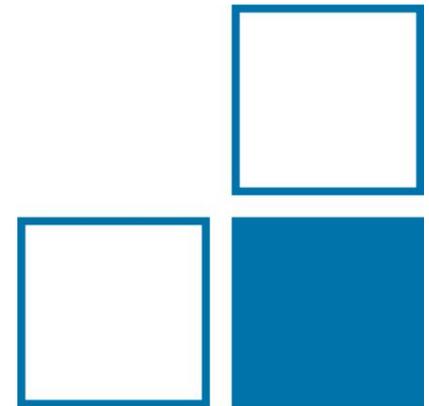# Heat and cold meters with glycol-based heat transfer media - Part 1: Research project status

Sebastian Baack, 7.5
Heat and Vacuum

Overview

- Introduction

- Past research project steps

- Current topics

  - Permanent stress

  - Speed of sound

  - Measuring concentration in field

- Future topics

Introduction

- glycol-water-mixtures are widely used heat transfer fluids in technical systems where temperatures below 0 °C occur

Solar Thermal Energy

Cooling

Geothermal Energy
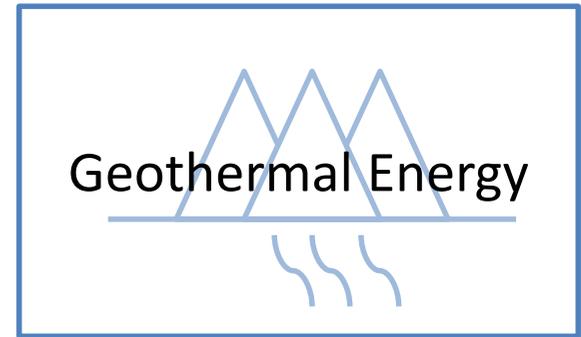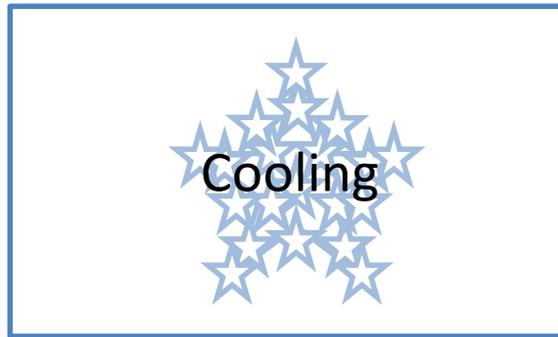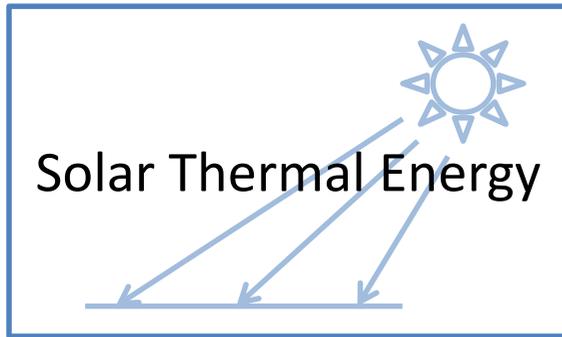
- Problem: physical properties differ from water

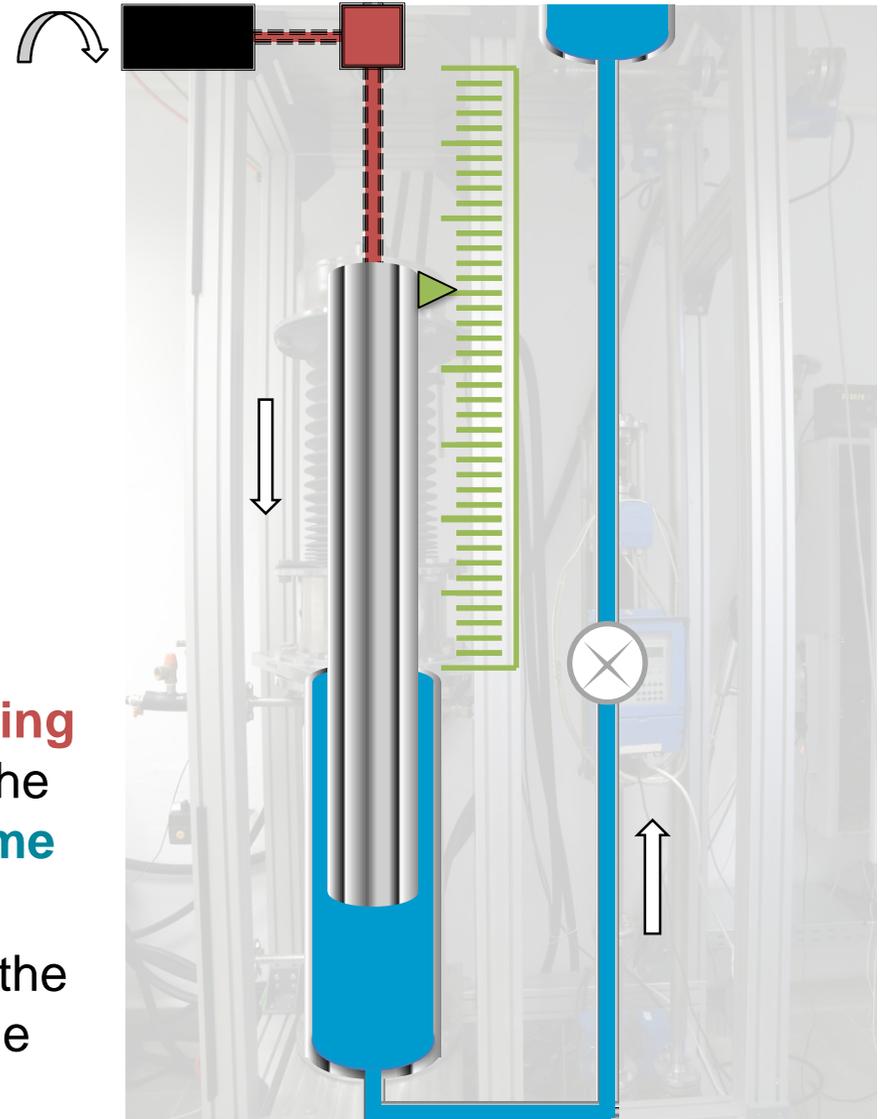| at 20 °C, 1 bar:	Water	Ethane-1,2-diol	1,2-Propanediol
c_p [kJ/kg K]	~4,182	~2,4	~2,5
Density [kg/m³]	~1000	~1113	~1036
dyn. Viscos. [mPas]	~1	~21	~55

