



EMATEM

European Metrology Association
for Thermal Energy Measurement

Qualifying immersion depth of $\varnothing 5.2$ mm temperature probes



Experimental determination in different
set-ups and a critical discussion about
influence quantities and the test
description in EN 1434 and EN IEC 60751



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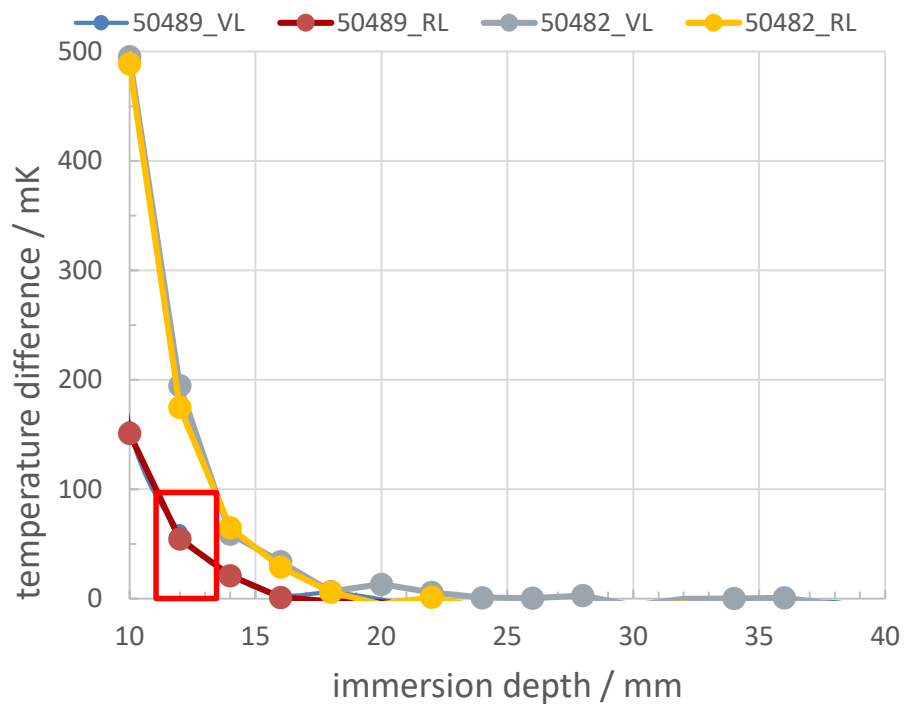


John Domino, Christian Bombis, Mads Wraa Hyttel

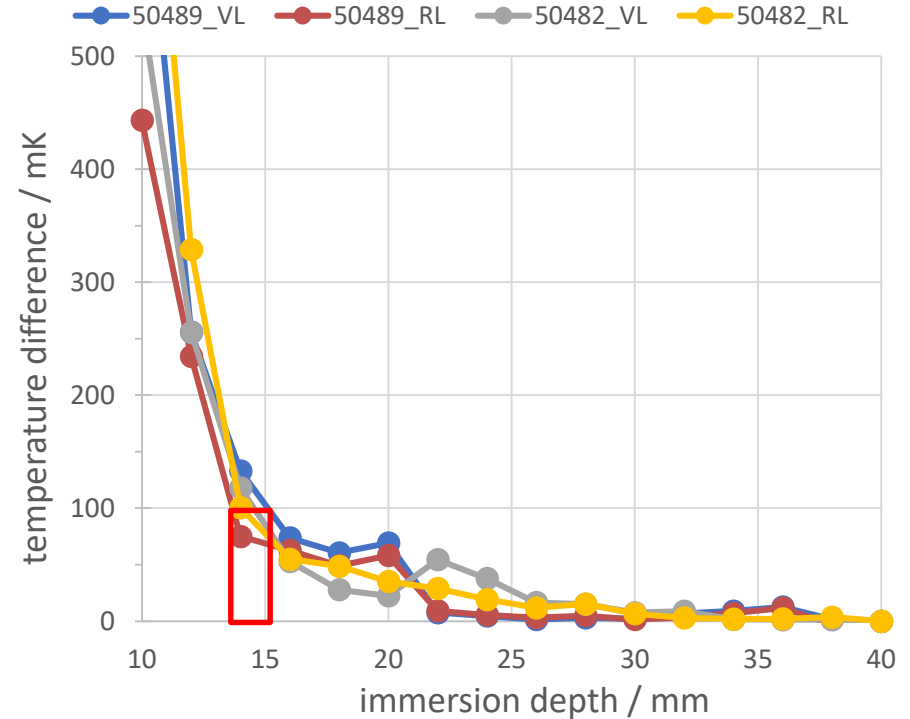


Reason for comparison

Kamstrup (automatic)



JUMO (manual)



Questions



- What are the reasons for the discrepancies?
- Automatic vs. manual measurement?
- Interpretation of standards?



