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New variant of our flow sensor family for cooling, heat and combined heat/cooling installations

ULTRAFLOW® 44
DN15-125
5HX Series (Cooling)
2HX Series (Heat)

Do you prefer to have waterproof flow sensors for your cooling, heat or combined heat/cooling installation? And is it important for you to have a particular accurate flow sensor with documented accuracy?

Kamstrup has developed a new variant of the flow sensor family ULTRAFLOW® 44 (DN15-125, qp 1.5...100 m^3/h), which is the 5HX/2HX Series of ULTRAFLOW® 44 with **documented accuracy of ±0.5% at permanent flow qp**.

The 5HX/2HX Series provides all benefits of ULTRAFLOW® 44. It is, among other things, particularly well protected against condensing water and in general damage caused by humidity and water on the outside of the flow sensor. The IP class is IP68 including its electronics box.

On the one hand, this feature makes ULTRAFLOW® 44 prepared for even harsh climatic environments for cooling meters. On the other hand, water protection can also become a critical issue in some heat installations. Here, it becomes important that the electronics box is not only moved away from the flow sensor exposed to condensation, but is also encapsulated in a waterproof manner. This allows the whole ULTRAFLOW® 44 flow sensor including the electronics box to be submerged for up to 2 months and is also your right choice of flow sensor for challenging installations in very humid environments and in locations, which are periodically flooded.

The ULTRAFLOW® 44 – 5HX/2HX Series comes with a Danish BEK-1178 cooling approval (TS 27.02 014) and the European Measuring Instruments Directive (MID) heat approval (DK-0200-MI004-044), both based on EN 1434, which is the most advanced standard within measuring of heat and cooling energy. This ensures that they can, like other Kamstrup heat and cooling meters, be utilized for billing, because they have proven to measure correctly, they are durable and robust with respect to a variety of environmental influences like, for example, electromagnetic influences in the installation.

This technical brochure will illuminate in more detail what you can expect from ULTRAFLOW® 44 – 5HX/2HX Series and why a high accuracy is particularly important to the permanent (nominal) flow qp. For this purpose, the terminology of different ranges of the flow sensor as well as accuracy classes are explained in technical detail. Based on these facts, the added value of higher accuracy where it counts for the 5HX/2HX Series will become obvious.

Working, operating and measuring range

All physical instruments have a (technical) **working range**, which they are suitable for. Among other things, this means that they will not be damaged and there will be no physical risks when utilizing the instruments within the technical working range. An example could be a flow sensor, which is suitable to be filled with water up to a given pressure and temperature.

A flow sensor is a measuring instrument with a given **operating range**. The operating range is, in this case, defined by a cut-off flow by which the instrument starts to measure and transmit a corresponding measurement signal and a maximum flow by which an often linear relation between the measurement signal and the measurand (the flow) stops. Thus, in case of measurements (e.g. flow) outside the operating range, the measuring instrument (e.g. flow sensor) is simply not operating according to the purpose of a measuring instrument anymore. Note that the operating range of a flow sensor is often also called the total dynamic range.

Finally, the **measuring range** of the instrument is defined according to [1] as a "set of values of quantities of the same kind that can be measured by a given measuring instrument or measuring system with specified instrumental measurement uncertainty, under defined conditions". In other words, this means for the flow sensor that limits for the minimum and maximum flow and corresponding limits of errors of the instrument are well-defined in this range. According to EN 1434, the measuring range is covered by the dynamic range given as ratio of permanent flow qp and minimum flow qi and the ratio of maximum flow qs and permanent flow qp. The limits of errors of a measuring instrument are determined by "accuracy classes" [2], which is outlined in more detail in Figure 1.

Figure 1 illustrates the operating and measuring ranges for a flow sensor with a nominal flow of qp 1.5 m^3/h as an example. Kamstrup flow sensors already start to measure at very low flow, which is called the cut-off flow. At even lower flow rates, i.e. below the cut-off flow, Kamstrup flow sensors are not measuring at all, but at these low flow rates, the water is almost not moving and can thereby not contribute to the transfer of significant amounts of thermal energy. The flow sensors are functioning until they reach a maximum flow, which corresponds to approximately 125 Hz for ULTRAFLOW®, which is emitting volume-proportional pulses.