Introduction

- Working equation of a stationary heating systems consists of roughly three parts:

$$E = V \cdot k(p, T_f, T_r) \cdot (T_f - T_r)$$
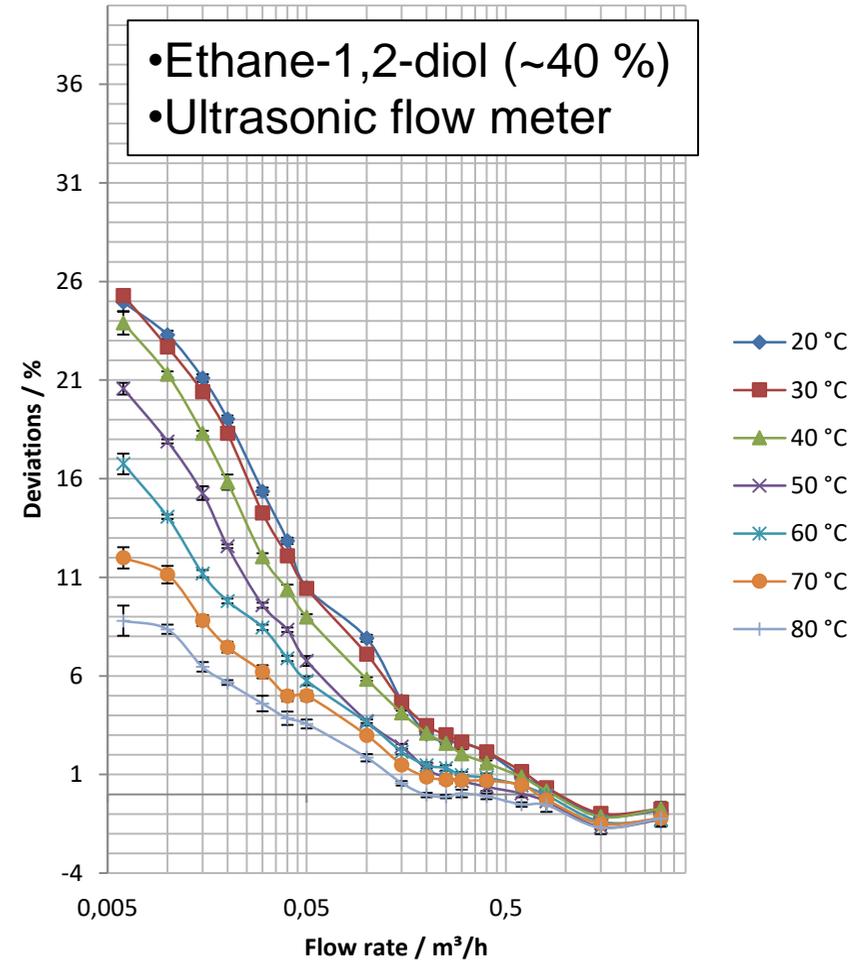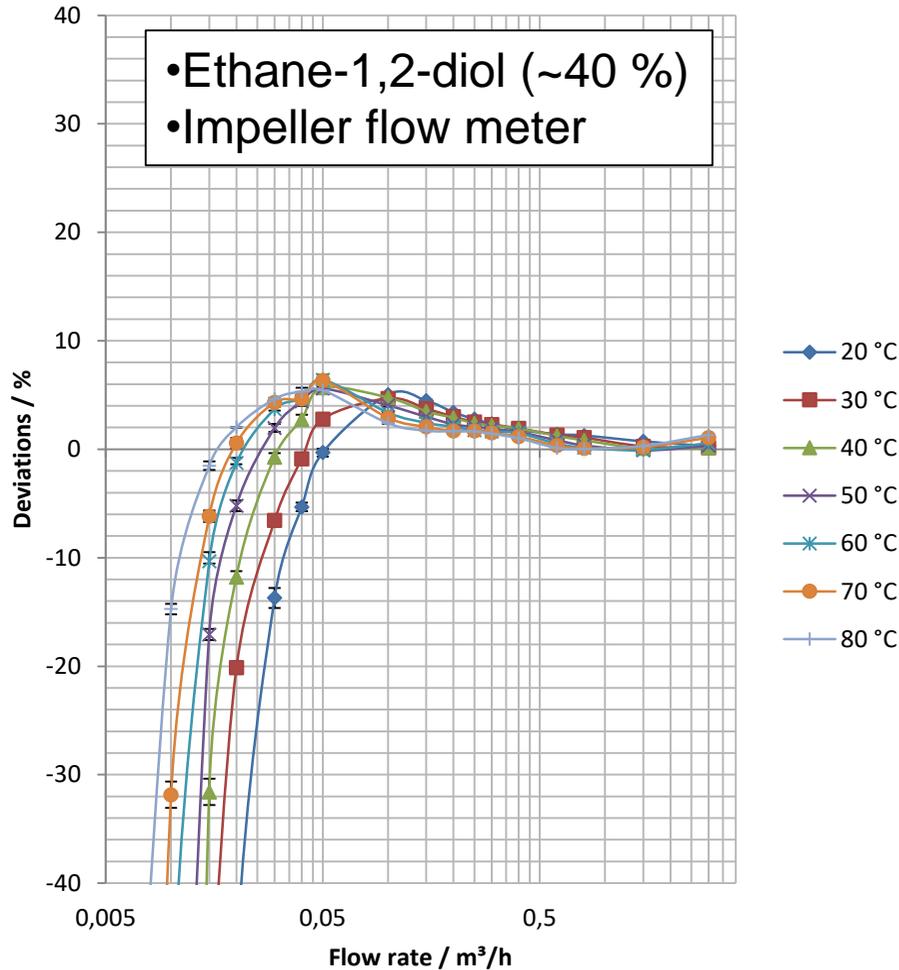
  - Volume