Standards

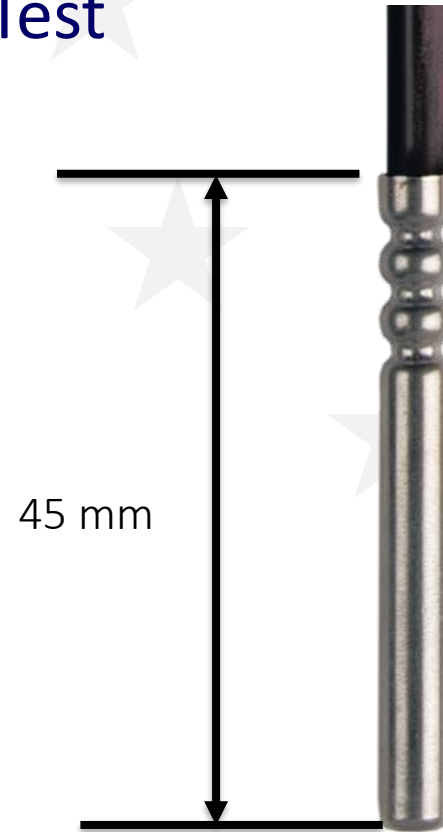


- DIN IEC 60751:2023: 6.5.9 Immersion depth
 - Extract the thermometer out of the temperature bath until a temperature change of 100 mK is reached
- EN 1434-4:2023: 7.4.4.1 Qualifying immersion depth
 - Show that the temperature reading is changing by not more than 100 mK for immersion depths greater than the qualifying immersion depth



Device under Test

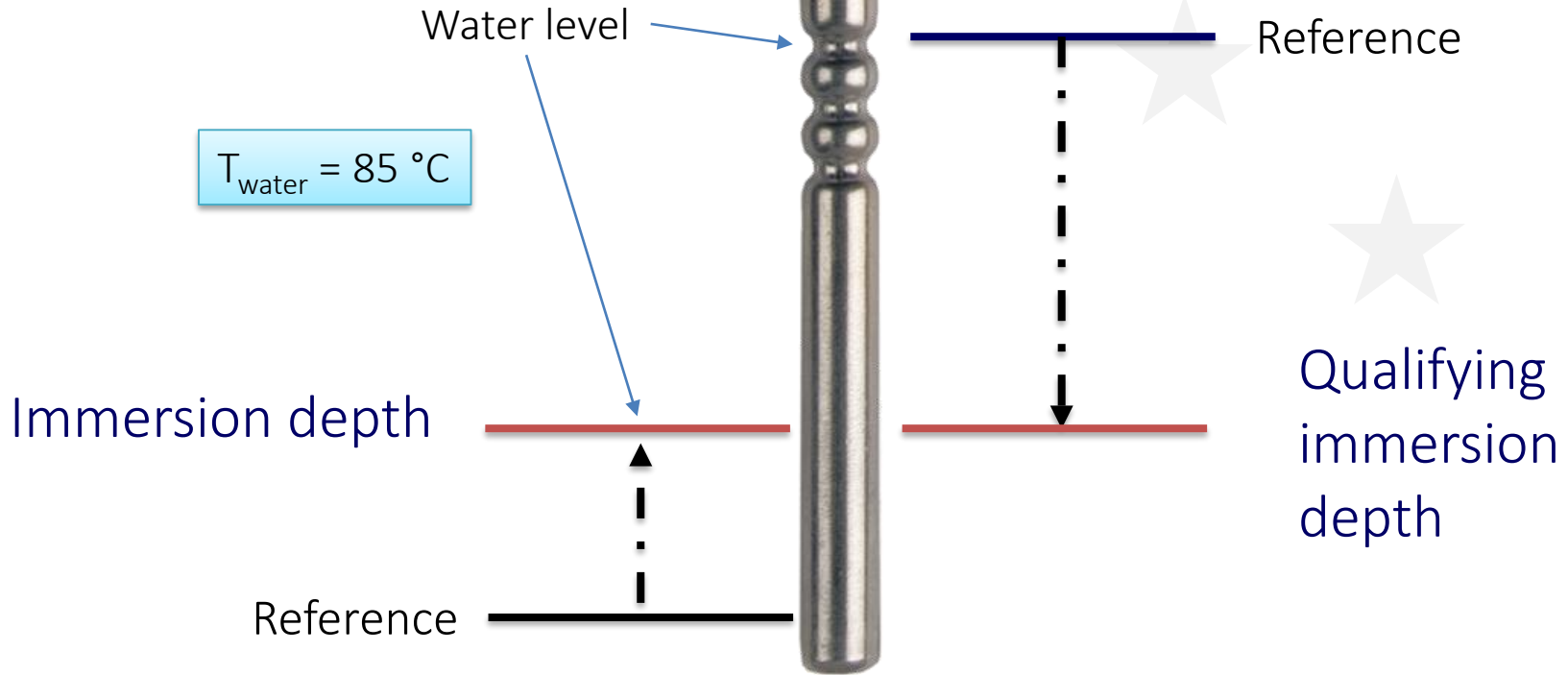
- JUMO Temperature probe
- What is the reference point, i.e. $\delta T_{\text{immersion}} = 0 \text{ K}$?
- DIN IEC 60751: Depth during Calibration
- EN 1434: ?



