



BSI Standards Publication

Thermal energy meters

Part 4: Pattern approval tests

National foreword

This British Standard is the UK implementation of EN 1434-4:2015+A1:2018. It supersedes BS EN 1434-4:2015, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by A1 A1.

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Wärmezähler - Teil 4: Prüfungen für die
Bauartzulassung

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European foreword

This document (EN 1434-4:2015+A1:2018) has been prepared by Technical Committee CEN/TC 176 “Thermal energy 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of an identical text or by endorsement, at the latest by May 2019, and conflicting national standards shall be withdrawn at the latest by May 2019.

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

This document includes Amendment 1, approved by CEN on 2018-07-18.

This document supersedes A1 EN 1434-4:2015 A1.

The start and finish of text introduced or altered by amendment is indicated in the text by tags A1 A1.

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, A1 *Thermal energy meters* A1 consists of the following parts:

- *Part 1: General requirements*
- *Part 2: Constructional requirements*
- *Part 3: Data exchange and interfaces¹⁾*
- *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;

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

- 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;
- 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 organisations 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, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies pattern approval tests for A_1 thermal energy meters A_1 . A_1 Thermal energy meters A_1 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 A_1 thermal energy meter A_1 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.

A_1 EN 1434-1:2015+A1:2018, *Thermal energy meters — Part 1: General requirements* A_1

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+A1:2018](#) 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 [thermal energy meters](#) or their sub-assemblies shall not exceed the maximum permissible error, MPE specified in EN 1434-1.

When [thermal energy 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	$f_{\text{nom}} \pm 2 \%$		
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 $\pm 2,5$ 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 A_1 thermal energy meter A_1 .

6.3 Reference values for the measurand, RVM

6.3.1 General

For A_1 bifunctional thermal energy meters A_1 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:	$(0,7 \text{ to } 0,75) q_p$ in m^3/h	$(0,7 \text{ to } 0,75) q_p$ in m^3/h
Outlet temperature:	(50 ± 5) °C	(15 ± 5) °C

The conditions, mentioned in Table 2, are reference values for a complete A_1 thermal energy meter A_1 . 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 A_1 thermal energy meter's A_1 environmental class. See A_1 EN 1434-1:2015+A1:2018, Clause 10 A_1 .

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 $\theta_{\min}$.

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 [A1](#) EN 1434-1:2015+A1:2018, 5.10 [A1](#). It shall be tested that the specific MPE according to [A1](#) EN 1434-1:2015+A1:2018, 5.10.5 [A1](#) 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 [A1](#) thermal energy meter [A1](#), 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 A_1 thermal energy meters A_1 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	Damp heat, cyclic	X	X ^a	X	X	1
	7.9.2	Damp heat, steady-state	X ^c	X ^c		X	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	Electromagnetic field		X ^{a,b}	X ^b	X	3
NSFd	7.13	Electromagnetic 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

Test	Subclause	Exposure	Temperature sensor pair	Flow sensor	Calculating device	Complete meter	Item number
NSFa	7.18	Internal pressure		X		X	1
	7.19	Pressure loss		X		X	1
	7.20	Electromagnetic emission		X ^a	X ^b	X	3
	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 A_1 EN 1434-1:2015+A1:2018, Clause 9 A_1 .						
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 A_1 bifunctional thermal energy meters A_1 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 A_1 thermal energy meter A_1 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:

$$q_{1-10}^0 \%, q_2 \pm 5\%, q_3 \pm 5\%, q_4 \pm 5\% \text{ and } q_5^{+10\%}_0$$

where

$$q_1 = q_s \text{ and } q_5 = q_i, q_1/q_2 = q_2/q_3 = q_3/q_4 = q_4/q_5 = K$$

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	$\theta_{\min}$ to $\theta_{\min} + 5) ^\circ\text{C}$ (but not less than $10 ^\circ\text{C}$)	$(15 \pm 5) ^\circ\text{C}$	
b	$(50 \pm 5) ^\circ\text{C}$	$(5 \pm 1) ^\circ\text{C}$	
c	$(85 \pm 5) ^\circ\text{C}$		

The water temperature at the $\overline{A_1}$ thermal energy meter $\overline{A_1}$ 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 $\mu\text{S}/\text{cm}$.

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 $q_p \leq 2,5 \text{ m}^3/\text{h}$ 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 $(1 \pm 0,2) \text{ s}$.

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) $\theta_{outlet} = (\theta_{min}^{+5})$	$\Delta\theta_{min}, 5, 20, \Delta\theta_{RVM}$
b) $\theta_{outlet} = (\theta_{RVM} \pm 5)$	$\Delta\theta_{min}, 5, 20, \Delta\theta_{RVM}, \Delta\theta_{max}^a$
c) $\theta_{inlet} = (\theta_{max}^0)$	$20, \Delta\theta_{RVM}, \Delta\theta_{max}$
^a The level corresponding to $\Delta\theta_{max}$ shall be reduced if needed to be within θ_{max} .	

Table 6 — Testing temperatures for cooling applications

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

The maximum temperature for these tests shall not exceed θ_{max} .

Tolerances:

For all temperature differences: $\pm 20 \%$,

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 **[A1]** EN 1434-1:2015+A1:2018, Figure 1 **[A1]**.

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 **[A1]** EN 1434-1:2015+A1:2018, 5.10.5.1 **[A1]**, 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 $\pm 0,7$ 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 $\pm 0,3$ 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

$$\Theta_s - 5 \text{ K} \leq \Theta_s \leq \Theta_s + 5 \text{ K}$$

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 $\pm 1,0$ 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	$\theta_{\min}$ to $(\theta_{\min} + 10 \text{ K})$	
θ_2	$\frac{\theta_1 + \theta_3}{2} \pm 5 \text{ K}$	
θ_3	$\theta_{\max} \leq 150 \text{ }^{\circ}\text{C}$	$(\theta_{\max} - 10 \text{ K})$ to $\theta_{\max}$
	$\theta_{\max} > 150 \text{ }^{\circ}\text{C}$	$(\theta_{\max} - 20 \text{ K})$ to $\theta_{\max}$, but in any case more than $140 \text{ }^{\circ}\text{C}$

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 $80 \text{ }^{\circ}\text{C}$, 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 [A1](#) EN 1434-1:2015+A1:2018, 9.2.2.2 [A1](#).

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 [A1](#) EN 1434-1:2015+A1:2018, 9.2.2.2 [A1](#).

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 $\boxed{A_1}$ thermal energy meters $\langle A_1 \rangle$ 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: $(55 \pm 2) ^\circ\text{C}$

Duration: 2 h

The duration of the test commences, after the $\boxed{A_1}$ thermal energy meter $\langle A_1 \rangle$ 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 $\boxed{A_1}$ thermal energy meter $\langle A_1 \rangle$ 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: $\theta_{\min}$ and θ_{RVM}

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

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

7.5.3 Flow sensor

Water temperature: $(50 \pm 5) ^\circ\text{C}$ for heating applications and $(15 \pm 5) ^\circ\text{C}$ for cooling applications

Flow rates

- a) $(1 \text{ to } 1,2) q_i$
- b) $(0,7 \text{ to } 0,75) q_p$.

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.