  - Heat coefficient for enthalpy change calculations

  - Temperature difference between feed and return

- All three parts are more or less affected by glycol-water-mixtures

- leads to errors of heat metering

Past research project steps - Flow
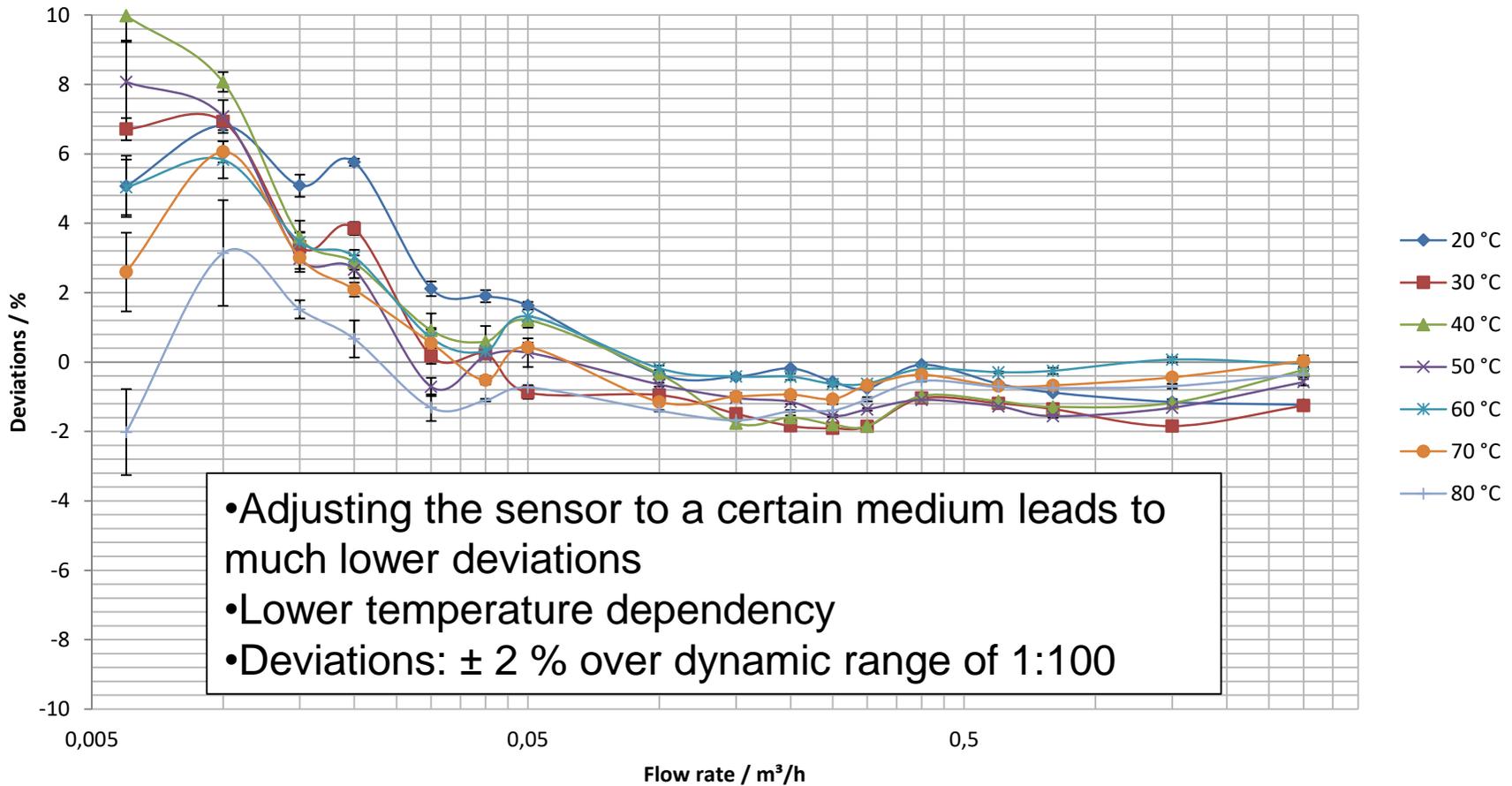
- Flow rate measurements on volumetric test rig

- 4 heat transfer fluids

- Flow points:

  - Temperature: 20 °C - 80 °C

  - Flow rate: 6 l/h - 3000 l/h

- Volumetric principle: **motor** drives **lifting spindle**, which leads displacer into the container to generate a defined **volume flow** through the measuring section

- displaced volume is calculated using the **length measurement system** and the displacer's cross section