Type 61-63-G0-0J3-221, $\varnothing 5.2 \text{ mm}$

DIN IEC 60751

EN 1434

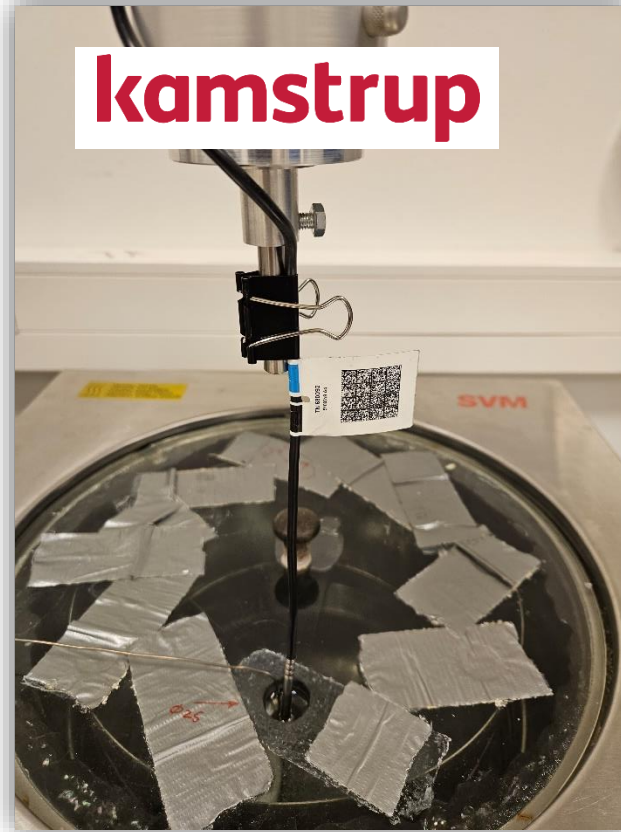


Hypothesis for discrepancy

- First assumption: Kamstrup uses a highly automated process and JUMO is having a manual setup
- Kamstrup robot setup has a very accurate positioning system
 - short term reproducibility*: QID = 0.1 mm
 - long term reproducibility* : QID = 1.1 mm
- JUMO manual marking
 - long term reproducibility*: QID = 1.5 mm
- *Derived from prior measurements

Automatic/Robot setups

- Automatic positioning
- Kamstrup: Movement in defined time intervals
- JUMO: Movement after stable measurement conditions