This maximum flow can be found in the corresponding technical descriptions. At flow above this maximum flow, Kamstrup flow sensors continue to measure and register this maximum flow. For ULTRAFLOW®, this means that it will maintain its maximum pulse frequency. The range between the cut-off flow and the maximum flow is the total dynamic range. EN 1434 defines a minimum flow rate qi [3] as the rate "above which the thermal energy meter shall function without the maximum permissible errors being exceeded" and an upper flow rate qs [4] as the rate "at which the thermal energy meter shall function for short periods (< 1 h/day; < 200 h/year), without the maximum permissible errors being exceeded." Note that these flow values belong to a group of test flows under type approval according to EN 1434. Therefore, this range is often called the approved dynamic range. Note that there is often a difference between the approved dynamic range and the marked dynamic range indicated on the type label. This difference has consequences for legal reverifications and market surveillance, but technically all instruments are equally good.

1) 4.7 of JCGM 200:2012, International vocabulary of metrology – Basic concepts and associated terms (VIM)
2) 4.25 of JCGM 200:2012, International vocabulary of metrology – Basic concepts and associated terms (VIM)
3) Clause 5.3.3 of EN 1434-1:2015
4) Clause 5.3.1 of EN 1434-1:2015

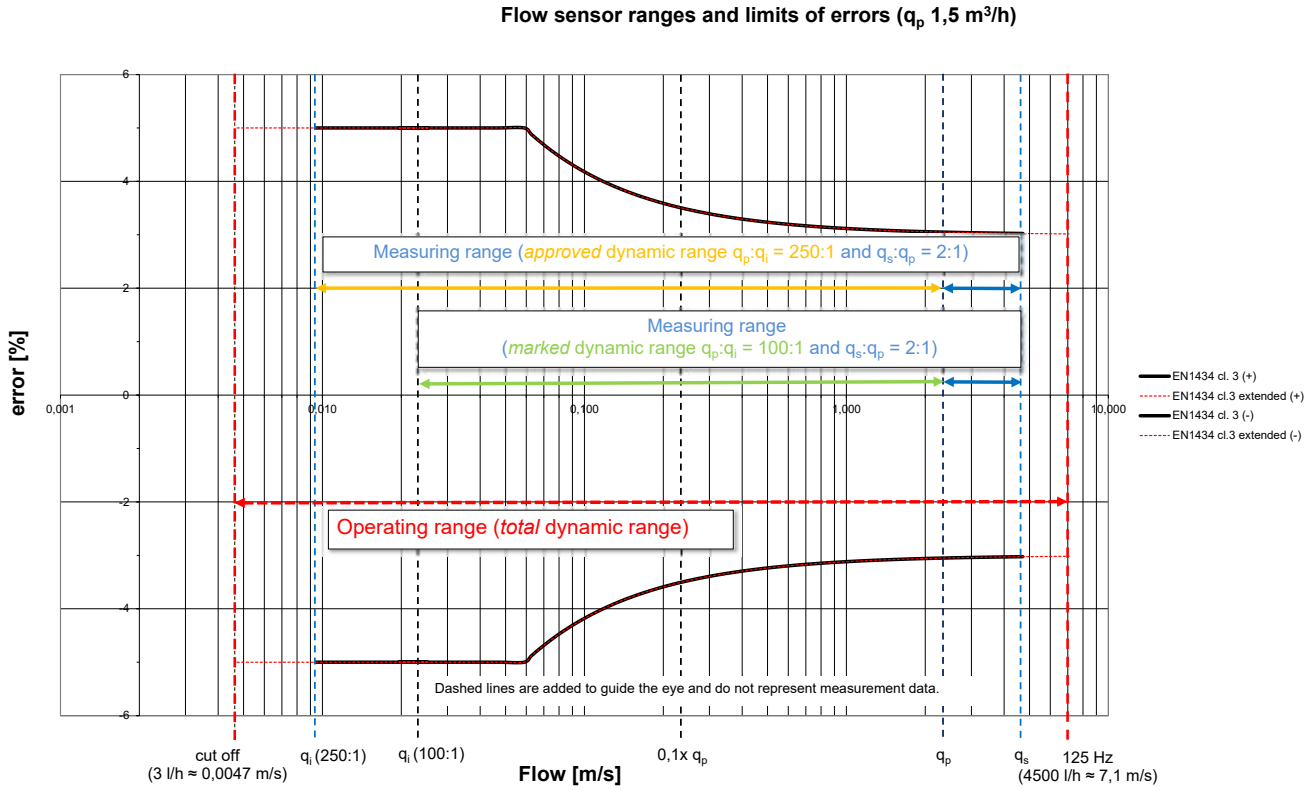


Figure 1: Operating (total dynamic) range and measuring (dynamic) range of a flow sensor with qp 1.5 m³/h.

Accuracy classes and limits of errors

According to EN 1434, the limits of acceptable errors of the measuring instrument are called the maximum permissible error (MPE).

The MPE of the flow sensors is defined according to accuracy classes [5] as shown in Equation 1:

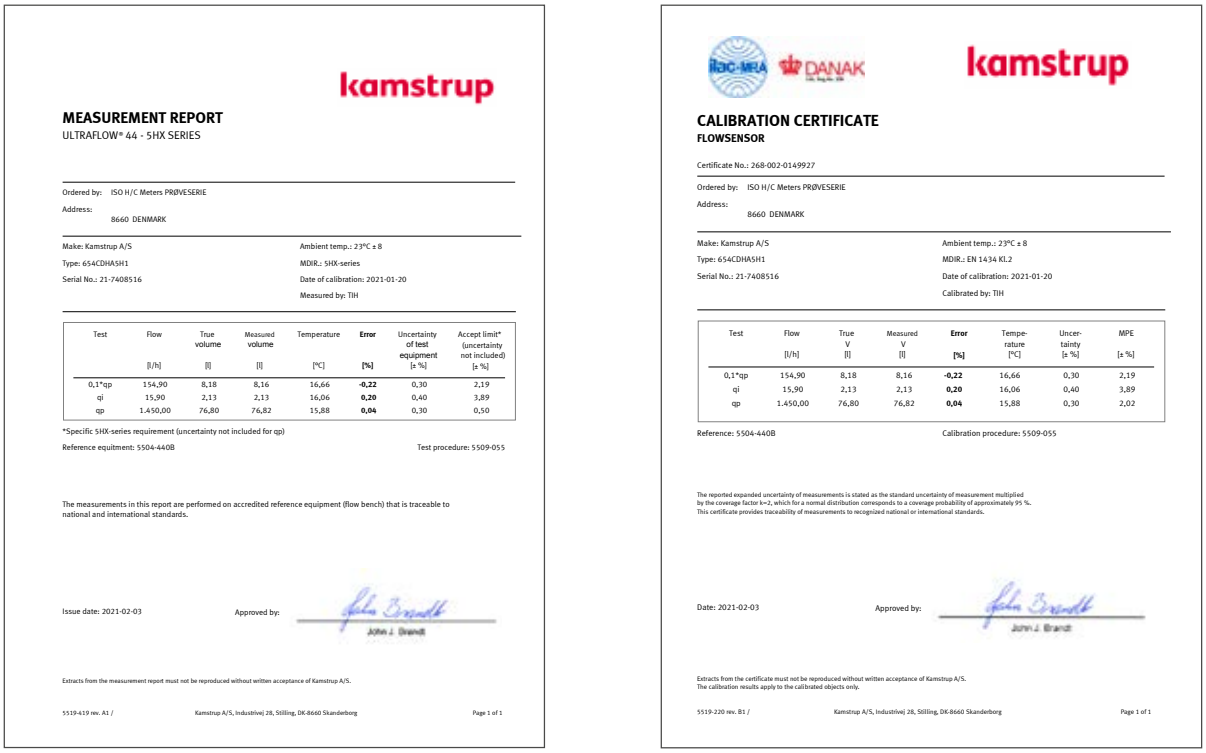
Class 1: $E_f = \pm (1 + 0.01\ q_p/q)$, but not more than ± 5%
Class 2: $E_f = \pm (2 + 0.02\ q_p/q)$, but not more than ± 5%
Class 3: $E_f = \pm (3 + 0.05\ q_p/q)$, but not more than ± 5%

Equation 1: Maximum permissible errors E_f for flow sensors for different accuracy classes according to EN 1434.

