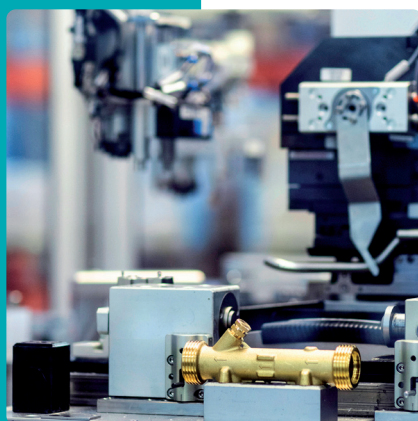


Heat sample test report 2026

## Result of sampling-controlled heat meters in 2025

- Heat metering with ultrasound technology
- Completed by accredited laboratory at Kamstrup A/S



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## Introduction

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Since 1991, Kamstrup has produced and delivered meters for heat metering based on the ultrasound principle. Today, Kamstrup's ultrasonic meters cover the flow range from 0.6 to 1,000 m<sup>3</sup>/h. A large part of these have been installed in Danish district heating systems, but many have also been exported to the Northern, Central and Eastern European markets.

The Danish district heating market is thus among the markets that were first on the forefront of changing meter technology from mechanical meters to static meters, primarily of the ultrasonic type. Therefore, the utilities have an understandable interest in documenting that the static ultrasonic meters are more precise and long-term stable than their mechanical competitors. In particular, the precision and long-term stability are among the most important parameters when selecting meters.

All Danish district heating utilities are committed to establish a control system that is built in such a way that it is secured that meters in operation do not exceed the permitted usage tolerances. For this purpose, the heat utilities divide their meter populations into lots, take down meters from the lots on the basis of sample tests and send these to an accredited laboratory for control.

This report is a follow-up on the reports from the years 1999 up to and including 2025. The report represents the results for the tested meters in 2025 where sample tests have been performed on 149 lots of meters. They represent a total of 2,982 meters in operation.

Sample tests are taken in accordance with ISO 2859 AQL4, inspection level II, which secures that less than 4 % of the lot deviate from the sample test limits.

For the lot to obtain an extension of the operational period for 9 years, Danish regulation requires that the measurement results are within the original verification limits. The lot can have its operation period extended for 6 years if the sample test does not meet the original verification limits, but is within the operation control limit. If this is not met either, the whole lot must be taken down and controlled in accordance with the verification limits and exchanged or refurbished within a year.

Results from the ultrasonic sensors are presented, partly for the year, partly accumulated from 1999, in the form of curves showing where measuring errors are found on the various measurement points.

## Measurement method

The meters are taken down by Danish district heating utilities and sent to Kamstrup's accredited meter laboratory.

The flow sizes of the meters are 1.5 m<sup>3</sup>/h. The numbers are not corrected for any deviations caused by special operating conditions in the individual district heating utilities.

It should be noted that all tested lots represent ordinary laboratory work for the district heating utilities, and the meters have thus not been taken down especially for this report. Samples are taken out according to CLM.VARME.01, edition 1, version 2.2 from 2019-12-18.

Term	MV	DS	CEN	PTB
Minimum volume flow rate	Q <sub>i</sub>	QV min	q <sub>i</sub>	Q <sub>min</sub>
Maximum volume flow rate	Q <sub>p</sub>	QV max	q <sub>p</sub>	Q <sub>n</sub>

The metrological guide CLM.VARME.01, edition 1, version 2.2 from 2019-12-18 describes in detail the implementation of self-inspection of heat meters. It describes best practice that is based on many years of experience at the Danish Center for Legal Metrology (CLM). It takes its starting point in guideline no. 9464 of 20 June 2018 from the Danish

Safety Technology Authority about the device owner's self-inspection of water, electricity and heat meters in operation included in the act no. 582 of 28 May 2018 from the Danish Safety Technology Authority about the use of measuring instruments for measuring the consumption of water, gas, electricity or heat.

### Scheme 2: Household Complete meter

As a minimum, the meters are controlled with the three different flows stated below with associated temperature differences.

