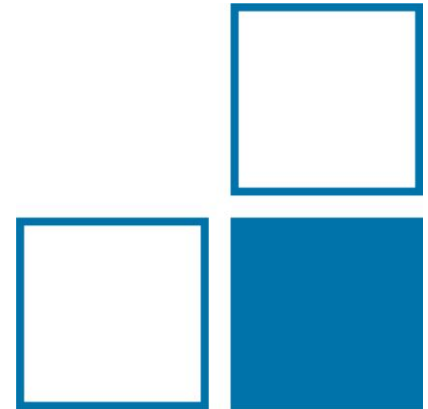
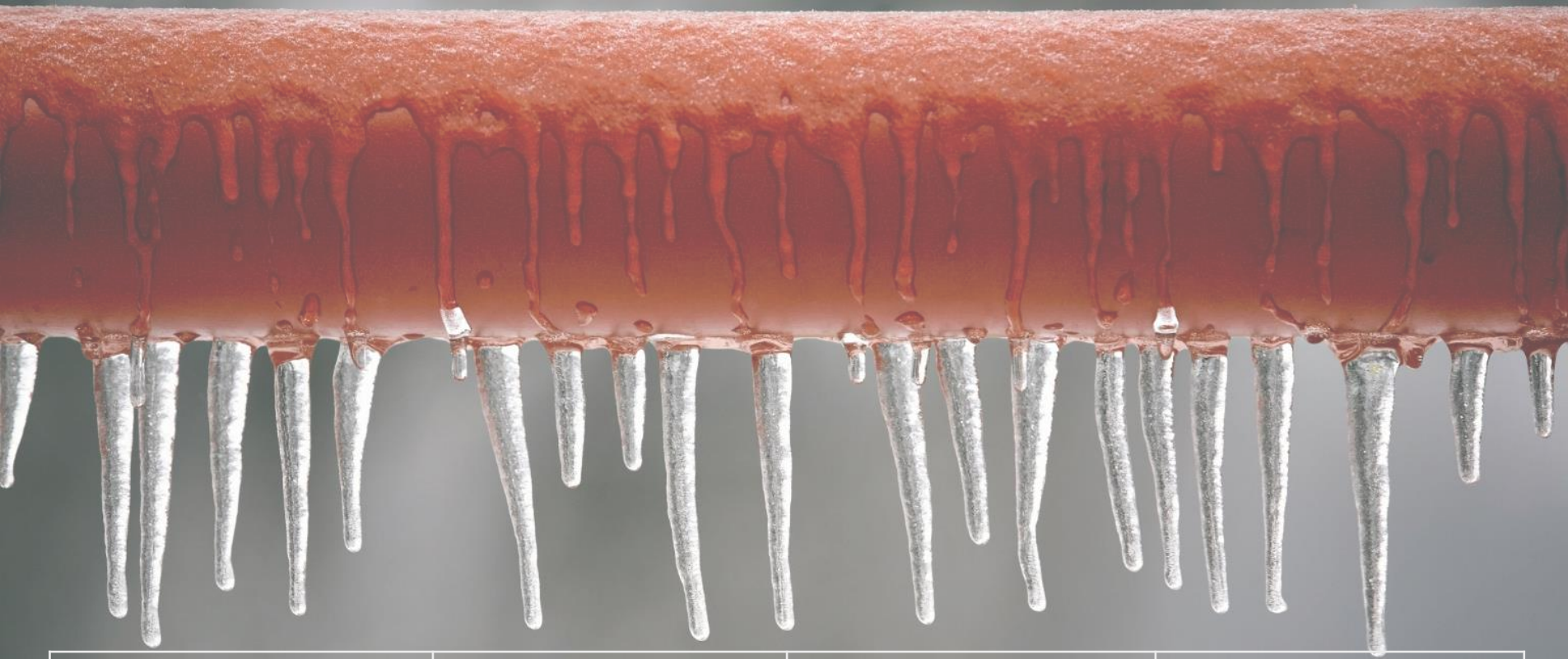


Heat and cold meters with glycol-based heat transfer media - a look at stability and testability

Sebastian Baack, 7.5
Heat and Vacuum



Introduction



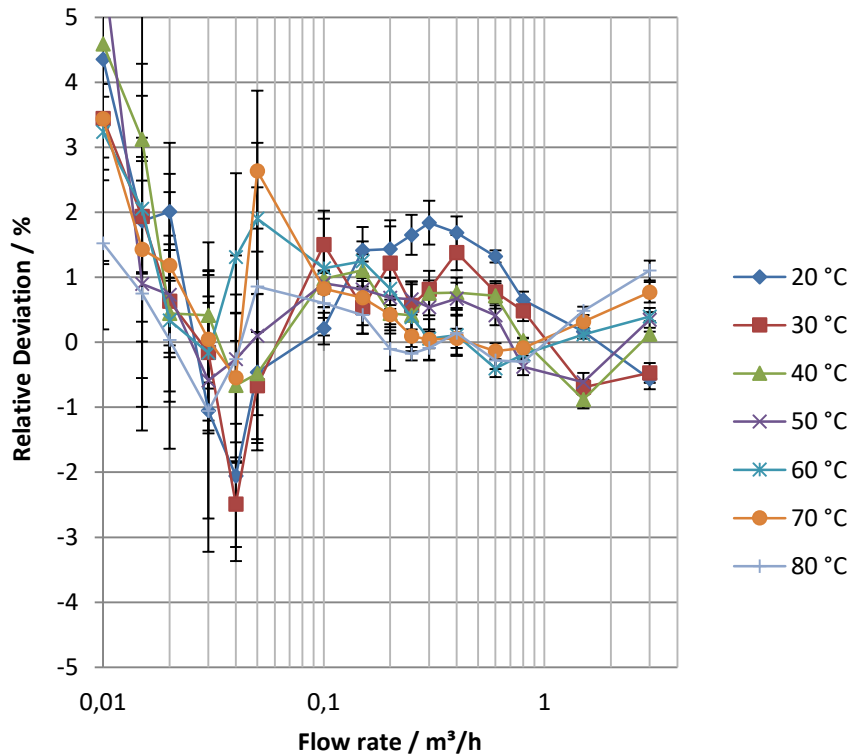
at 20 °C, 1 bar:	Water	Ethane-1,2-diol	1,2-Propanediol
c_p / kJ/kg K	~4.182	~2.4	~2.5
Density / kg/m ³	~1000	~1113	~1036
dyn. Viscos. / mPas	~1	~21	~55