Past research project steps - Flow

- Ethane-1,2-diol (~40 %)
- Impeller flow meter

Legend: 20 °C, 30 °C, 40 °C, 50 °C, 60 °C, 70 °C, 80 °C

Deviations / % vs Flow rate / m³/h

- Ethane-1,2-diol (~40 %)
- Ultrasonic flow meter

Legend: 20 °C, 30 °C, 40 °C, 50 °C, 60 °C, 70 °C, 80 °C

Deviations / % vs Flow rate / m³/h

Past research project steps - Flow

- Adjusting the sensor to a certain medium leads to much lower deviations
- Lower temperature dependency
- Deviations: ± 2 % over dynamic range of 1:100
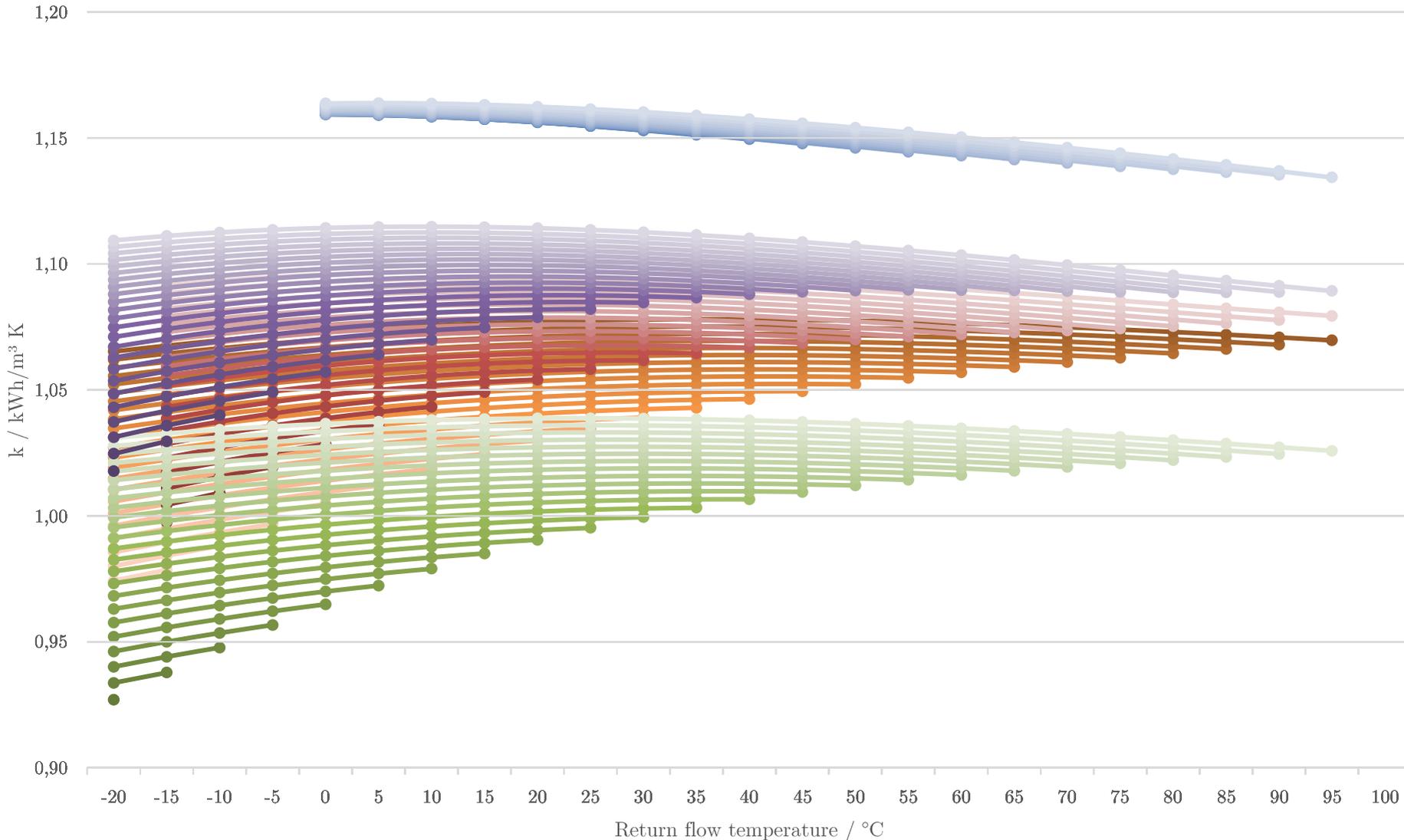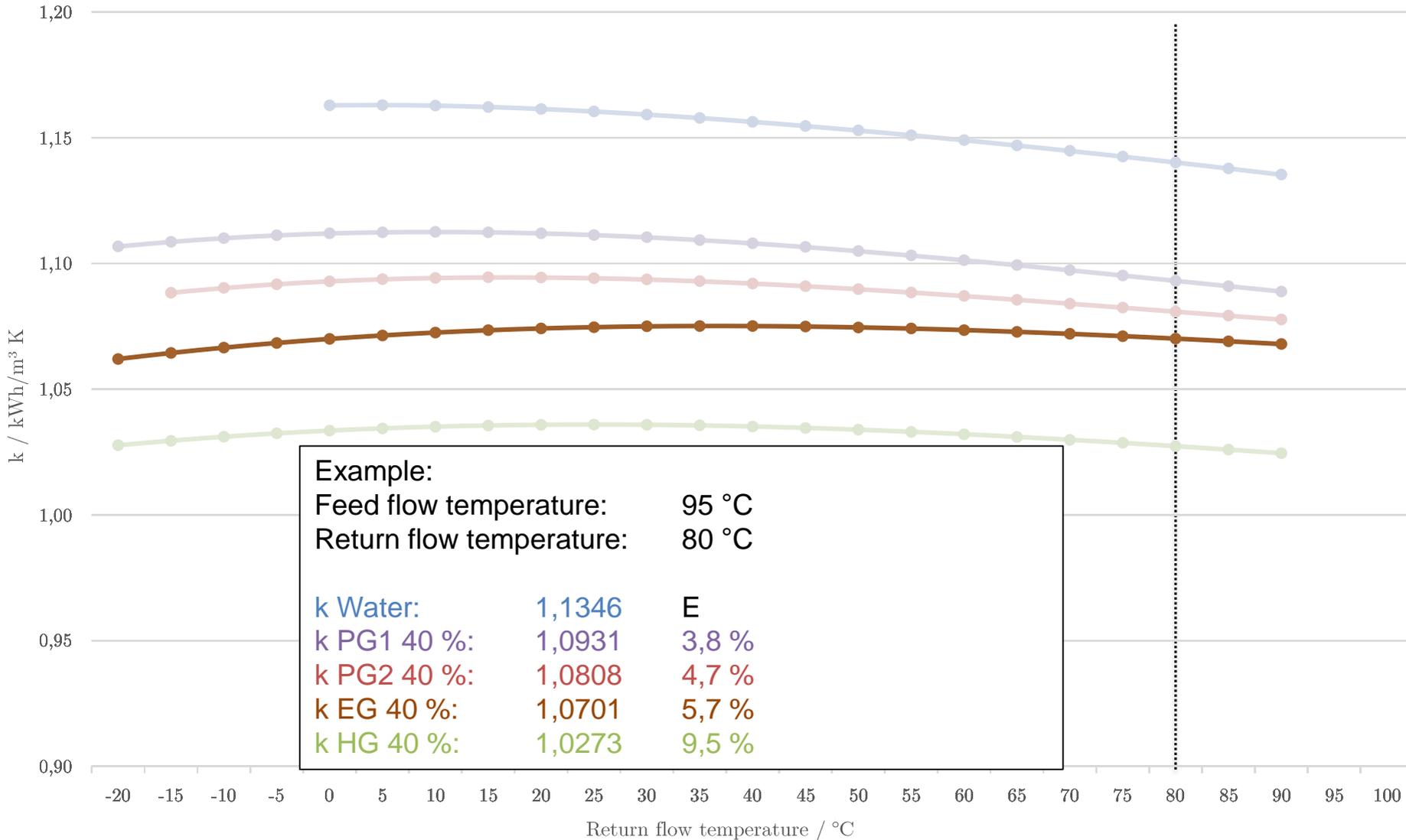
Past research project steps - Enthalpy