Manual measurements

- Manual height setup
- Markings on temperature probe
- Long measurement time

➔ Refilling of the bath



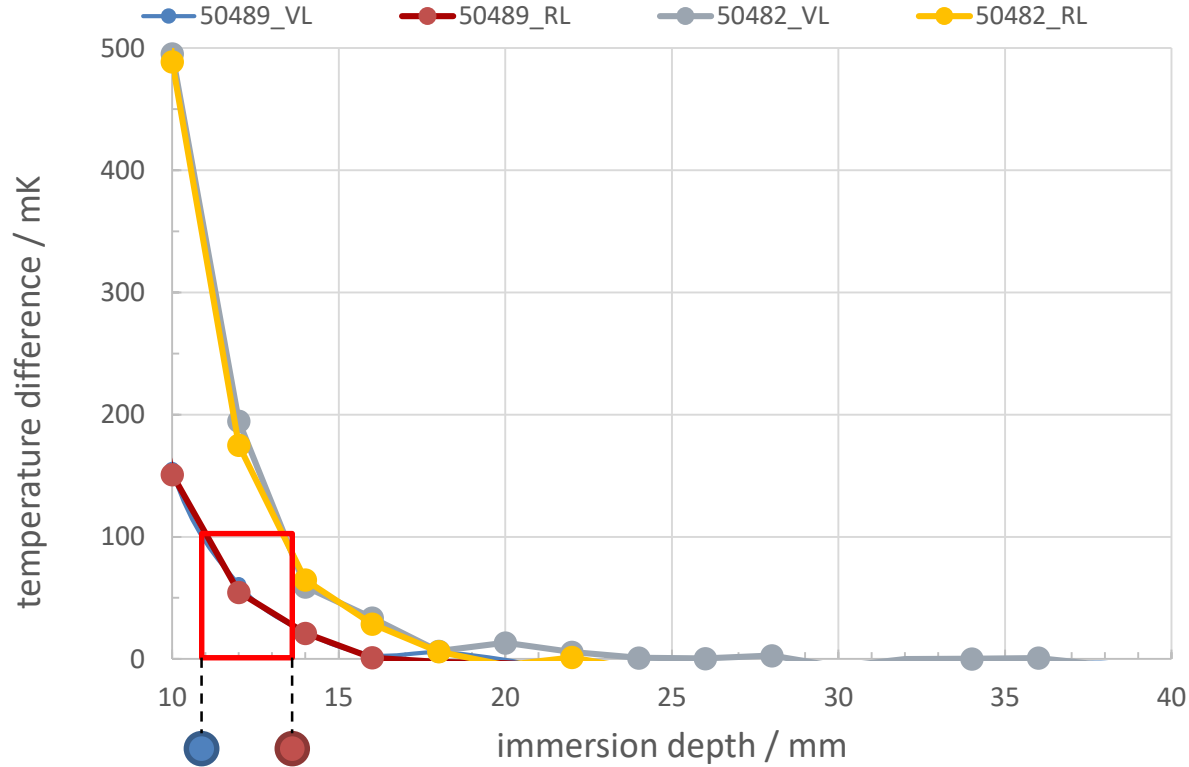
Challenges



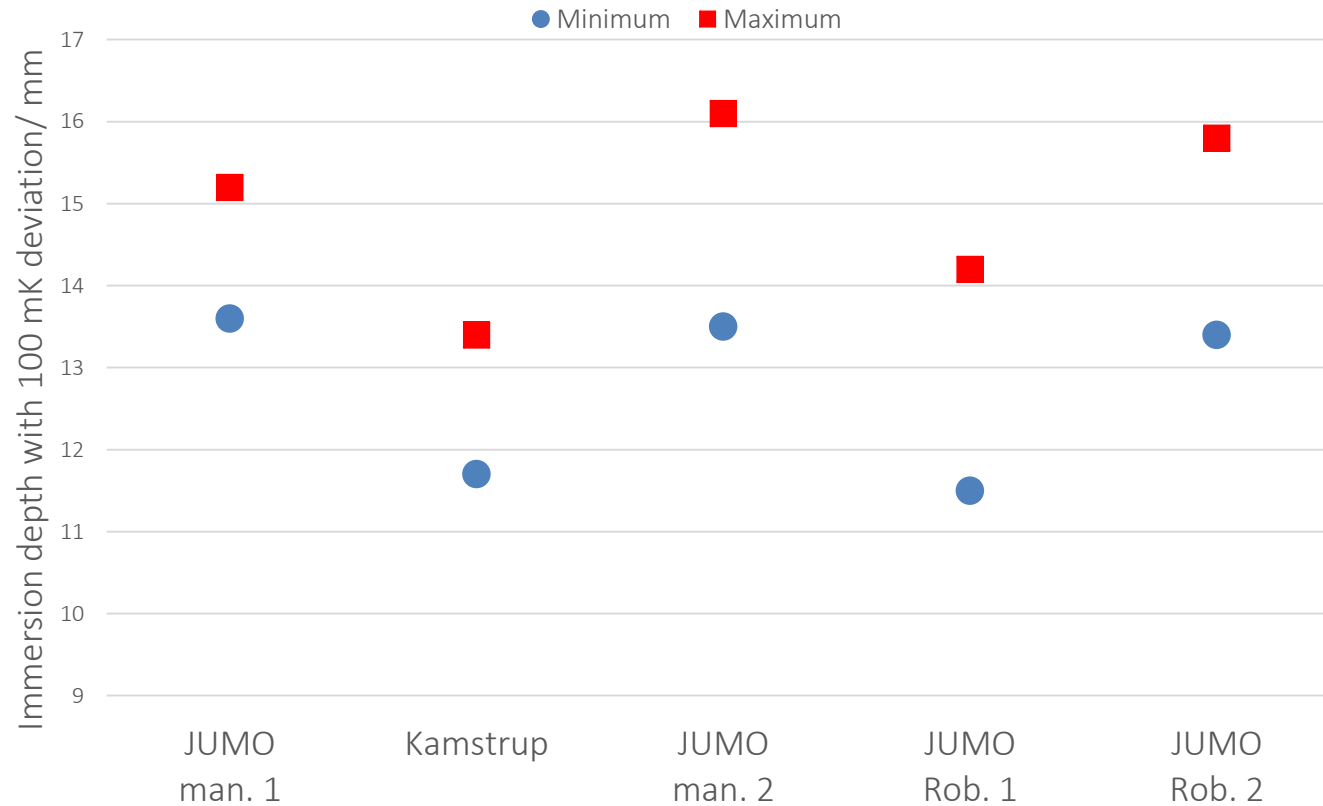
- Robot: Level in bath can vary due to evaporation
- Manual: Markings are not accurate, but the bath can be refilled
- Both: Level is varying due to stirring of bath



Explanation: Short form of analysis



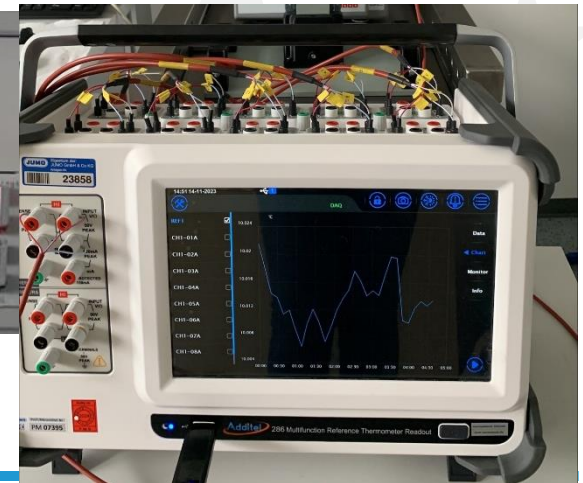
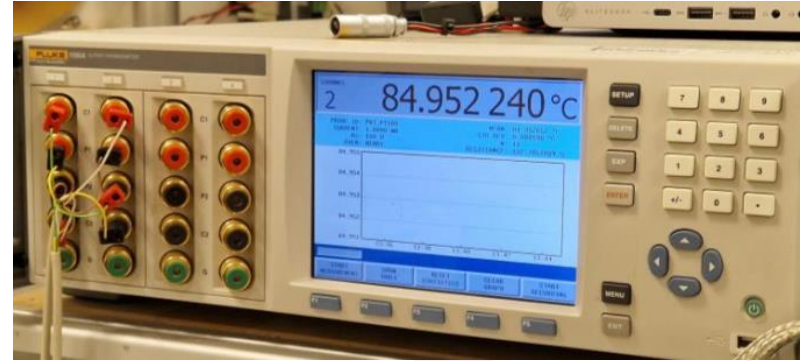
First comparison