	Verification error limit	Centre point	Usage tolerance
1. Lower test point. $1 \times q_{50:1} \leq q \leq 1,2 \times q_{50:1}$ at $38 \text{ K} \leq \Delta\Theta \leq 42 \text{ K}$	± 6.3 %	± 9.5 %	± 12.6 %
2. Centre test point. $0,1 \times q_p \leq q \leq 0,11 \times q_p$ at $16 \text{ K} \leq \Delta\Theta \leq 22 \text{ K}$	± 5.0 %	± 7.5 %	± 10.0 %
3. Upper test point. $0,9 \times q_p \leq q \leq 1,1 \times q_p$ at $8 \text{ K} \leq \Delta\Theta \leq 10 \text{ K}$	± 5.2 %	± 7.8 %	± 10.4 %

Table 1 Measurement limits and tolerances, dynamic range as of 2019.

The controls are performed at a water temperature of 50 °C ± 5 °C, unless otherwise stated in the type approval. However, 40 °C ± 3 °C can be used if the operating conditions justify this. The tolerances are set at an  $\Delta\Theta_{\text{min}}$  of 3 K.

In legislation, the accuracy requirements are set as "floating values" that depend on the selected measuring points. The stated values thus only apply to the defined measuring points.

## Sample test results

The measuring results are from sampling-controlled Kamstrup meters in 2024.

Table 2 shows the results of the meters, divided into 4 error groups according to 4 new items.

- > Usage tolerance
- < Usage tolerance
- < Central point
- < Verification limits

Ultrasonic meters are 1.5 m<sup>3</sup>/h with the dynamic range qi:qp 1:100.

This composition reflects the total meter population.

At the same time, the composition shows the field of application when the meters' dynamic range has been taken into account.

> Usage tolerance	< Usage tolerance	< Central point	< Verification limits	Total number of meters
5	1	5	2,971	2,982

Tabel 2

\* Number of units in the error group ">Usage tolerance" :

- 1 meter from 2006
- 1 meter from 2007
- 1 meter from 2011
- 1 meter from 2014
- 1 meter from 2015

Table 2 shows the measuring results from table 1 converted into consequences for the underlying meter lots.

Table 3 shows the length of operation extension that the meter lots have obtained.

Dismounted within 1 year	3 years extension	6 years extension	9 years extension	Total number of lots
1 [33 meters]	0	0	148 [57,068 meters]	149

Tabel 3

Figure 1 shows in percent the number of lots for which the operating time has been extended by 1 year, 3 years, 6 years and 9 years.

Kamstrup meters [1.5 m<sup>3</sup>/h].

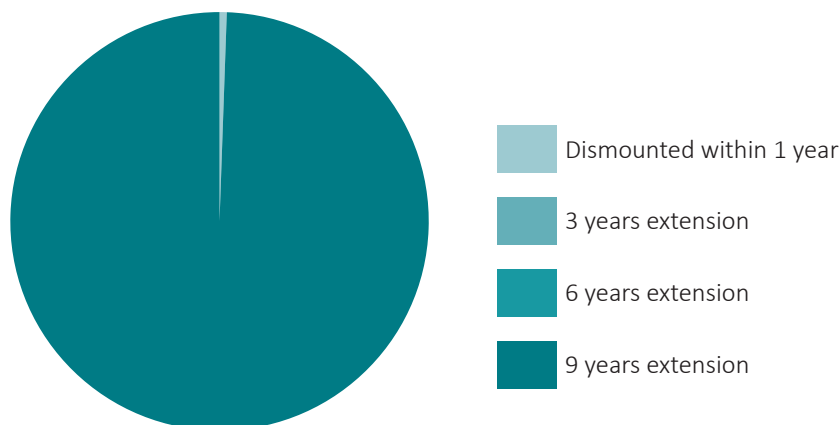


Figure 1

**How good are Kamstrup’s ultrasonic sensors after many years of operation?**

The measuring results for the ultrasonic meters are shown for the actual measurement points.

The numbers are based on the tested meters in the yearly report.

The accumulated results of the tested meters from 1999 up to and including 2025 appear in the section “Postscript” in this report.