- Physical properties investigated

    - Density

    - Viscosity

    - Spec. heat capacity at constant pressure

- Data Base for calculating heat coefficient k (U = 1.5 %, k=2)
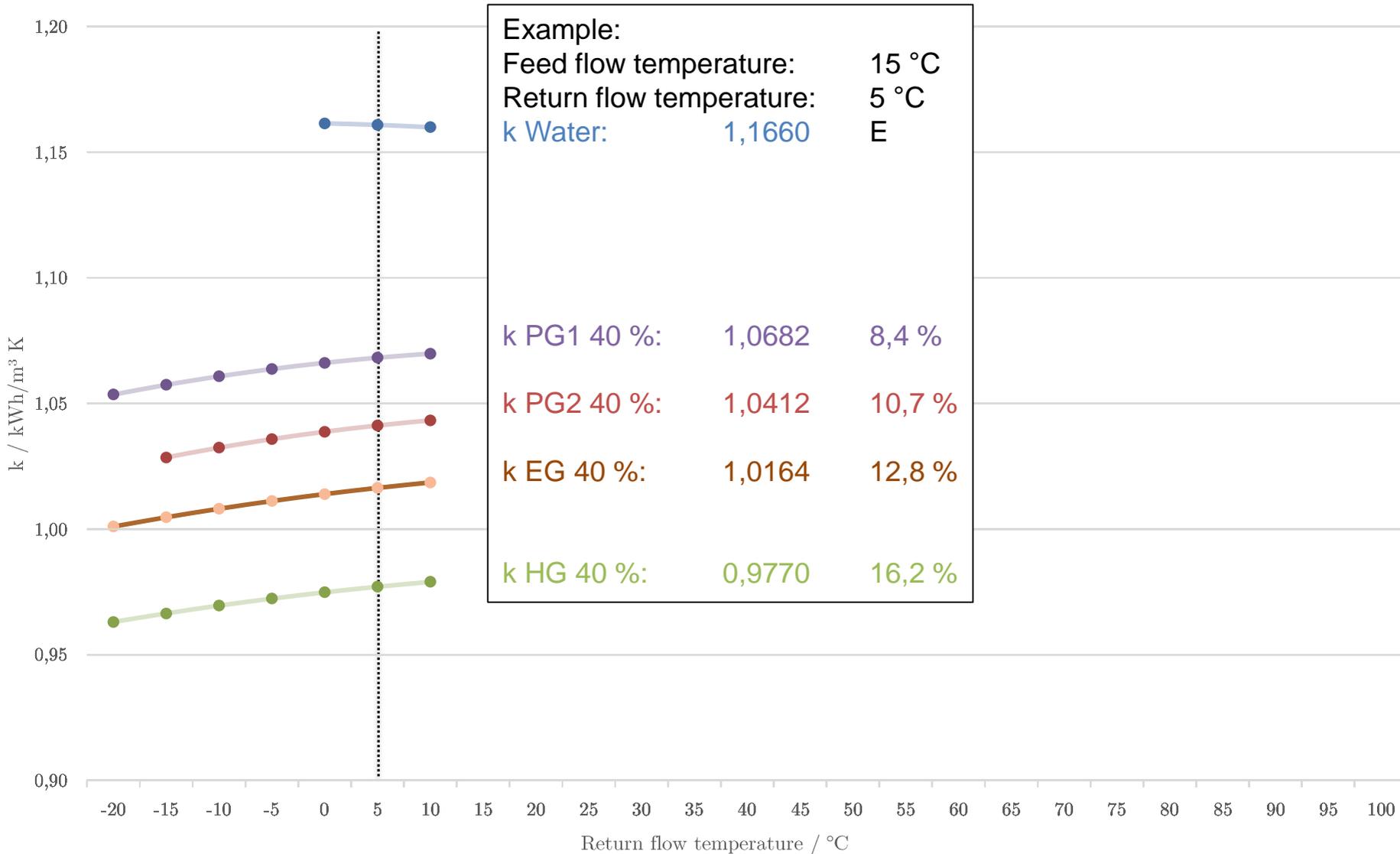
Past research project steps - Enthalpy

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Past research project steps - Enthalpy

Example:
Feed flow temperature: 95 °C
Return flow temperature: 80 °C

k Water:	1,1346	E
k PG1 40 %:	1,0931	3,8 %
k PG2 40 %:	1,0808	4,7 %
k EG 40 %:	1,0701	5,7 %
k HG 40 %:	1,0273	9,5 %