Any more influences? - Equipment

- Kamstrup: Fluke 1595A
- JUMO: Keysight 34970A
- Additional test with Additel

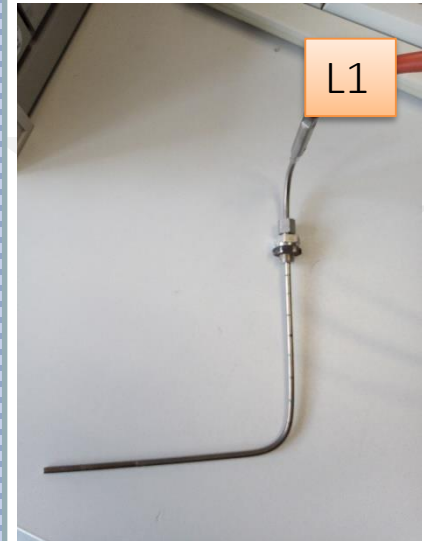
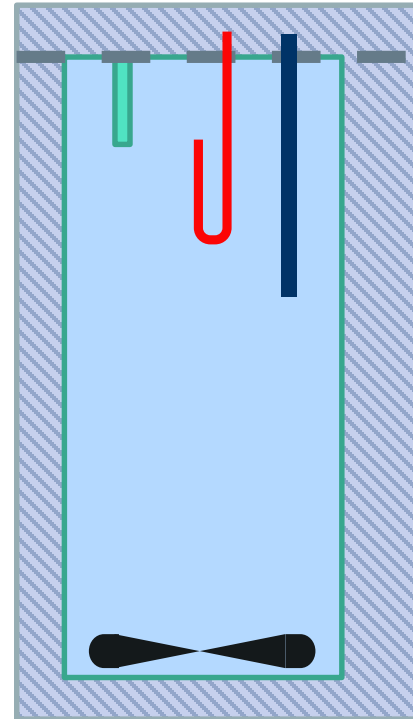
ADT-286

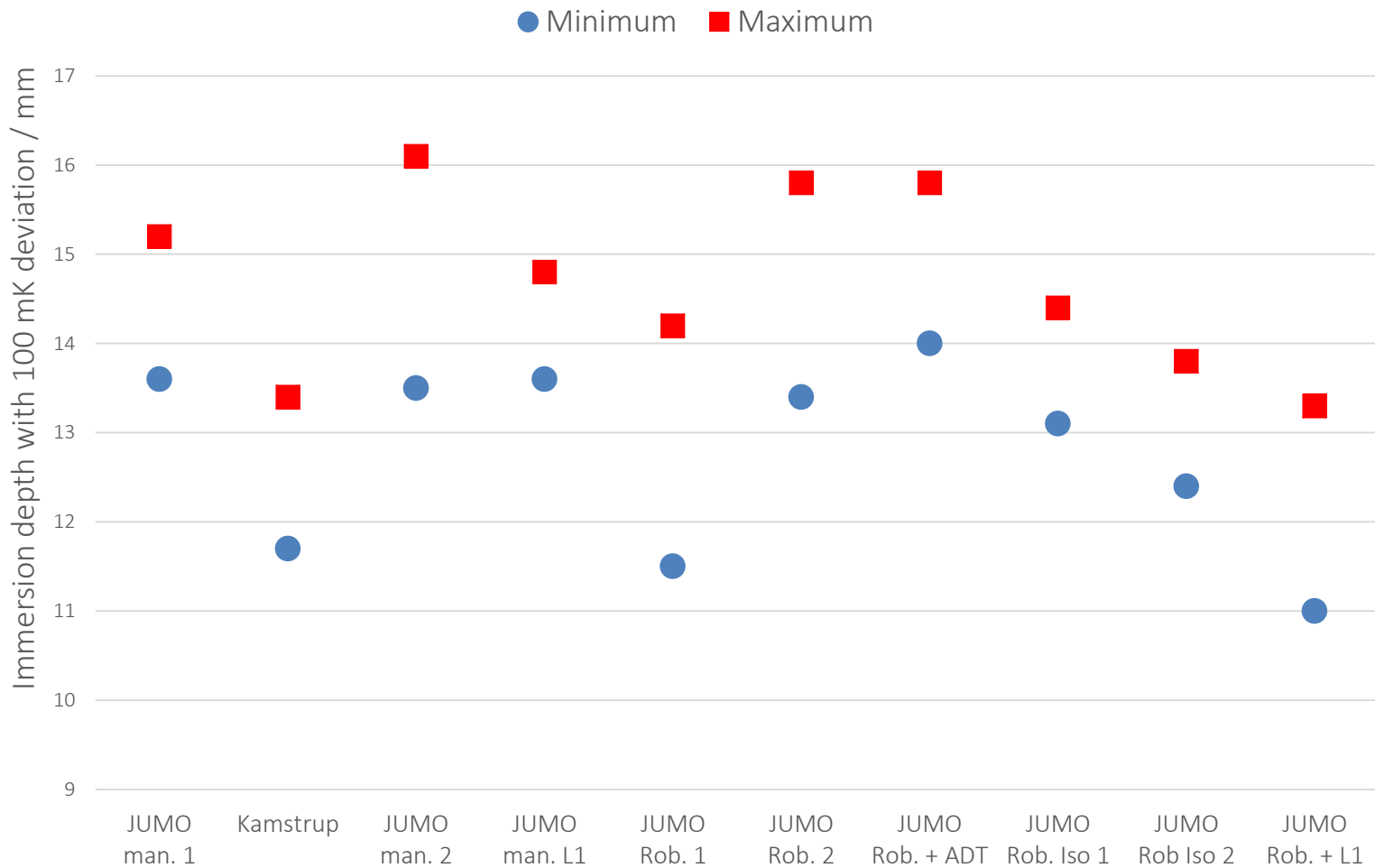


Reference temperature

- Reference thermometer is also having an heat dissipation error
- Maximum immersion depth realized by bending