source: <https://www.shutterstock.com/g/wheelerigor>

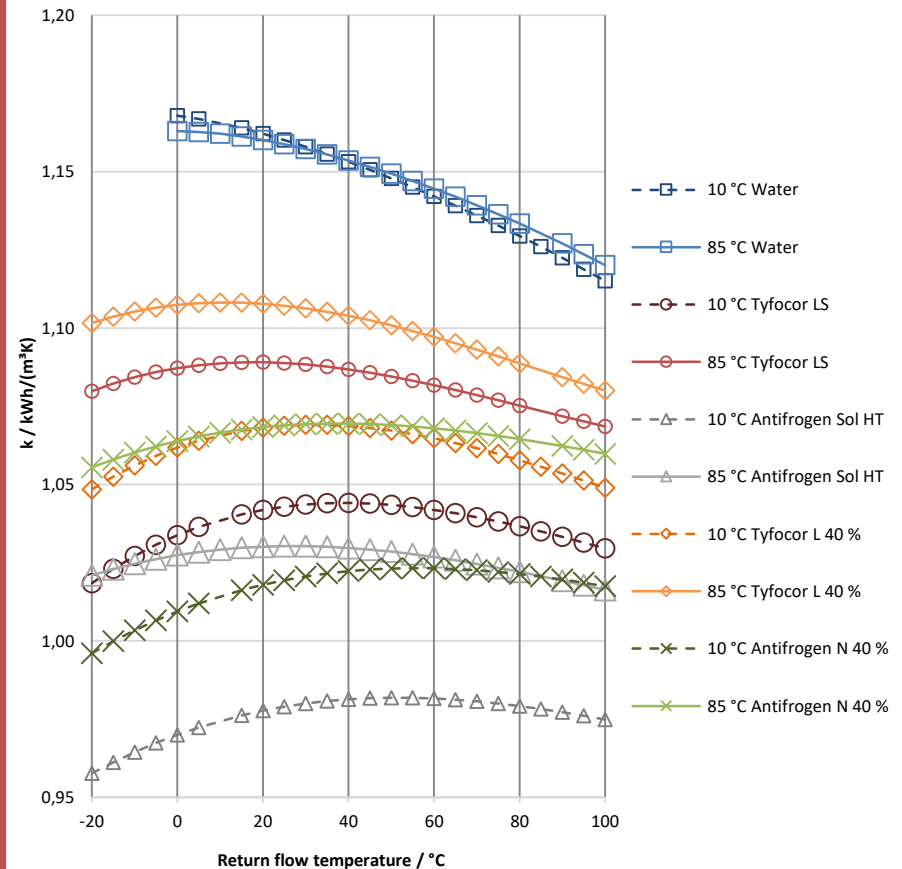
Introduction

- heat metering is affected

Flow measurement



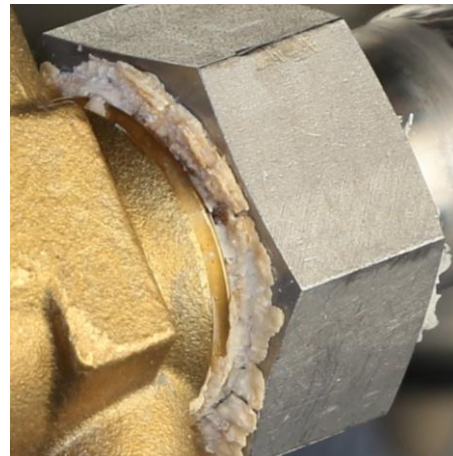
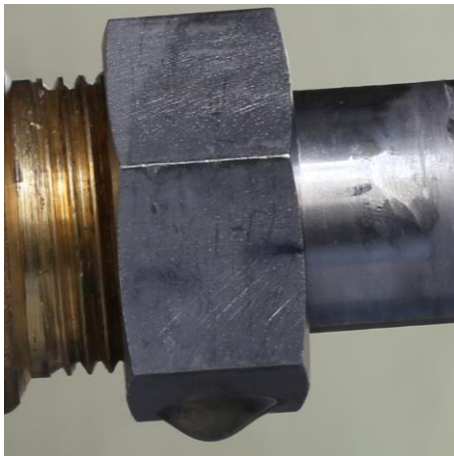
Heat coefficient k



- it has been shown that sensors are capable of producing decent flow rate results under laboratory conditions
- in field and especially over years, conditions may be less stable
 - durability of a sensor during its lifetime (alternating temperature and flow rate)
 - influence of medium stability on sensor (degradation or changing concentration may affect physical properties)
- those questions should be answered

Durability of sensor

- durability testing facility at PTB
- 4000 rapid temp. changes between 10 °C and 95 °C at q_s
- Simulation of lifespan stress on sensor within ~2 weeks
- With glycol-based medium
- see Peetz EMATEM 2018

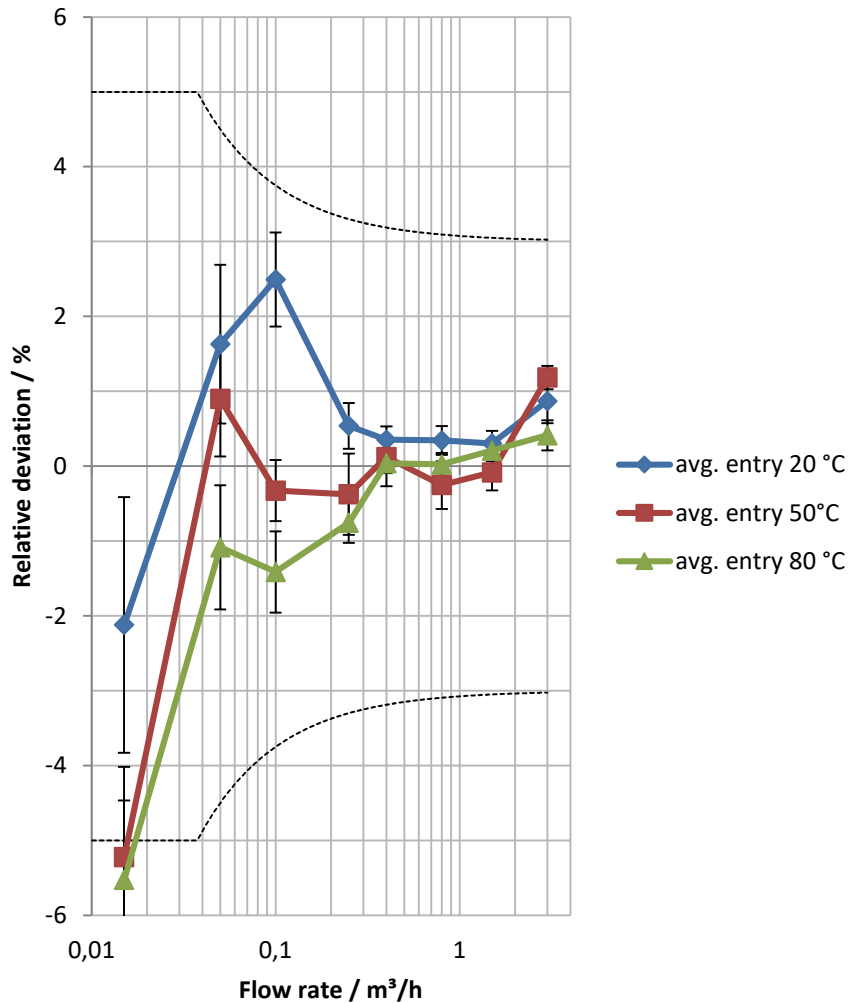


Durability of sensor

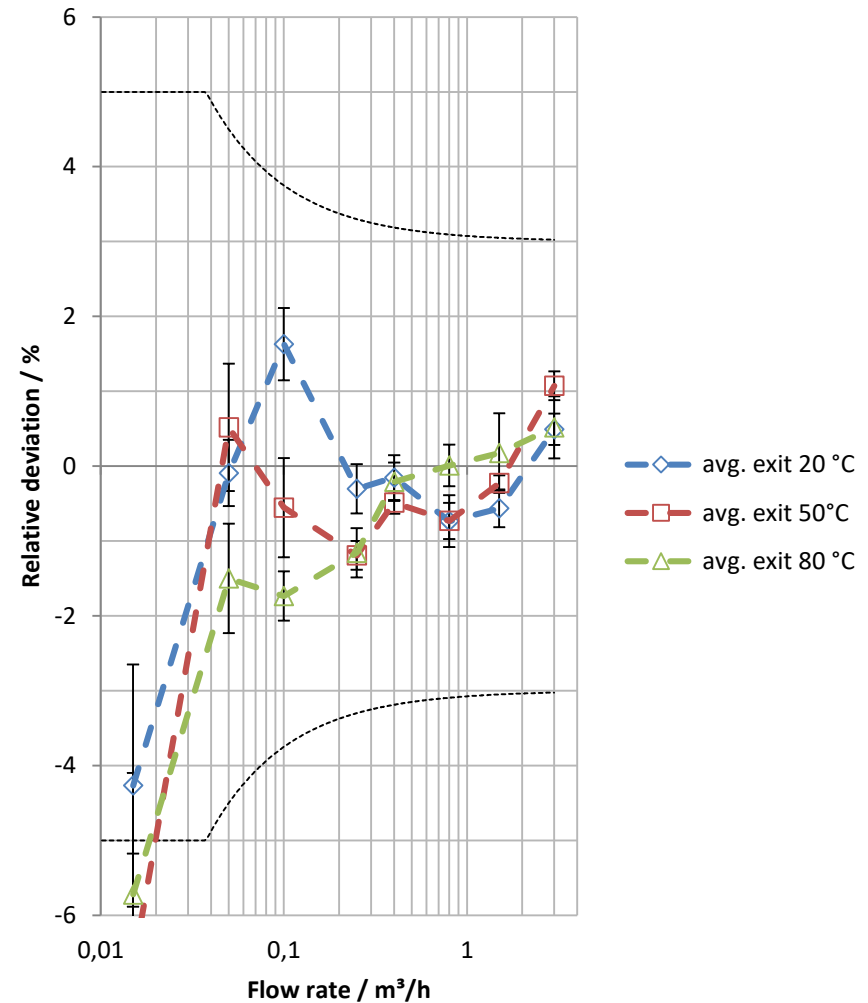
- Investigation of a package of 3 impeller flow sensors and 3 ultrasonic flow sensors
- both have been adjusted to a certain medium
- Procedure:
 - entry measurements at 8 flow rates at 20 °C, 50 °C, 80 °C
 - Simulation of assumed lifetime stress
 - exit measurements at 8 flow rates at 20 °C, 50 °C, 80 °C
 - comparison between entry and exit measurements