In Figure 1, the MPE of the accuracy class 3 is plotted as an example versus flow. Note that there are no legal requirements for the range outside the approved dynamic range. However, the red dashed lines indicate a reasonable extended maximum permissible error for the total dynamic range of the flow sensor. Figure 3 covers the same range as shown in Figure 1 but has focus on illustrating different accuracy classes and in particular the accept limits of the 5HX/2HX Series with particular accuracy at the permanent flow rate qp [6], "which is the highest flow rate, at which the thermal energy meter shall function continuously without the maximum permissible errors being exceeded." In addition to the MPE of the accuracy class 3, the MPE of the accuracy class 2 is plotted in figure 3. The indicated error of Kamstrup flow sensors during initial verification on an accredited flow bench will typically be within half of the MPE of the accuracy class 2.

With the 5HX/2HX Series of ULTRAFLOW® 44, we go even beyond that.

Every single ULTRAFLOW® 44 flow sensor will be initially verified at flows qi, 0.1 qp and qp on an accredited flow bench at Kamstrup (accredited laboratory DK 268). Depending on the test result, the 5HX/2HX Series will be fine-adjusted to ensure the indicated error of a subsequent qp test being within ±0.5% [7]. Kamstrup can document the test result with a dedicated measurement report or with the DANAK accredited calibration certificate, stating that the individual flow sensor has been tested on an accredited flow bench at permanent flow qp with an accuracy of ±0.5 %, which means that the indicated error at that flow is within ±0.5%. The documents can be ordered together with the meter in paper or by email. The measurement report is provided as standard. Kamstrup can provide the test results up to 10 years after delivery of the meter.



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MEASUREMENT REPORT
ULTRAFLOW® 44 - 5HX SERIES

Ordered by: ISO H/C Meters PRØVESERIE
Address: 8660 DENMARK

Make: Kamstrup A/S
Type: 654CDHASH1
Serial No.: 21-7408516

Ambient temp.: 23°C ± 8
MDIR.: 5HX-series
Date of calibration: 2021-01-20
Measured by: TIH

Test	Flow [l/h]	True volume [l]	Measured volume [l]	Temperature [°C]	**Error [%]**	Uncertainty of test equipment [± %]	Accept limit* (uncertainty not included) [± %]
0,1*qp	154,90	8,18	8,16	16,66	**-0,22**	0,30	2,19
qi	15,90	2,13	2,13	16,06	**0,20**	0,40	3,89
qp	1.450,00	76,80	76,82	15,88	**0,04**	0,30	0,50

*Specific 5HX-series requirement (uncertainty not included for qp)
Reference equitment: 5504-440B
Test procedure: 5509-055

The measurements in this report are performed on accredited reference equipment (flow bench) that is traceable to national and international standards.

Issue date: 2021-02-03
Approved by: John J. Brandt

Extracts from the measurement report must not be reproduced without written acceptance of Kamstrup A/S.

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CALIBRATION CERTIFICATE
FLOWSENSOR

Certificate No.: 268-002-0149927
Ordered by: ISO H/C Meters PRØVESERIE
Address: 8660 DENMARK

Make: Kamstrup A/S
Type: 654CDHASH1
Serial No.: 21-7408516

Ambient temp.: 23°C ± 8
MDIR.: EN 1434 Kl.2
Date of calibration: 2021-01-20
Calibrated by: TIH

Test	Flow [l/h]	True V [l]	Measured V [l]	**Error [%]**	Tempe-rature [°C]	Uncer-tainty [± %]	MPE [± %]
0,1*qp	154,90	8,18	8,16	**-0,22**	16,66	0,30	2,19
qi	15,90	2,13	2,13	**0,20**	16,06	0,40	3,89
qp	1.450,00	76,80	76,82	**0,04**	15,88	0,30	2,02

Reference: 5504-440B
Calibration procedure: 5509-055

The reported expanded uncertainty of measurements is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95 %.
This certificate provides traceability of measurements to recognized national or international standards.