DUT References





First results

- Measurement equipment has no significant effect
- Automatic positioning (Robot) has no significant effect
- Thermal insulation seems to have an effect



Closer look at the influence of the bath

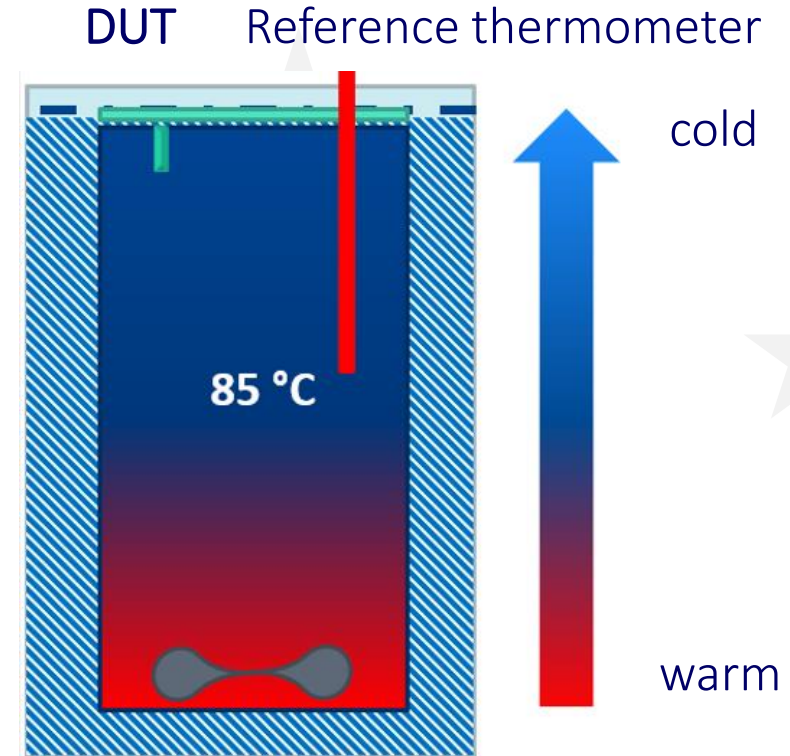
Heat dissipation

$T_{\text{ambient}} = 23\text{ }^{\circ}\text{C}$

- Reference thermometers in both setups were different
- Thermal insulation had some effect

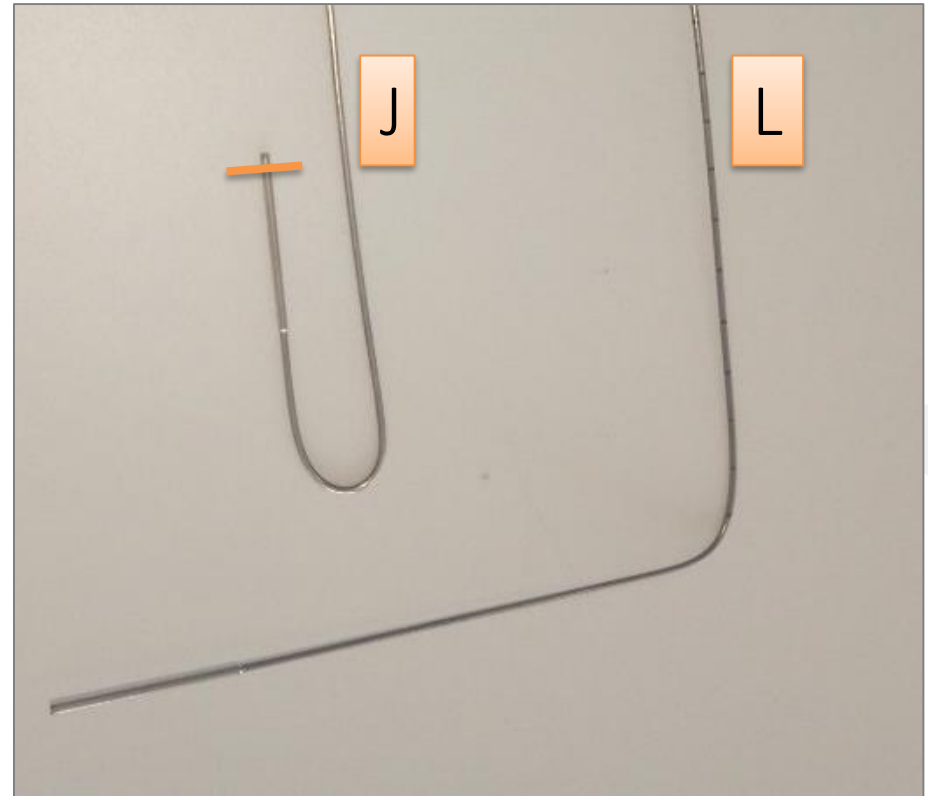
Question:

What is the temperature at the location of the DUT?