Return flow temperature / °C

k / kWh/m³ K

Past research project steps - Enthalpy

Example:
Feed flow temperature: 15 °C
Return flow temperature: 5 °C
k Water: 1,1660 E

k PG1 40 %: 1,0682 8,4 %

k PG2 40 %: 1,0412 10,7 %

k EG 40 %: 1,0164 12,8 %

k HG 40 %: 0,9770 16,2 %

Return flow temperature / °C
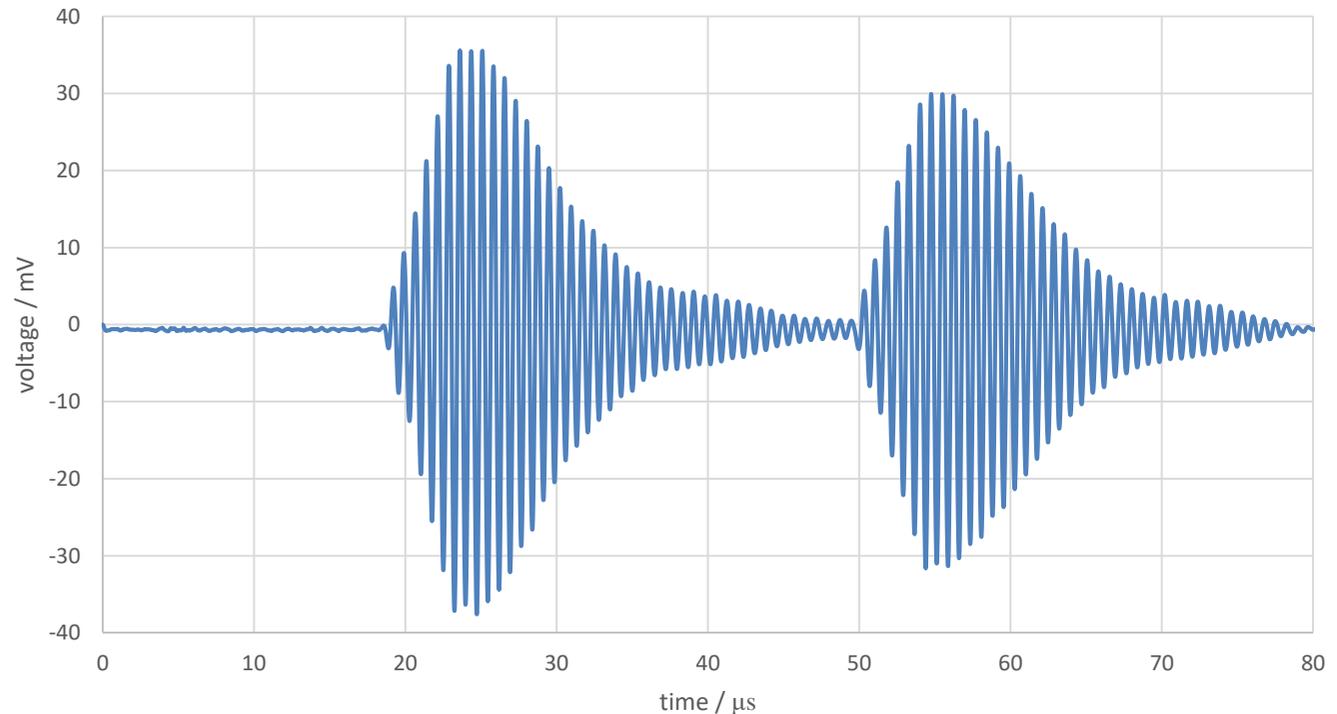
k / kWh/m³ K

Current topics - permanent stress

- After showing that sensors are capable of producing decent flow rate results, the question of durability arised

- new test rig built
- it allows rapid temperature changes between 10 °C and 95 °C
- Simulation of lifespan stress on sensor within ~2 weeks
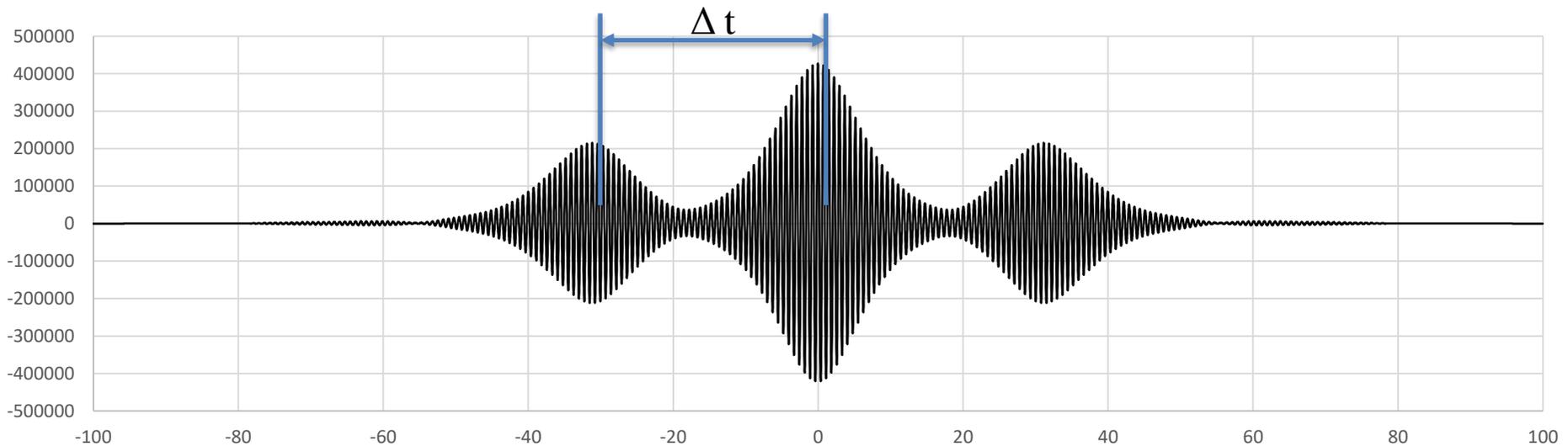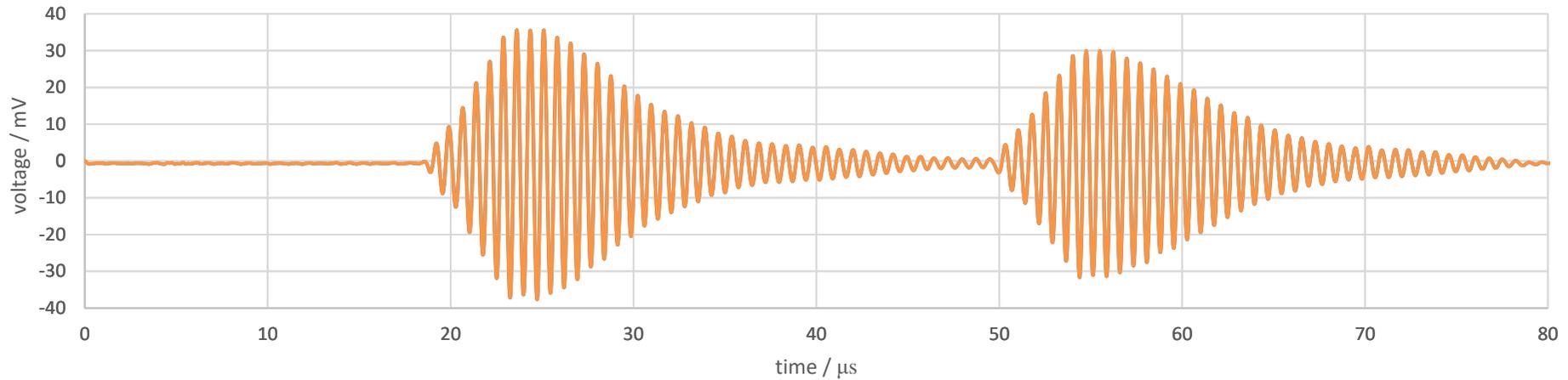- With glycol-based media