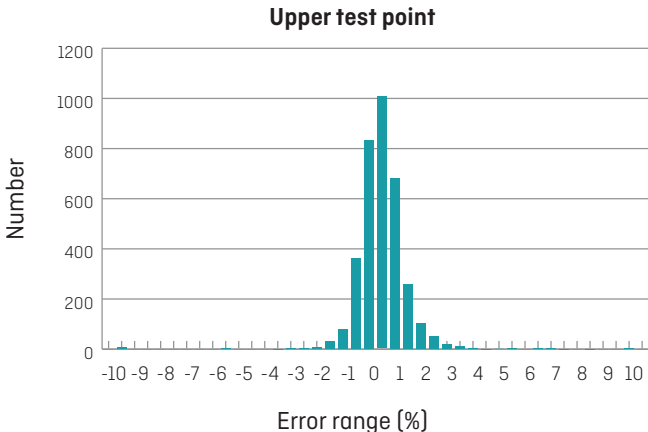


Figure 2

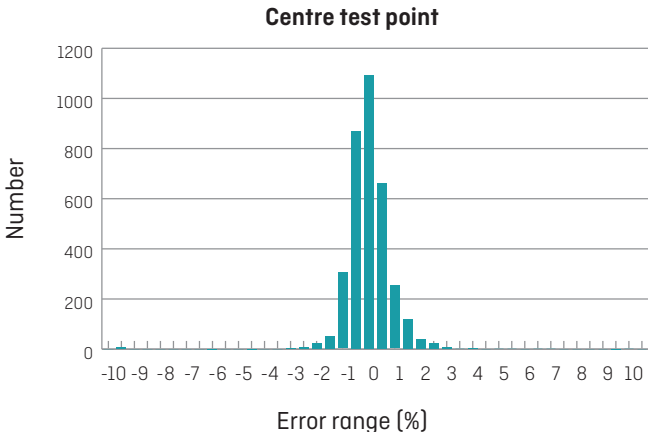


Figure 3

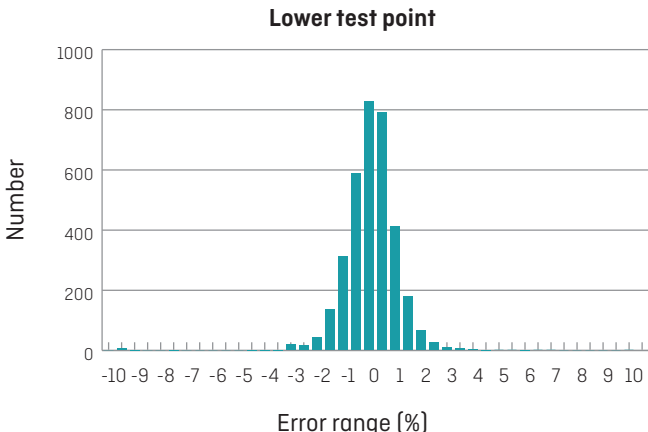


Figure 4

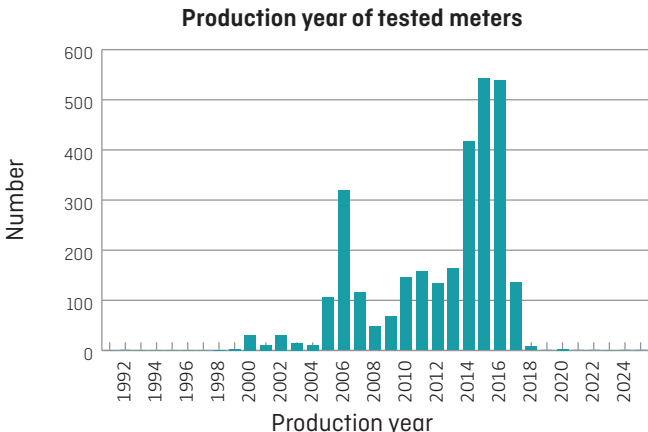


Figure 5

## Conclusion

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As it appears from table 2, the measuring results of the ultrasonic meters show stability over the last year as more than 99 % lie within the very strict limit values.

The calculation is based on lots that have been subject to a sample test in 2025 and here, it is shown very clearly that 99,9 % of the meters have obtained an operation extension of additional 9 years, despite some meters being up to 27 years old.

The long-term stability of the ultrasonic principle has been documented through the results of the latest years. The long-term stability and the long life of ultrasonic meters ensure the lowest possible meter costs for the consumer and the heat utility.

The reliability and the stability of the meters are important factors as they ensure that the supplied energy is measured correctly and that billing is thus taking place on the correct basis. A long-term stable meter that does not, over time, measure more and more inaccurately at the same time secures the heat utility against an always creeping billing loss.

## Postscript

Accumulated results of the sample tests from 1999 up to and including 2025.

The meters that have been sample-tested for control purposes in this report are of Kamstrup's first, second, third and fourth generation of ultrasonic sensors. From 1999 to 2025, 65,284 ultrasonic sensors have been subject to sample tests.