Durability of sensor – US sensor

avg. entry measurement

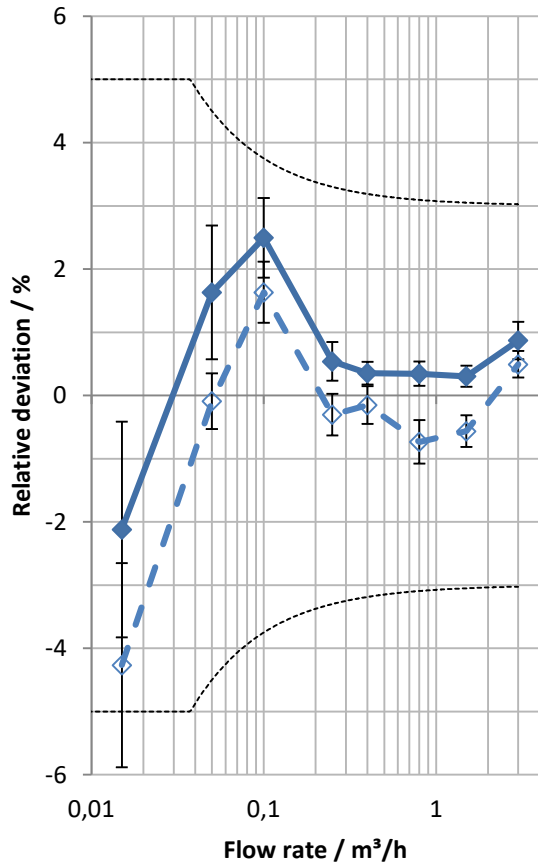


avg. exit measurement



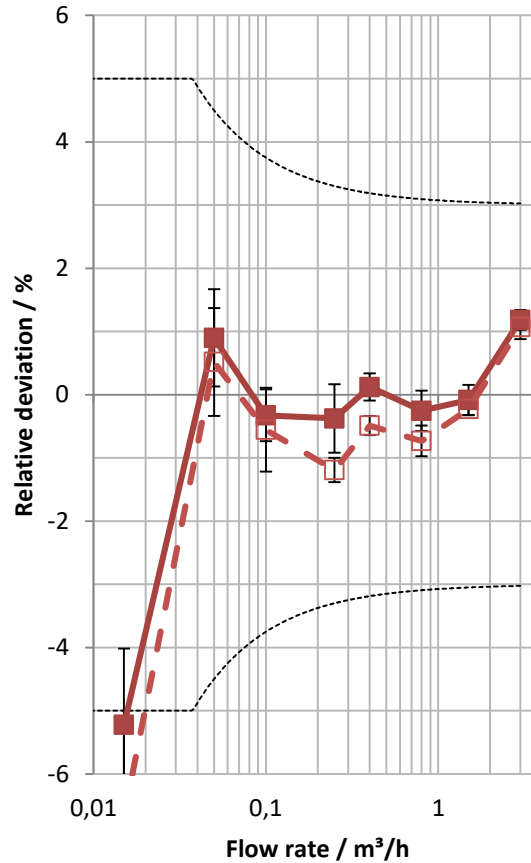
Durability of sensor – US sensor

Comparison 20 °C



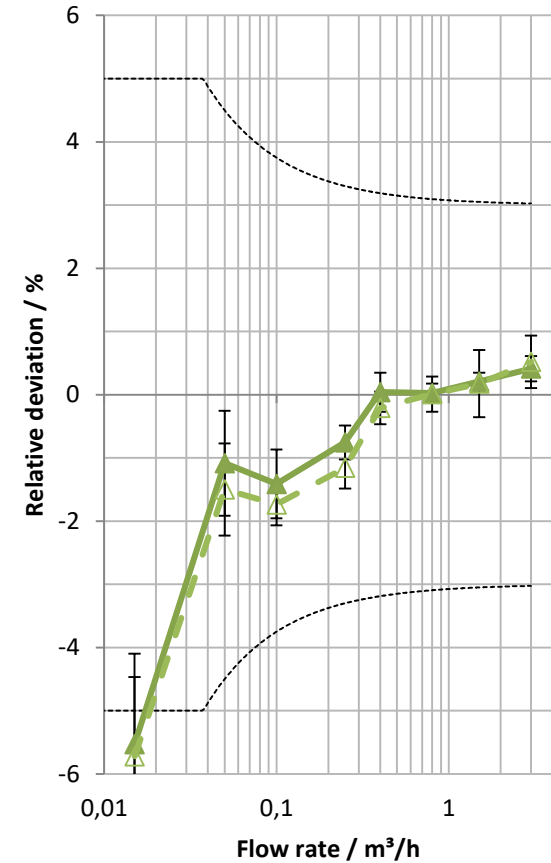
◆ avg. entry 20 °C ◇ avg. exit 20 °C

Comparison 50 °C



■ avg. entry 50 °C □ avg. exit 50 °C

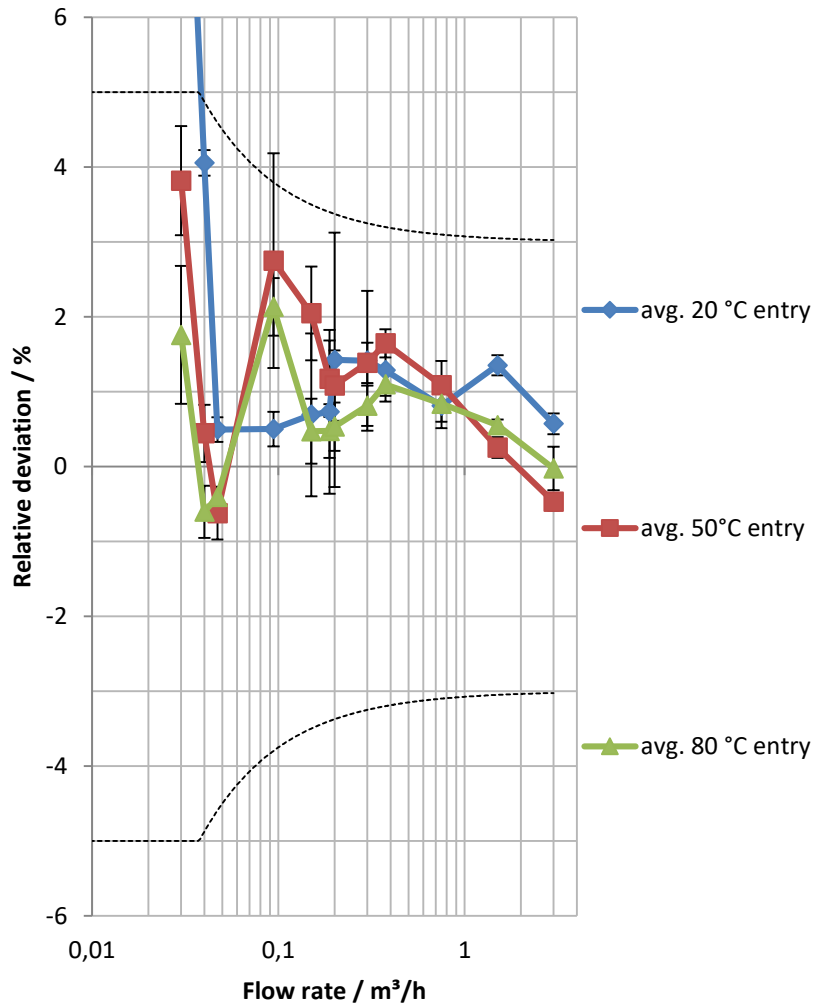
Comparison 80 °C



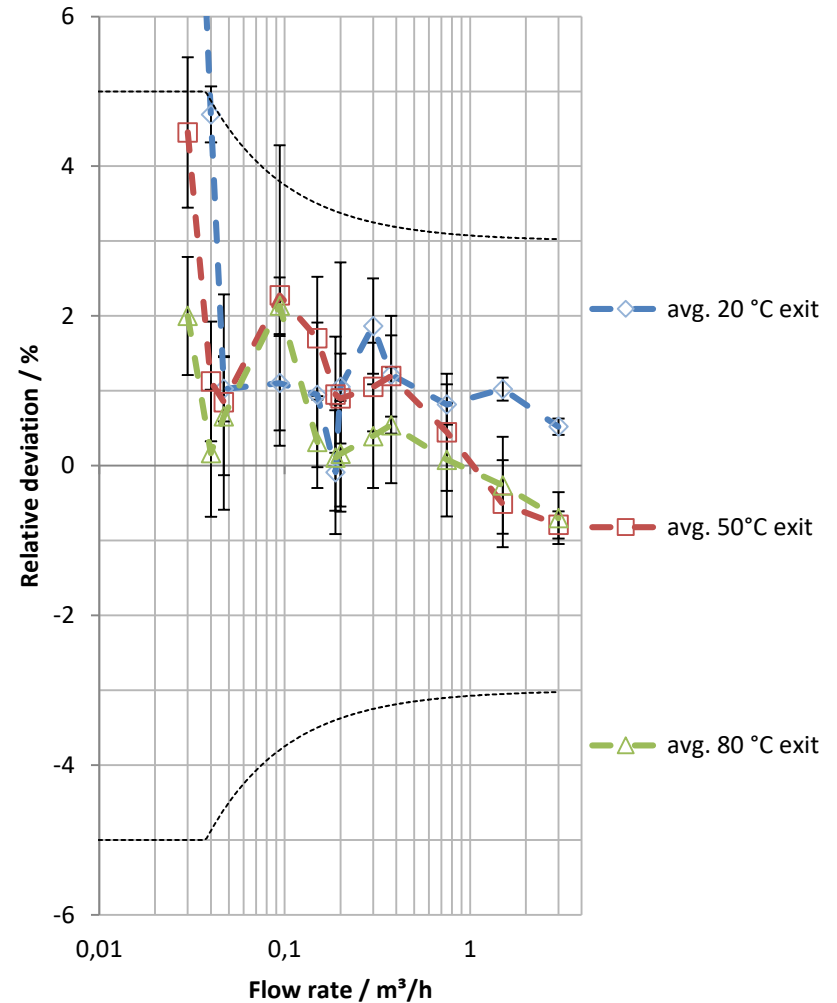
▲ avg. entry 80 °C △ avg. exit 80 °C