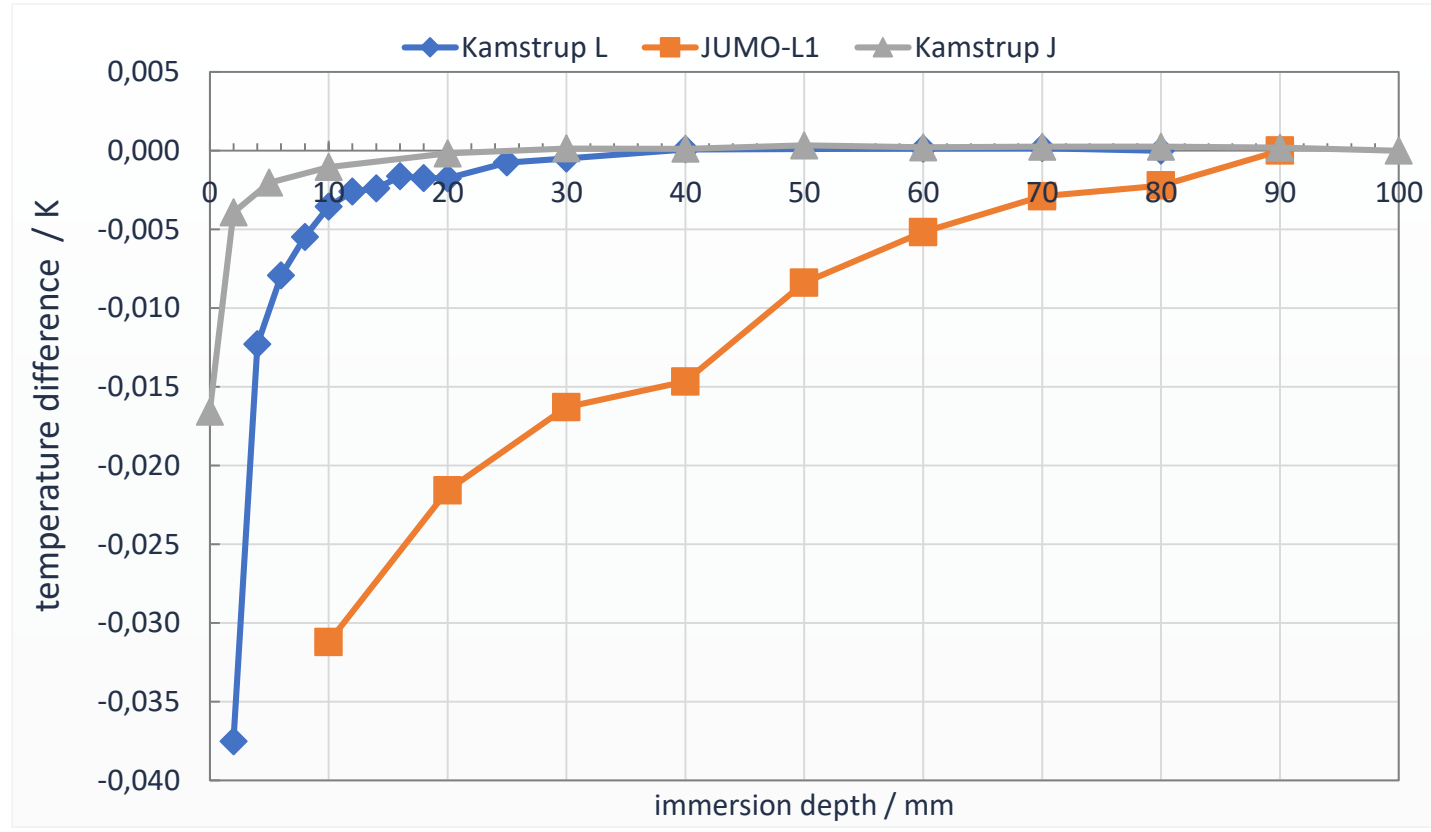
Reference Thermometers

- Bend reference thermometers
- Best immersion depth
- Lowest error due to heat dissipation
- Measurements at small immersions
- Sensor located 2 mm from end of thermometer



Temperature profile of the bath

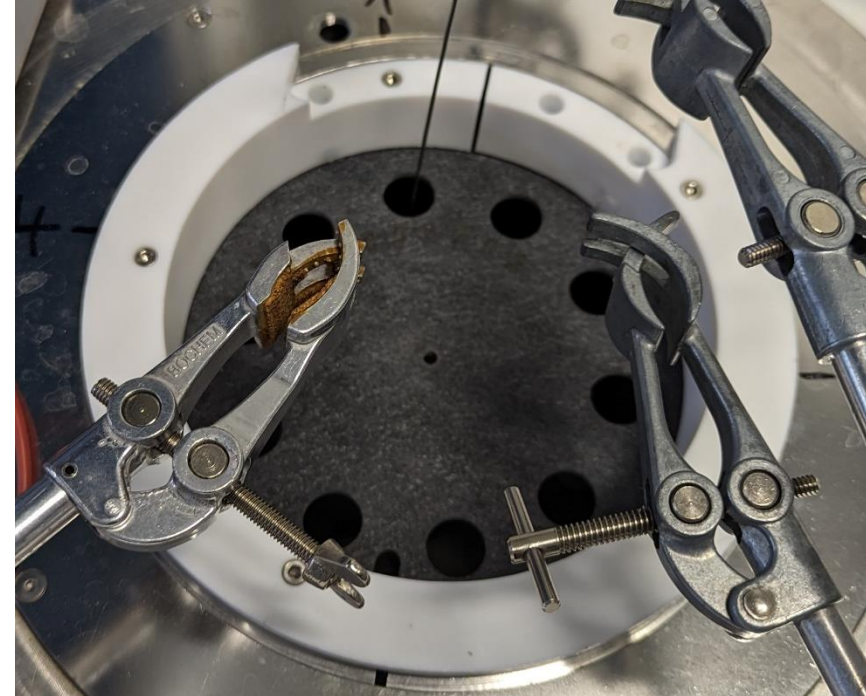
- Measurement of two references
- One is pulled out the other one is stationary