Date: 2021-02-03
Approved by: John J. Brandt

Extracts from the certificate must not be reproduced without written acceptance of Kamstrup A/S.
The calibration results apply to the calibrated objects only.

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Figure 2: Dedicated Measurement Report for the 5HX Series (example) and Calibration Certificate, which both document that the indicated error of the flow sensor has been within ±0.5%.

5) Clause 9.2.2.3 of EN 1434-1:2015
6) Clause 5.3.2 of EN 1434-1:2015
7) Uncertainties of the test method are not considered.

The permanent flow qp is particularly important in many applications. However, to provide additional information about the flow sensor performance at different flows, we also indicate typical empirical standard deviations of the 5HX/2HX Series at certain flows with squares. Kam-Sigma is, finally, showing a trend line following these observed empirical standard deviations based on many tests in the flow laboratory DK268.

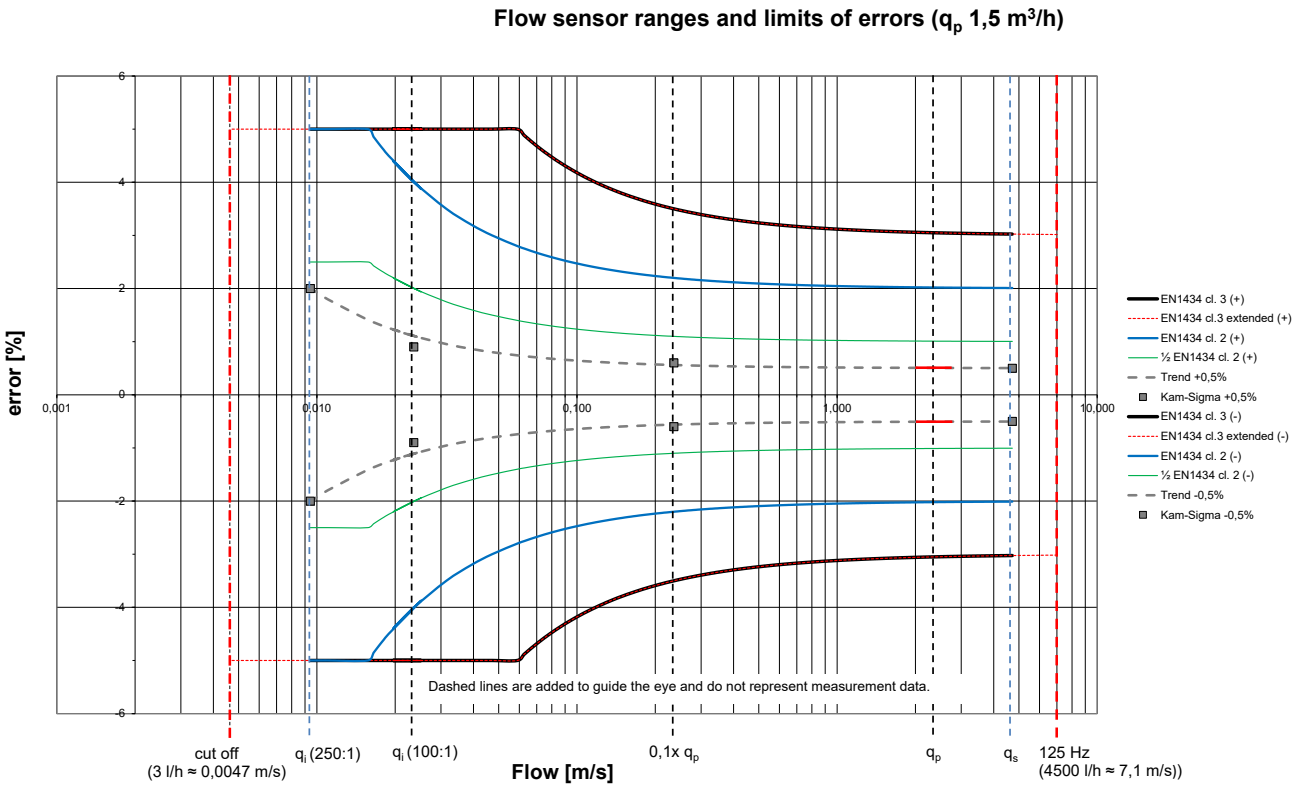

Figure 3: Limits of errors according to EN 1434 and for the 5HX Series in particular.