Durability of sensor – Impeller

avg. entry measurement

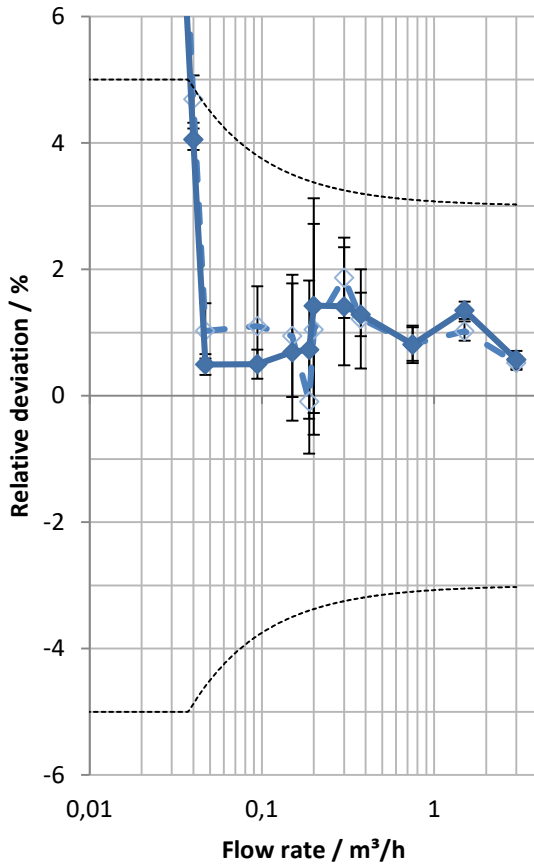


avg. exit measurement



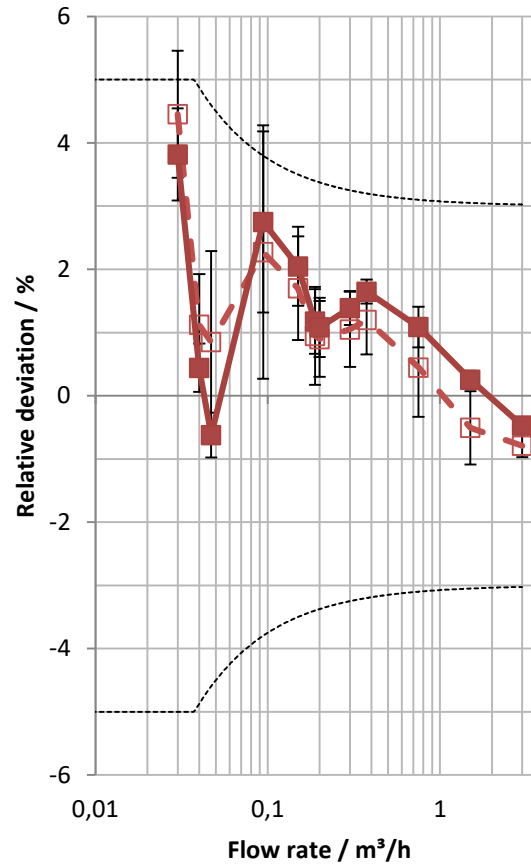
Durability of sensor – Impeller

avg. 20 °C - entry / exit



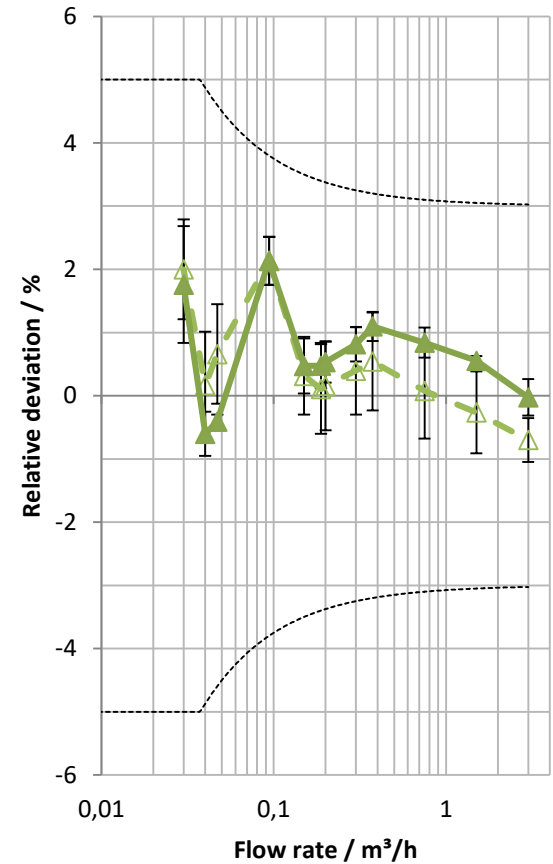
◇ avg. 20 °C exit ◆ avg. 20 °C entry

avg. 50 °C - entry / exit



□ avg. 50 °C exit ■ avg. 50 °C entry

avg. 80 °C - entry / exit



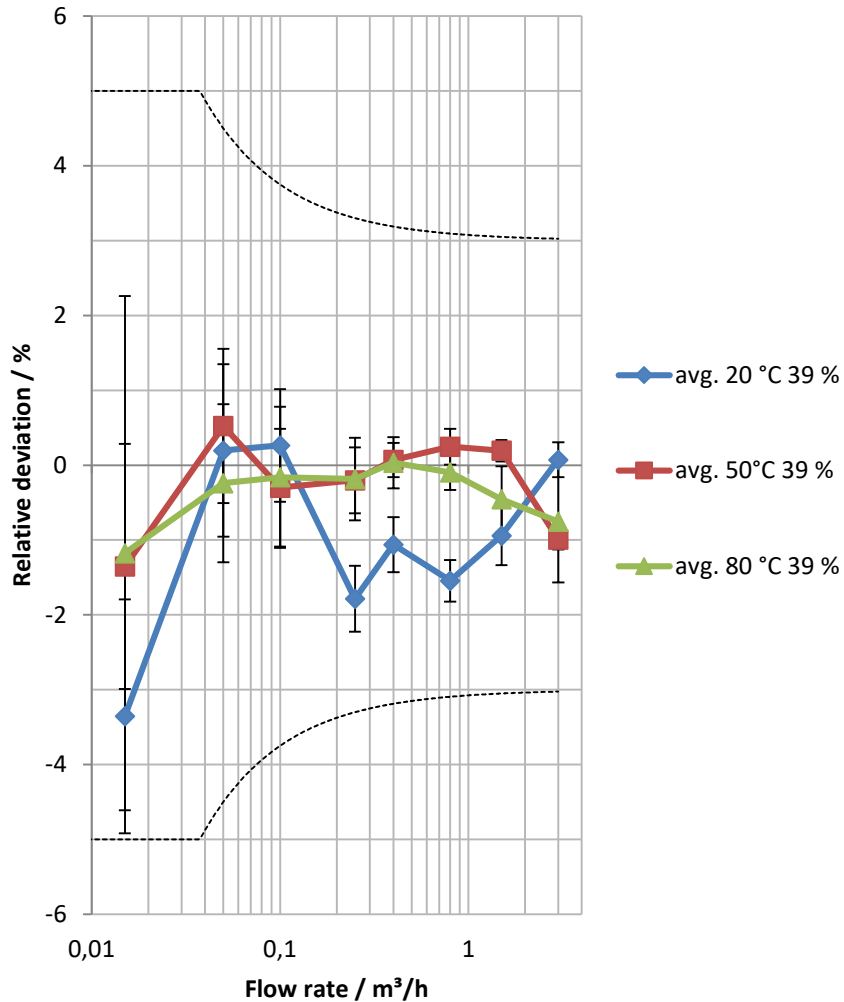
△ avg. 80 °C exit ▲ avg. 80 °C entry

Influence of medium stability