Cover with different thermal conductivity

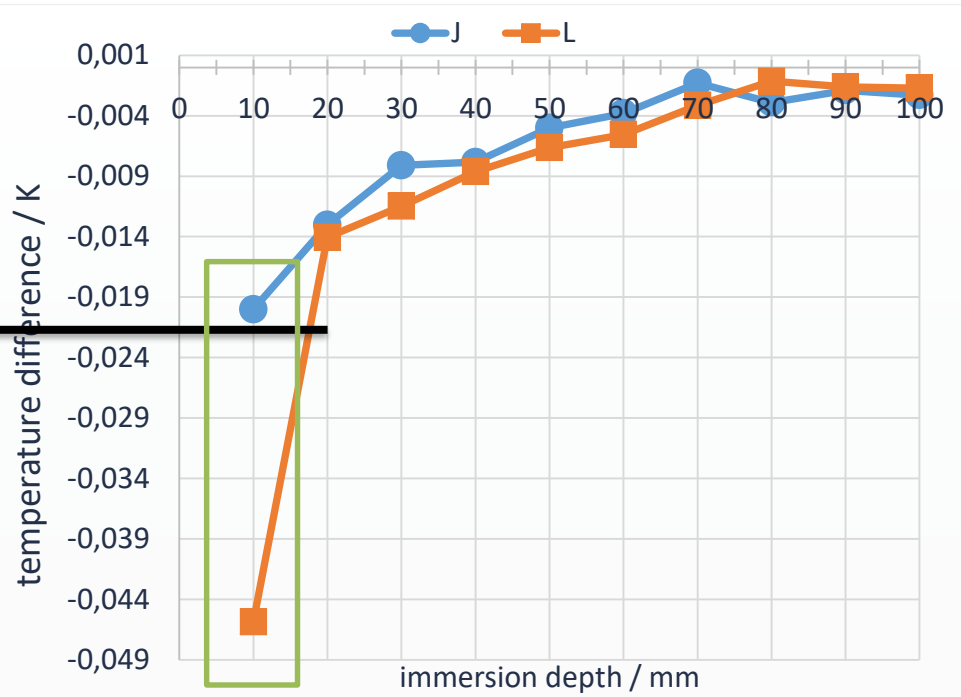
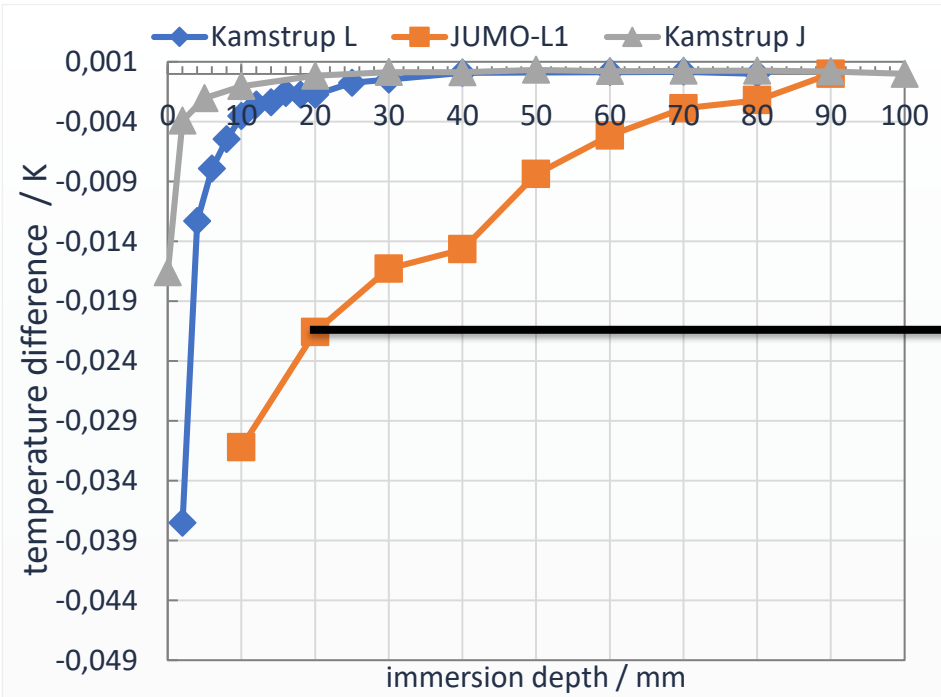
Material	$A / W \cdot (m \cdot K)^{-1}$
Glas (Kamstrup)	0,8 ... 1
Metal (JUMO)	> 50
GFK	0,3

What is the influence of the thermal coupling to the surrounding?



Influence of design and cover

ongoing research



Design of reference

Conclusions

- Initial hypothesis: “Robot is the reason for the discrepancies” proved to be wrong
- The critical point is the determination of the temperature the probe should measure
- Uncertainty contributions of this were underestimated

Temperature of bath due to heat dissipation to the surrounding	< 30 mK
Cover of bath	16 mK
Construction of reference thermometer	Relevant for immersion depths ≤ 10 mm

We are looking forward to your feedback!

Dr. Ivan Jursic

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