Current topics - Speed of sound
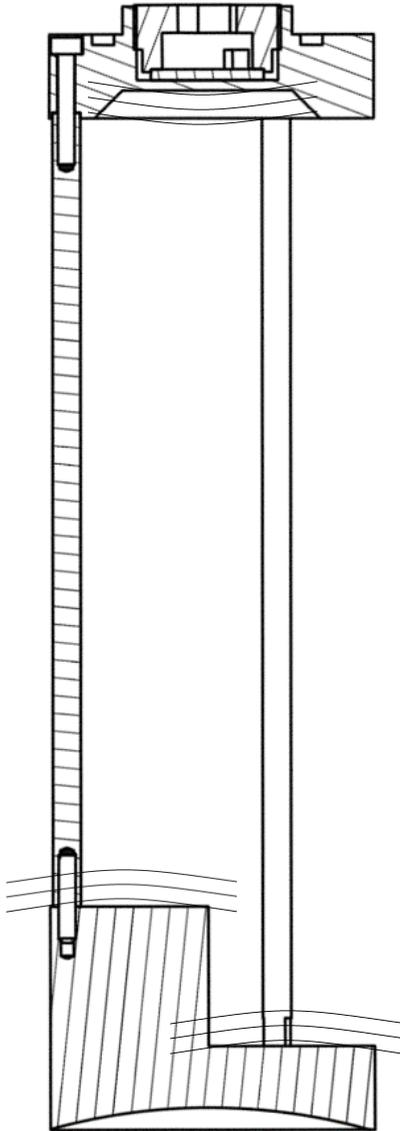
- Principle: time of flight applying two reflecting planes

- Knowledge of distance between planes and measurement of time => speed of sound
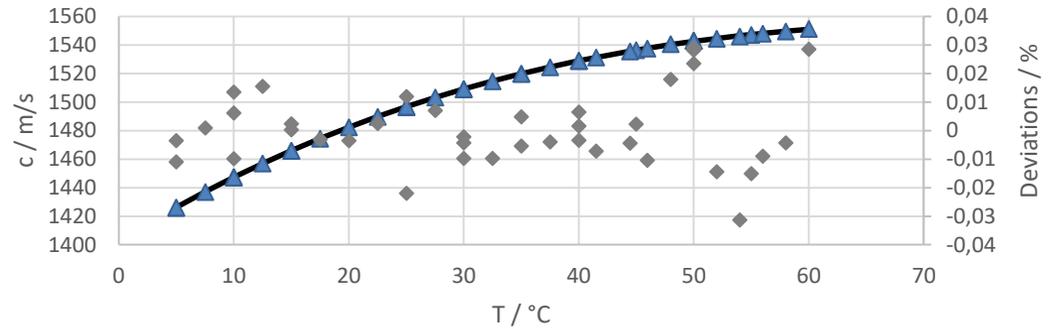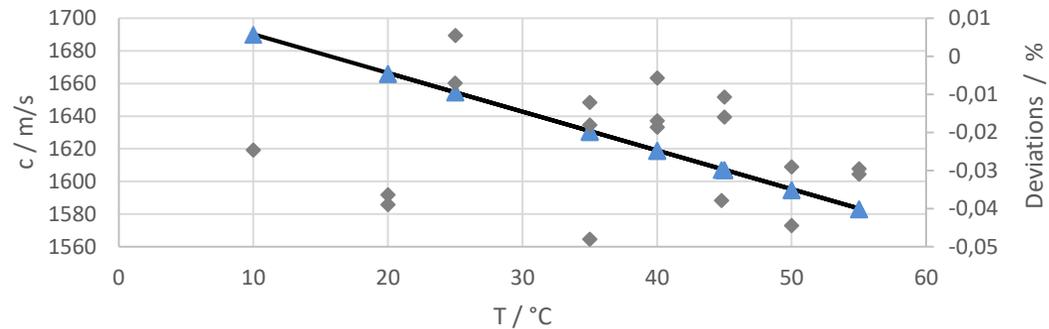
Current topics - Speed of sound

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Current topics - Speed of sound