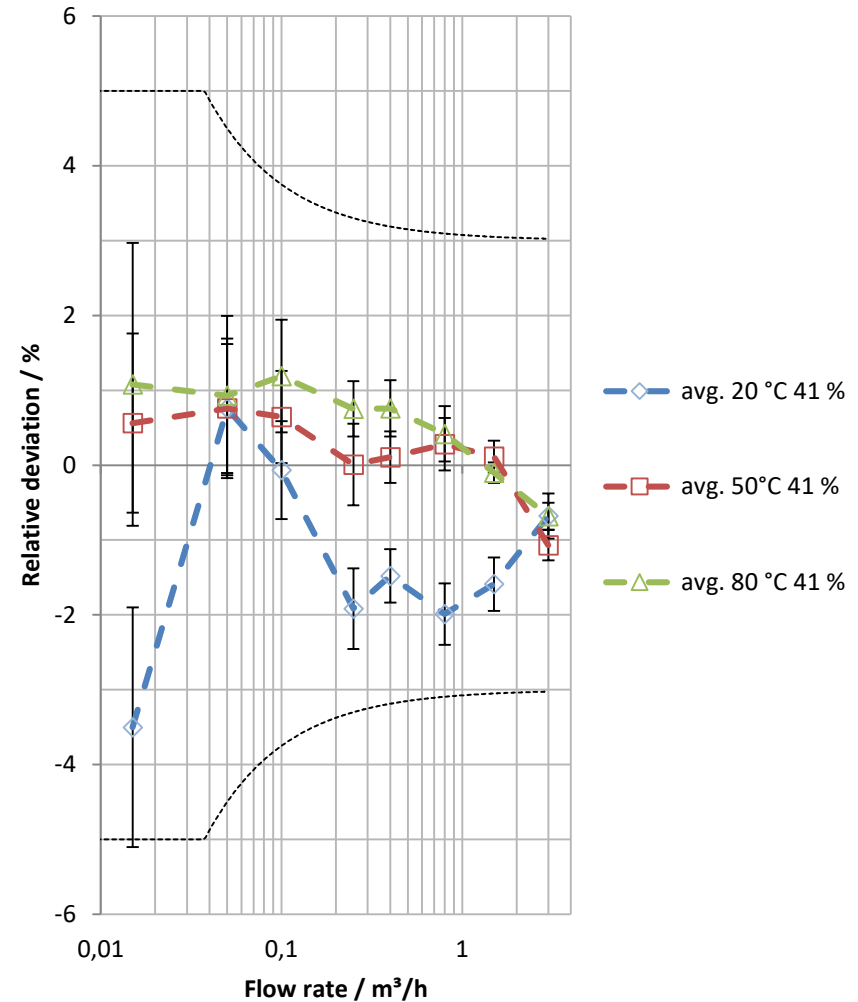
- medium stability may be subject to degradation processes or demixing
- Assumption: both cases can be simulated with adjustments to glycol concentration (e.g. 40 % \Leftrightarrow 38 %; 41 % \Leftrightarrow 39 %)
- both the flow sensor and the calculation unit are affected
 - flow: Δ of viscosity, density, speed of sound
 - calculation unit: density, spec. heat capacity
- concerning flow sensor, two sensors have been tested for glycol concentration-related deviations