The ultrasonic meters that are produced today have been improved in many areas, which additionally ensure the long-term stability, especially in qi that, from experience, can be problematic.

We will continuously collect results from the control measurements and in that way continue to expand the documentation of the accuracy and stability of Kamstrup's meters.

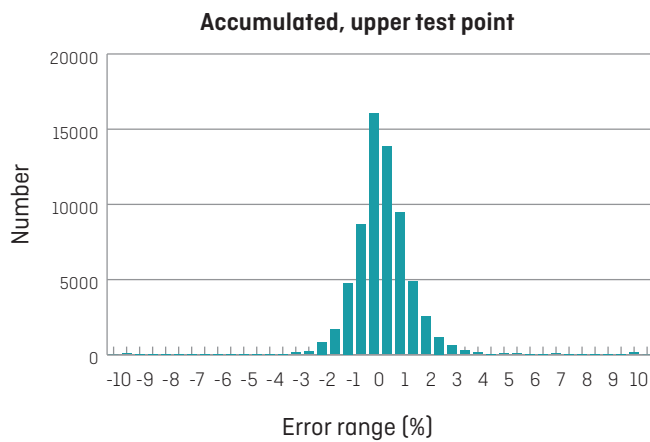


Figure 6

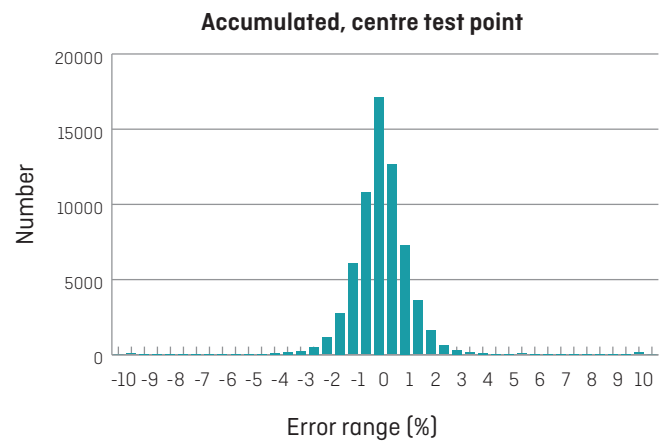


Figure 7

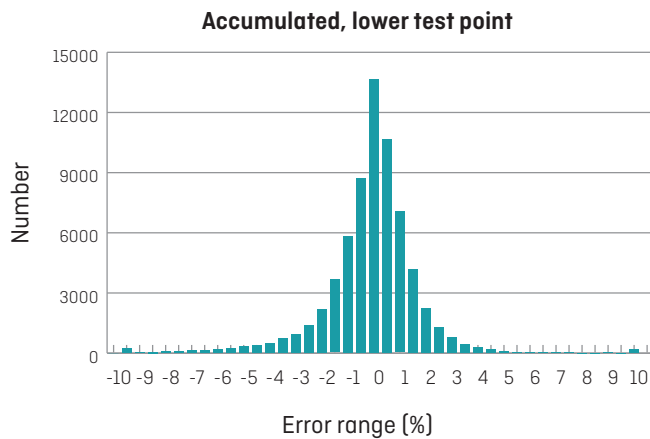


Figure 8

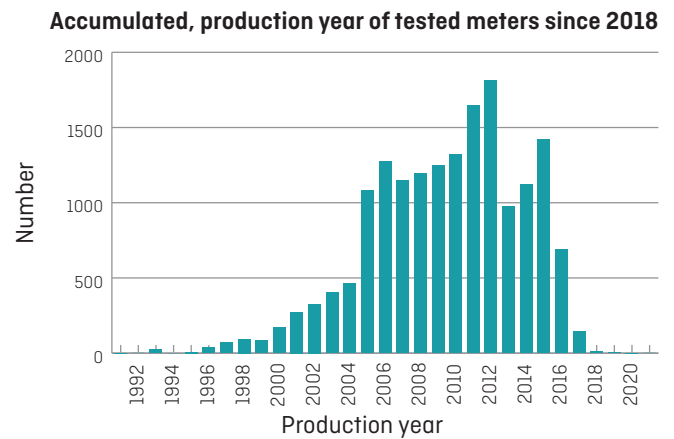


Figure 9

# Heat sample test report 2026

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