Electromagnetic field specifically caused by digital radio equipment			
7.14	Radio frequency amplitude modulated			
7.15	Electrostatic discharge			
7.16	Static magnetic field			
7.17	Electromagnetic field at mains frequency			
7.18	Internal pressure			
7.19	Pressure loss			
7.20.2	Conducted emission on power AC lines			
7.20.3	Conducted emission on signal and DC power lines			
7.20.4	Radiated emission			
7.21	24 h interruption in supply voltage			
7.22	Flow disturbances			
7.23	Mechanical classes			

Annex C
(informative)

Criteria for a fully developed flow profile

Reference: [5]. Task Force Laseroptical FLOW DIAGNOSTICS PTB-METAS-BEV-OPTOLUTION-ILA

To state fully developed velocity distributions it is recommended to use characteristic values for the so called Profile-, Asymmetry- and Turbulence factors and the Swirl angle. At least following measurements should be carried out in the test lines of the calibration facilities:

a) By comparison between fully developed flow profiles according to the theoretical velocity distributions for laminar flows according to HAGEN-POISEULLE resp. to GERSTEN&HERWIG/SCHLICHTING for turbulent flows with curves measured by state-of-the-art techniques, e.g. Laser-Doppler-Velocity, under at least horizontal and vertical centric traces, the deviations of the velocities at the AICHELEN' and centric points shall not be more than 5 %.

b) The measurement locations at the test bench shall be the same as for the locations of the flow sensors under test and additional at the inlet of the test bench with the maximum of diameter. Flow test points are at q_i, at 0,1 q_p and at q_p. Medium temperatures are at q_i: (20 ± 5) °C, at 0,1 q_p and at q_p: (50 ± 5) °C.

c) The tangential deviation (swirl angle) calculated by the tangential and radial velocities in flow direction shall not be more than 2°. The swirl angle shall be measured at q_p with the minimum diameter of the tube of the test bench, as the swirl angle will increase at q_p with the minimum diameter of the tube of the test bench.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2004/22/EC, MID

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 2004/22/EC, MID.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Directive 2004/22/EC, MID

Clause(s)/sub-clause(s) of this EN	**Essential Requirements (ERs) of Directive 2004/22/EC, MID**	**Qualifying remarks/Notes**
	Annex I, Essential Requirements, Definitions:	
Scope	Measurand	In scope of standard defined.
7 “Test and Measurements”	1.4.1 Basic rules for testing 1.4.2 Ambient humidity	

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Bibliography

[1] EN 60870-5, *Telecontrol equipment and systems — Part 5: Transmission protocols (IEC 60870-5)*

[2] EN 60068-3-8, *Environmental testing — Part 3-8: Supporting documentation and guidance — Selecting amongst vibration tests (IEC 60068-3-8)*

[3] EN 61000-6-1, *Electromagnetic compatibility (EMC) — Part 6-1: Generic standards — Immunity for residential, commercial and light-industrial environments (IEC 61000-6-1)*

[4] EN 61000-6-4, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments (IEC 61000-6-4)*

[5] *Guidelines for the Fluid Mechanical Validation of Calibration Test-Benches in the Framework of EN 1434 (March 2007). Task force Laseroptical FLOW DIAGNOSTICS PTB-METAS-BEV-OPTULUTION-ILA*

[6] ISO 4064-3:2014, *Water meters for cold potable water and hot water — Part 3: Test report format*

[7] CEN/TR 16911, *Heat meters — Recommendations for circulation water in industrial and district heating systems and their operation*

[8] OIML D11:2013, *General requirements for measuring instruments — Environmental conditions*

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