Influence of medium stability – US sensor

avg. - 39 %

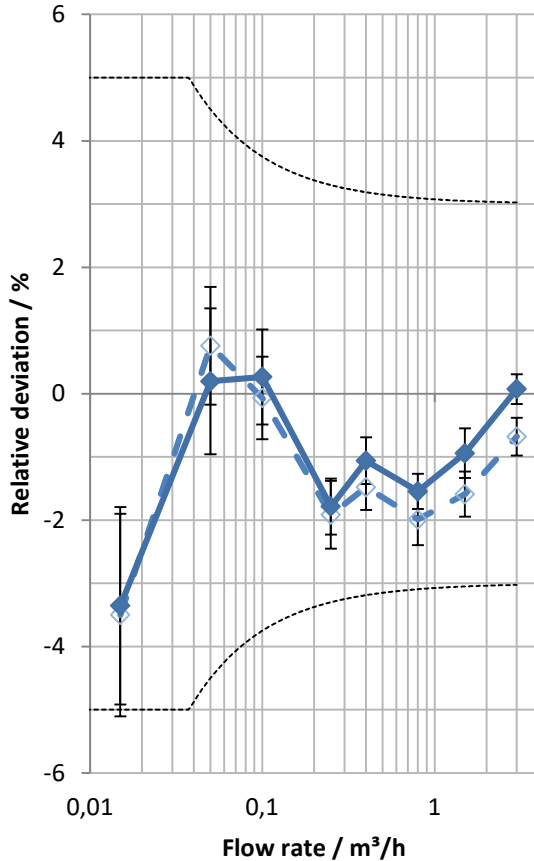


avg. - 41 %

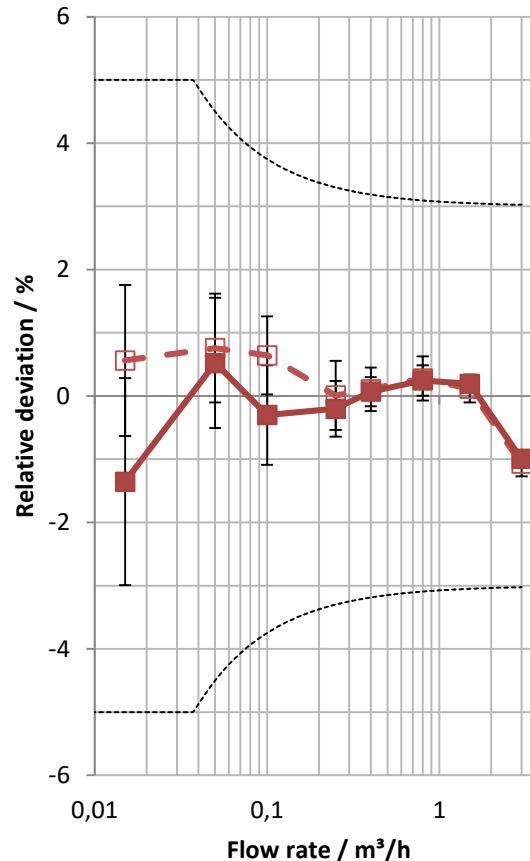


Influence of medium stability – US sensor

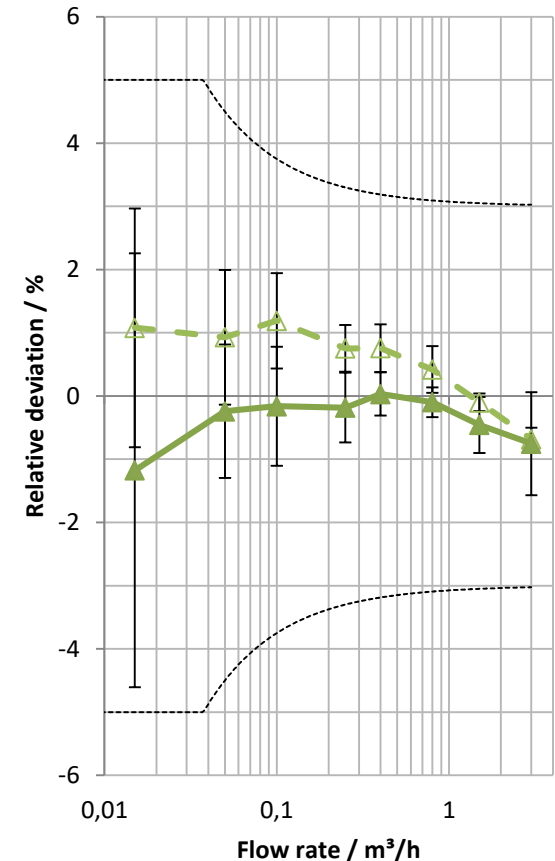
avg. 20 °C - 39 %/41 %



avg. 50 °C - 39 %/41 %



avg. 80 °C - 39 %/41 %



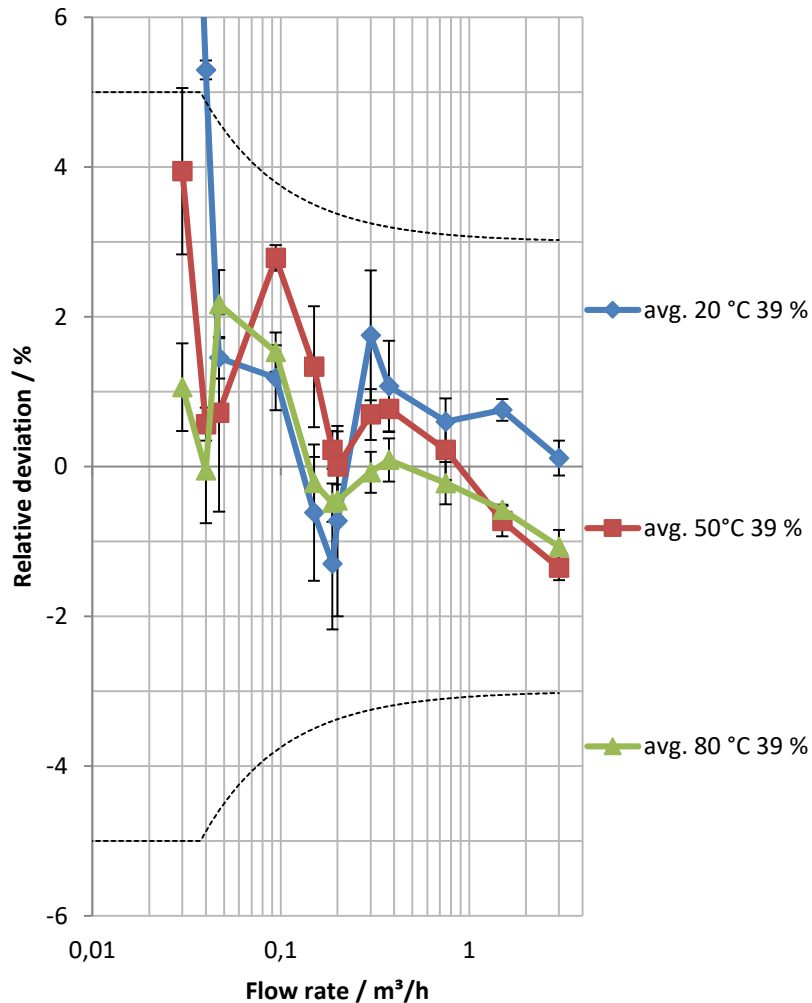
—◇— avg. 20 °C 41 % —◆— avg. 20 °C 39 %

—□— avg. 50 °C 41 % —■— avg. 50 °C 39 %

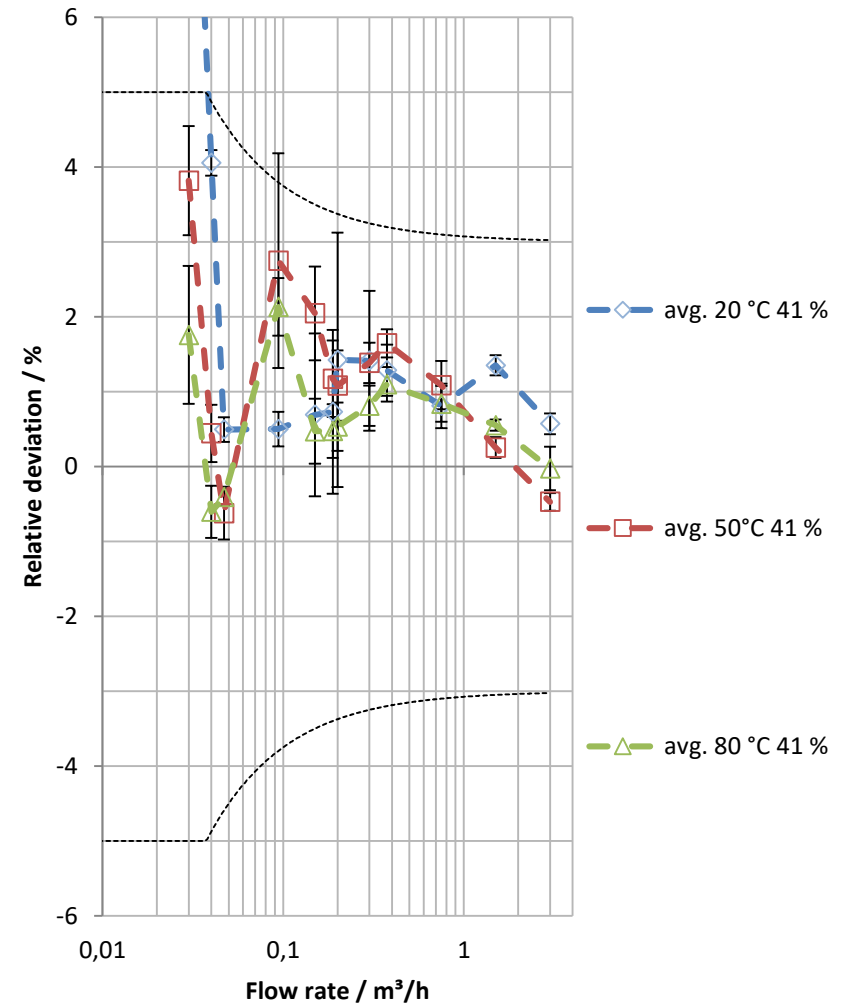
—△— avg. 80 °C 41 % —▲— avg. 80 °C 39 %

Influence of medium stability – Impeller

avg. - 39 %

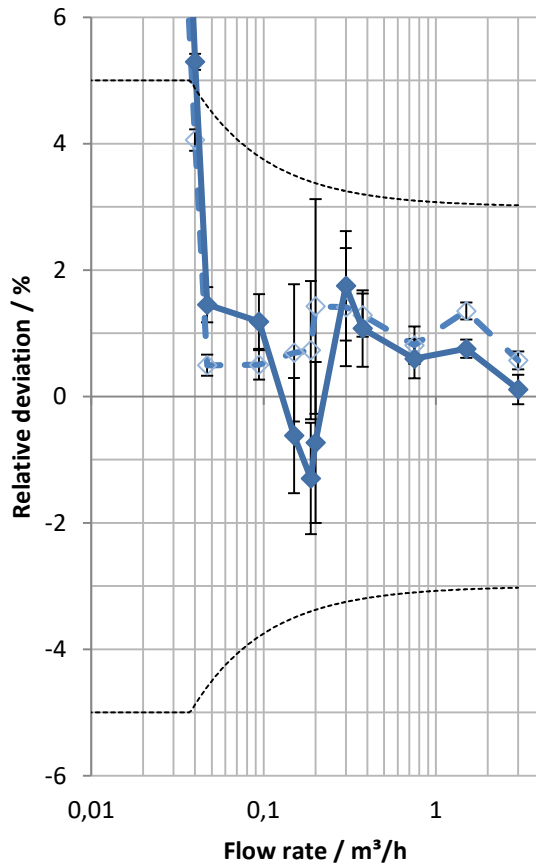


avg. - 41 %

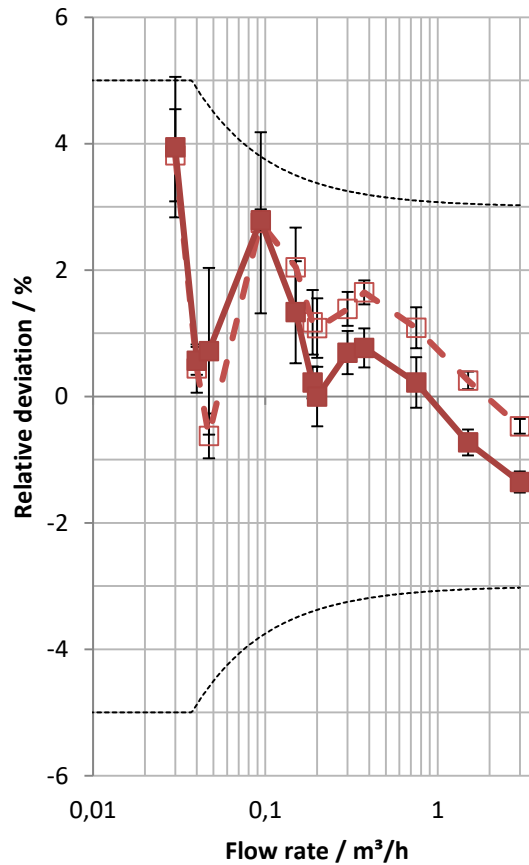