Comparison with reference data

Current topics - Speed of sound
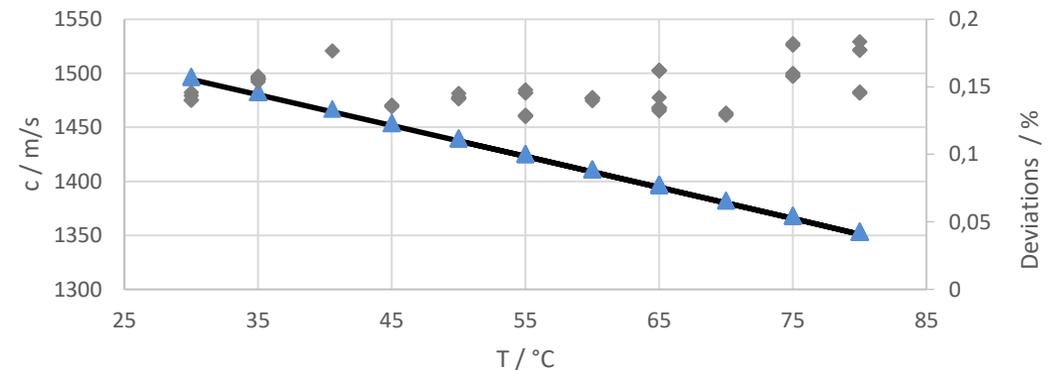
Current topics - Measuring concentration
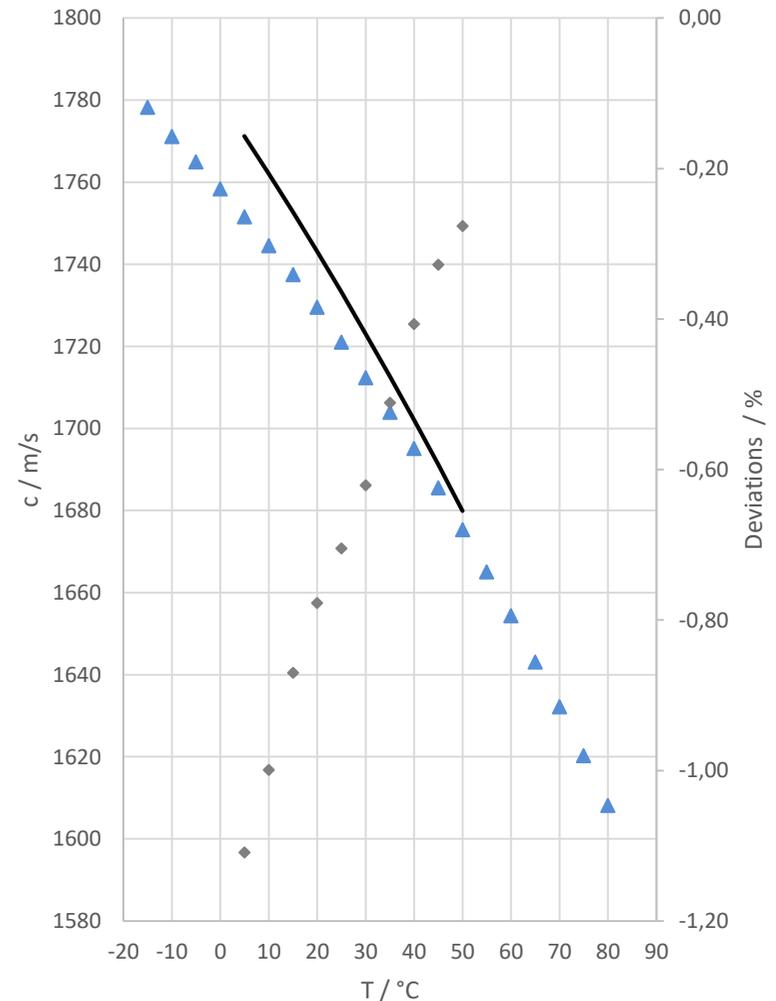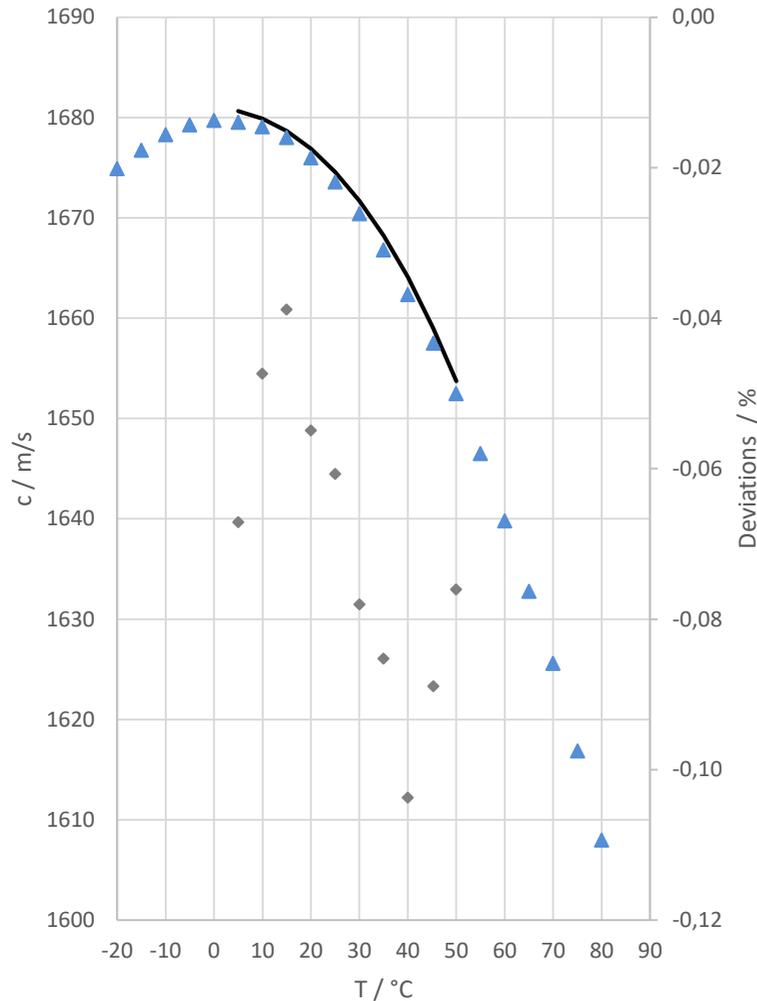
- in field concentrations are usually controlled through density or refractive index measurements

- what is the influence of typical measurement related uncertainties on the heat meter

- this question will be discussed in Mr. Arnold Sammler's presentation (Part II)

- But: Are there other ways to measure concentration in field? Or is the concentration really necessary?

Future topics

- Determine influence of slightly differing glycol concentrations on flow sensor (f.e. 38 % and 42 %) to

  - cover concentration errors

  - estimate degradation influences

  - partial leakage

- Usage of speed of sound measurements to

  - calculate pressure dependend heat coefficients

  - gather more information on measuring fluid

  - additional in-field use?

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