High accuracy where it counts

As outlined above in detail, your heat or cooling meter from Kamstrup is of course measuring accurately in the whole measurement range and thereby counting the consumed thermal energy correctly. This is why it can be used for billing. However, in general, it makes sense to pay extra attention to the accuracy of your meter in the limited range in which it is typically operating.

According to our installation recommendations, the permanent flow qp can, in many cases, be considered as a typical operation flow. The time period with higher flow in the installation should in general be limited according to EN 1434 and is often also in praxis technically limited by the difficulty to maintain a sufficient static pressure in the installation. In case that the typical flow in the installation is significantly lower than qp, a meter with a smaller qp might have been the better choice for that installation. In general, we recommend to equip your installation with a flow sensor of a size where the maximum flow in the system does not exceed the permanent (nominal) flow of the flow sensor.

For cooling meters (5HX Series), the following must in particular be taken into account. The transferred thermal energy is calculated in the meter according to Equation 2. This applies of course to both heat and cooling meters.

$$E = V \times k \times \Delta\theta$$

Equation 2: Simplified energy calculation for thermal energy meters according to EN 1434. V = volume, k = thermal coefficient, $\Delta\theta$ = temperature difference between inlet and outlet.

In a cooling installation, the temperature change $\Delta\theta$ of the medium water is typically rather low. It is here where the pair of temperature sensors with an approved temperature change of $\Delta\theta_{min}$ = 3 K sets a limit for legal measurements. A sufficient thermal energy exchange in a cooling installation thus requires a fairly high volume V. To cool down sufficiently fast, the transferred power must be high corresponding to a (permanent) high flow q.

In summary, the permanent flow qp can be considered as typical for many heat installations (2HX Series) and even more for cooling installations (5HX Series). Therefore, with the 5HX/2HX Series, it makes sense to pay extra attention to the accuracy of your flow sensor at that flow. This is what we call extra accuracy where it counts.

ULTRAFLOW® 44 is your right flow sensor for heat meters in case that

- You need extra condensation protection of your flow sensor (IP68) in your installation
- Your installation becomes temporarily flooded (for up to 2 months)
- You prioritize to have the opportunity to directly mount a temperature sensor in the flow sensor, also in the flanged meters qp 6 m^3/h (DN25 x 260 mm) and qp 10 m^3/h (DN40 x 300 mm)
- You prioritize to reduce the pressure loss of your flanged flow sensor qp 6 m^3/h (DN25 x 260 mm) by more than one half to only 0.06 bar @ qp

ULTRAFLOW® 44 is your right choice for cooling meters, because

- It reduces loss of your valuable and cost-intensive heat or cooling energy
  ULTRAFLOW® 44 is waterproof (IP68) and allows to be completely insulated.
- It reduces your installation costs
  With the ability to mount one temperature sensor directly in the flow sensor (qp 1.5...10 m^3/h), an additional ball valve, T-piece or similar becomes unnecessary in new installations.
- It reduces the pressure loss (and thereby operation costs for pumps) in your installation
  Flow sensors with qp 1.5 and 6 m^3/h have reduced their pressure loss by more than one half to below 0.1 bar @ qp.
- It ensures to bill also low quantities of cooling energy correctly
  The approved dynamic range for most of the types is qp:qi = 250:1.

Additional values of the 5HX/2HX Series of ULTRAFLOW® 44

- High accuracy where it counts
  The 5HX/2HX Series of ULTRAFLOW® 44 gives you the documented high accuracy of 0.5% right where it counts, at the permanent flow qp.

New variant of our flow sensor family for cooling, heat and combined heat/cooling installations

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Kamstrup A/S
Industrivej 28, Stilling
DK-8660 Skanderborg
T: +45 89 93 10 00
F: +45 89 93 10 01
info@kamstrup.com
kamstrup.com