Influence of medium stability – Impeller

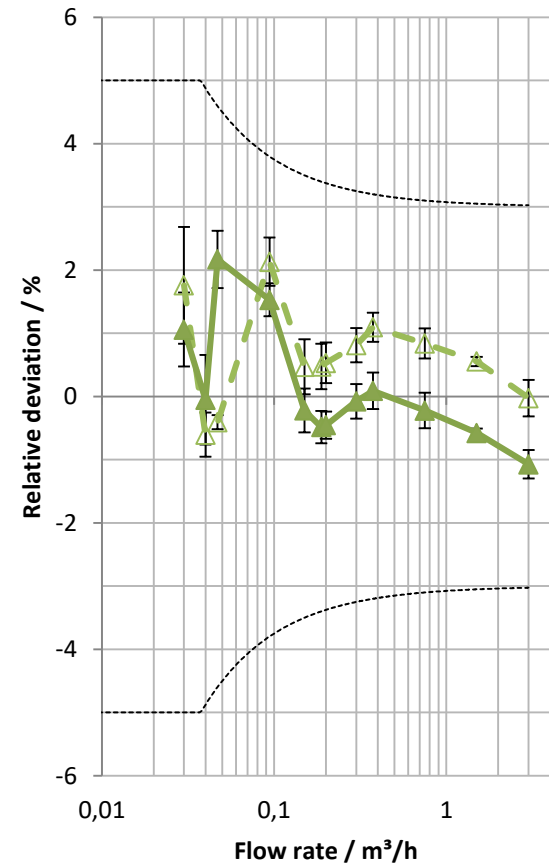
avg. 20 °C - 39 % / 41 %



avg. 50 °C - 39 % / 41 %



avg. 80 °C - 39 % / 41 %



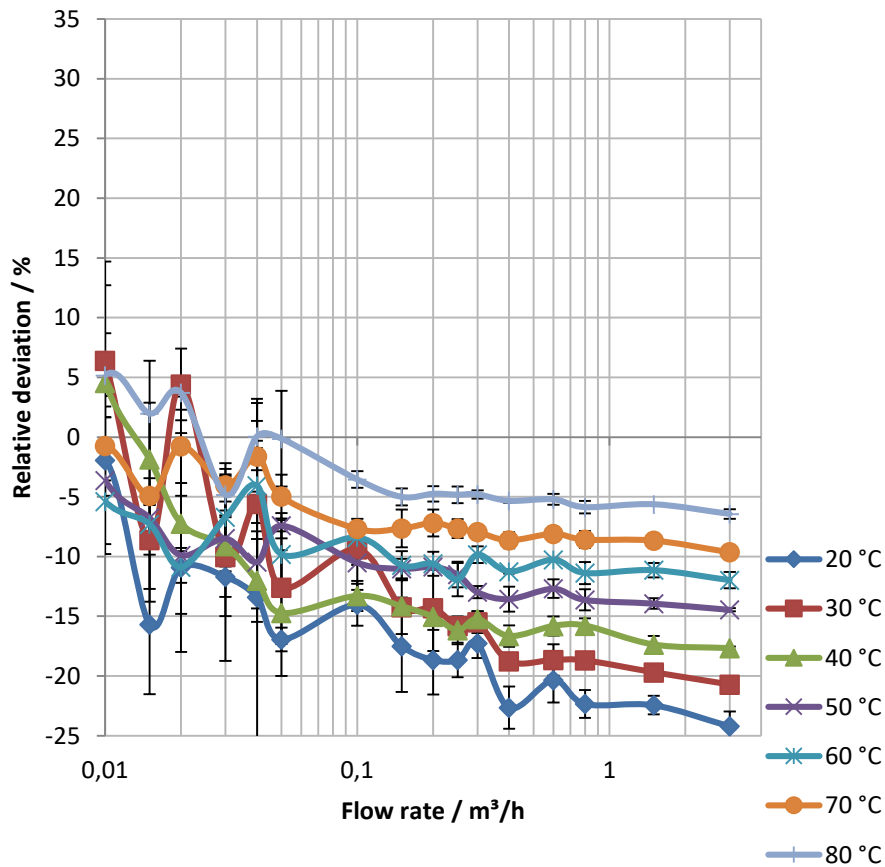
—◇— avg. 20 °C 41 % —◆— avg. 20 °C 39 %

—□— avg. 50 °C 41 % —■— avg. 50 °C 39 %

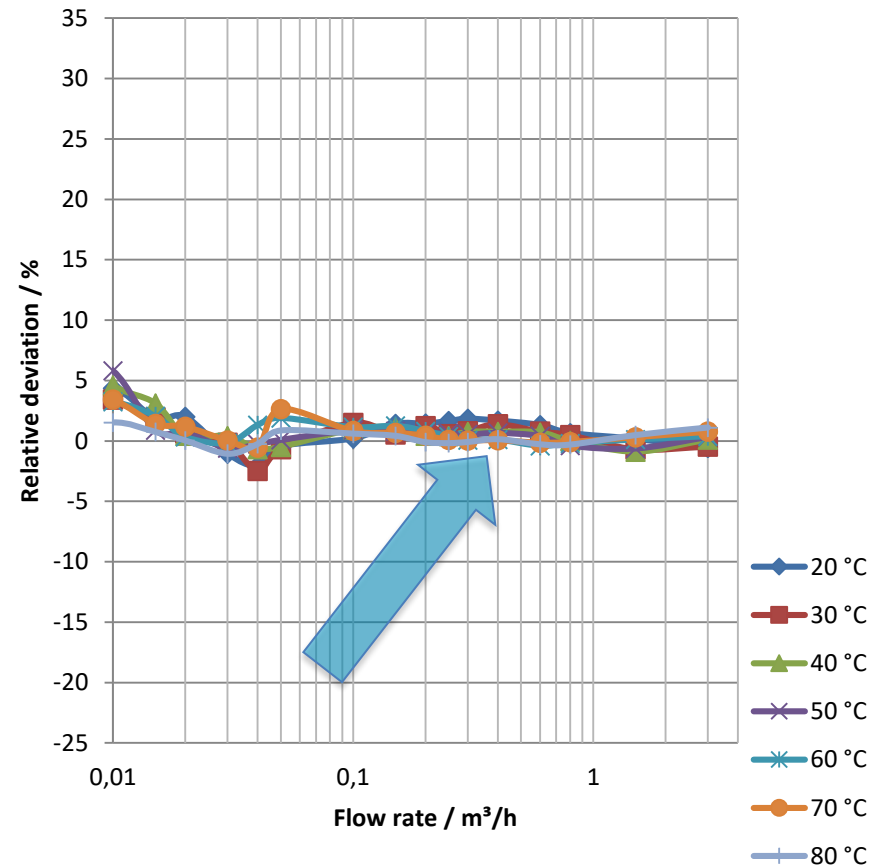
—△— avg. 80 °C 41 % —▲— avg. 80 °C 39 %

- extensive testing of sensors is required
 - during production
 - official calibration
 - re-calibration
- water is the preferred testing medium
 - for manufacturers
 - for notified bodies
- make use of prior measurement deviations with glycol and measure with water

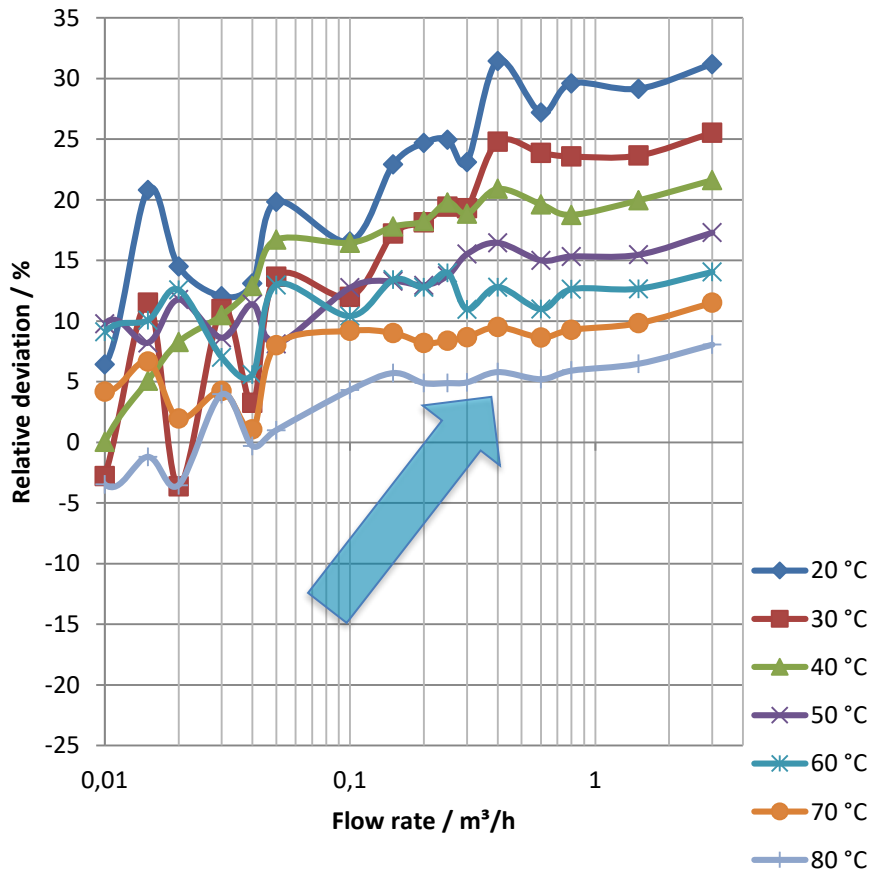
1. „water sensor“ with glycol



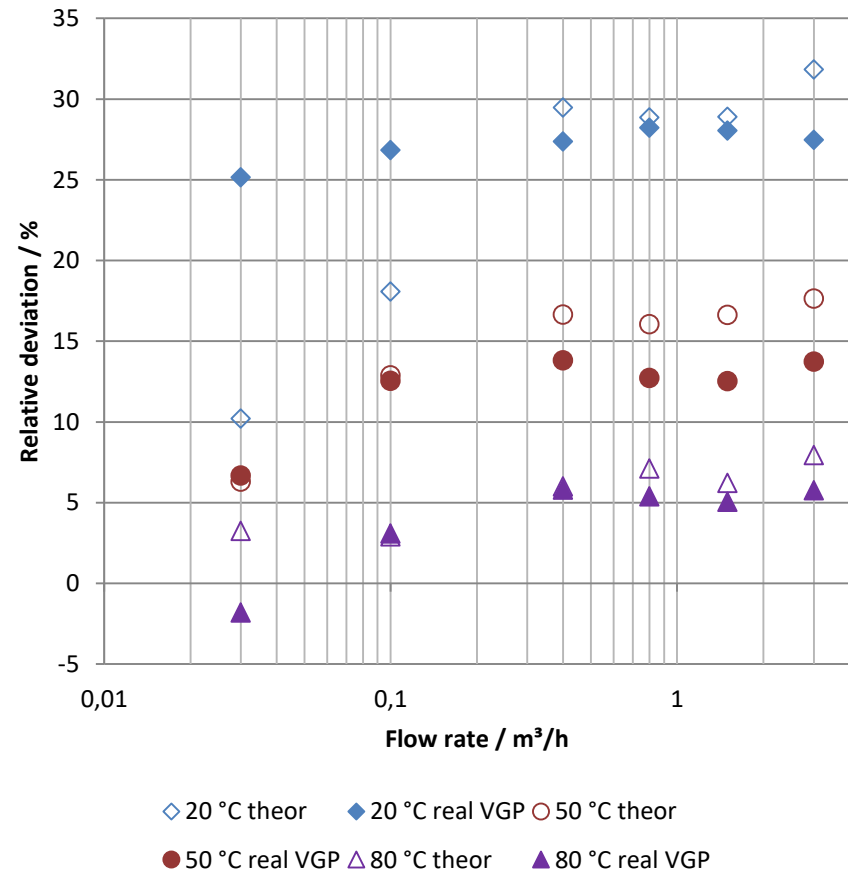
2. „adjusted sensor“ with glycol



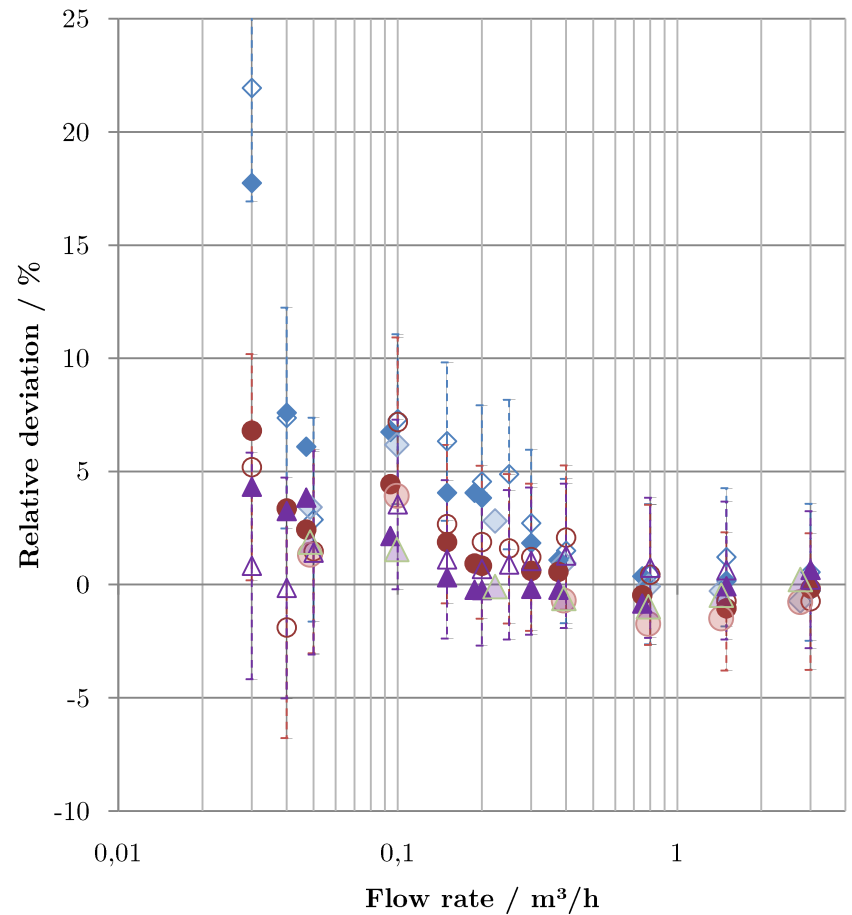
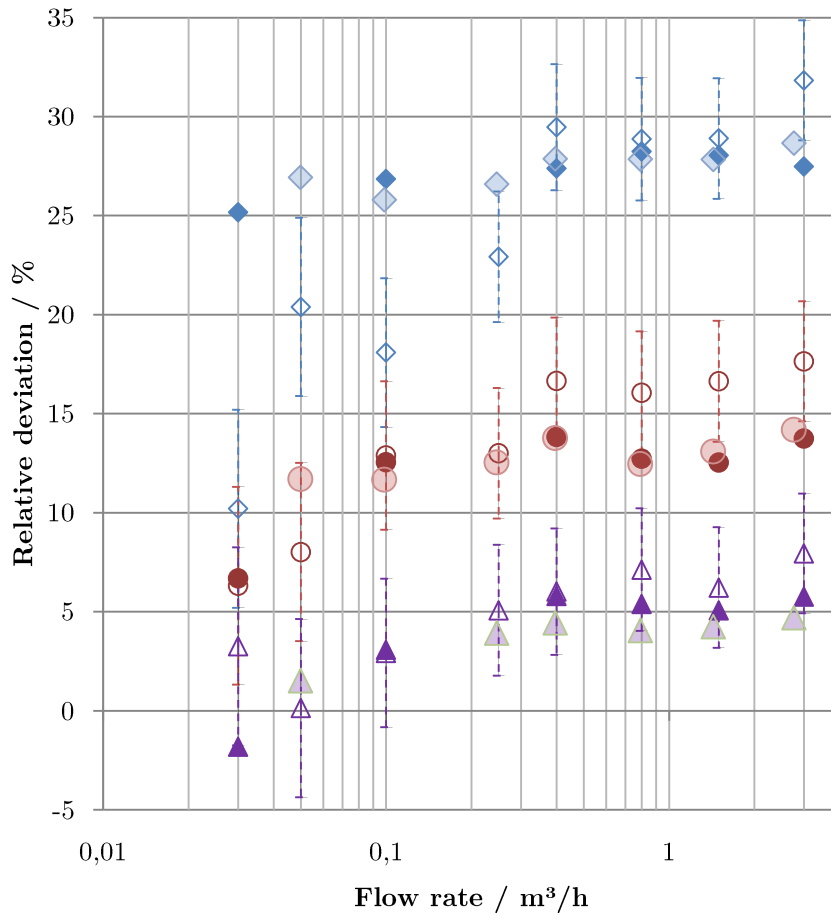
3. theoretical deviations with „adjusted sensor“ with water



4. measured deviations with „adjusted sensor“ with water



Testability



- ◇ 20 °C theor ◆ 20 °C real VGP ◇ 20 °C real HZP
- 50 °C theor ● 50 °C real VGP ○ 50 °C real HZP
- △ 80 °C theor ▲ 80 °C real VGP ▲ 80 °C real HZP

- ◇ 20 °C theor ◆ 20 °C real VGP ◇ 20 °C real HZP
- 50 °C theor ● 50 °C real VGP ○ 50 °C real HZP
- △ 80 °C theor ▲ 80 °C real VGP ▲ 80 °C real HZP

- Stability of sensors
 - accelerated durability test has slight effect on sensor, but within acceptable range
 - medium stability (39 % \Leftrightarrow 41 %) has comparable slight effect on sensor, but within acceptable range
- Testability
 - testing with water appears feasible
 - shown with two sensor types and two different PTB testing facilities



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