

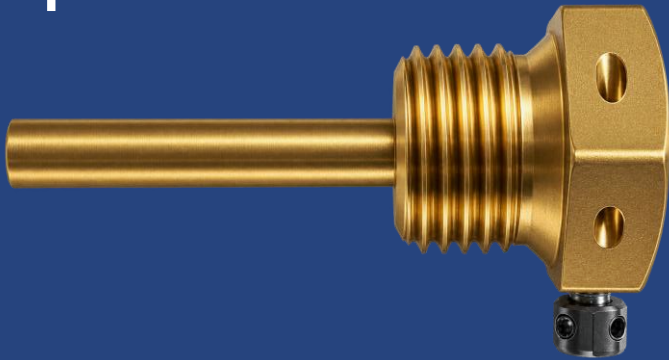
The influence of real-world installation conditions on heat dissipation errors in temperature measurement points

EMATEM

AGENDA

Part 1

Real-case validation of tolerated short pockets



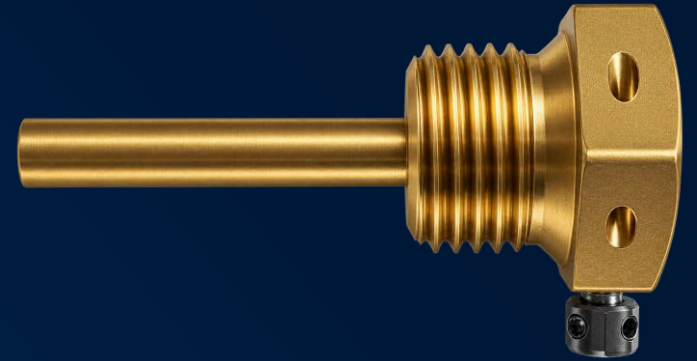
Part 2

Installation-related measurement deviations in T-pieces



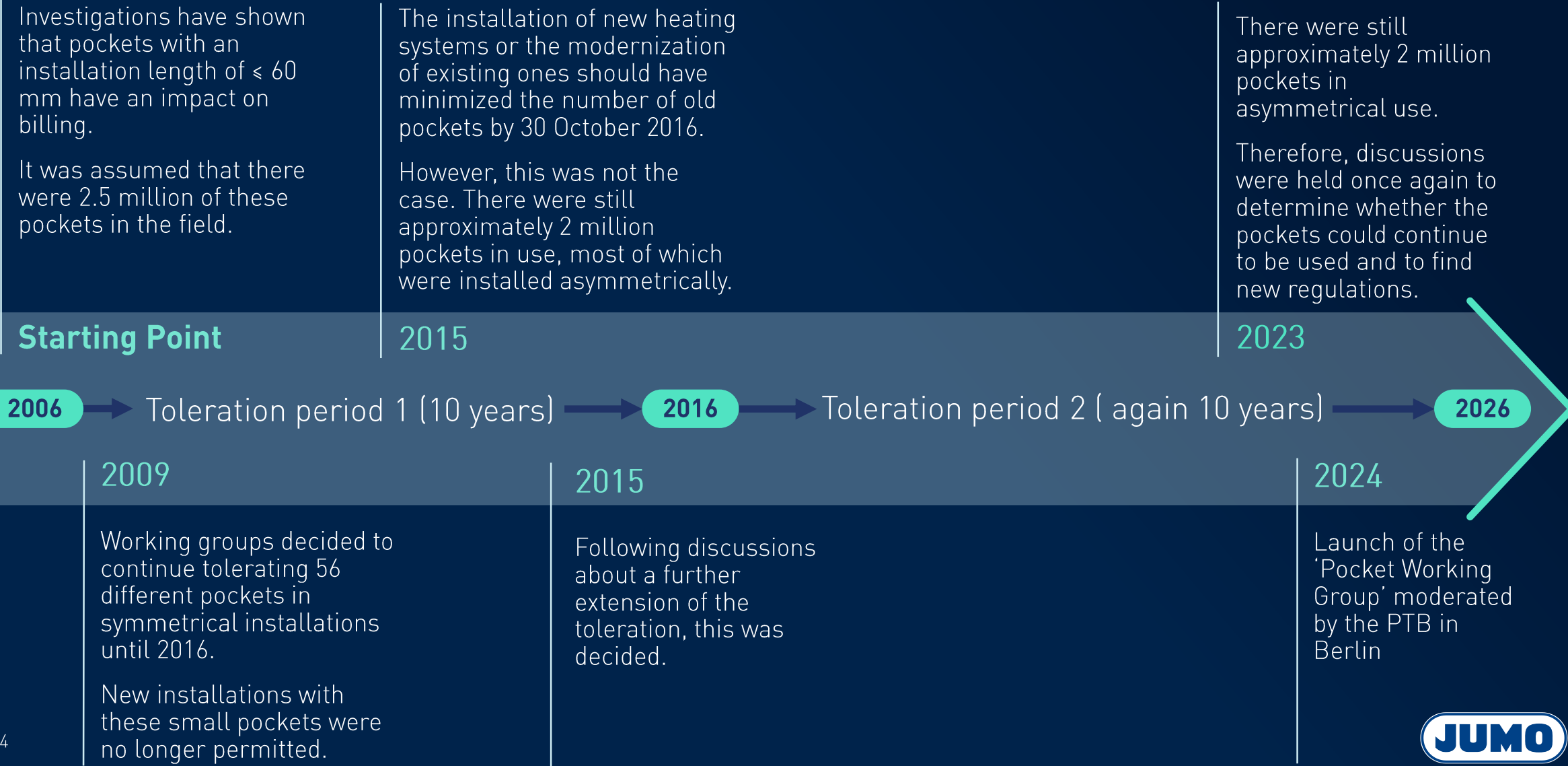
Part 1

Real-case validation of tolerated short pockets



Dipl.-Ing. Daniel Bott
Industry Manager Metering

THE SHORTEST SUMMARY



What does the working group do?



Selection of a representative group of participants

The working group includes representatives from the PTB, FIGAWA, the German calibration authorities, as well as manufacturers of heat meters and their components.

Meetings will be held online approximately every three months.

Establishment of necessary definitions

Terms such as 'symmetry' and 'asymmetry' are used, but these are not defined (e.g. in EN1434).

Furthermore, this is not only relevant for existing immersion sleeves, but for all installation situations that differ between flow and return sensors.

The new definition was presented for the first time in my EMATEM lecture in 2024.

Determination of requirements for a metrological examination

What are the requirements for a test bench for the investigation?

What parameters and measurement range should be used to conduct an investigation?

Various measurement series and comparative measurements are carried out for this purpose.

However, current procedures remain valid.

Find a solution for the existing pockets

A solution is being wanted without having another 10-year toleration period.

Since the existing short pockets are almost exclusively used asymmetrically, the old rule does not apply anyway.

So the new regulation for Germany should continue to protect consumers from incorrect billing.

TRK 8 has already been revised.

Here's what's NEW in the TR-K 8

2.7 Symmetrischer und asymmetrischer Einbau

2.7.1 Symmetrischer Einbau

Die im Abschnitt 3.1 beschriebenen Einbauarten sind vorzugsweise symmetrisch vorzusehen. Das heißt, sowohl die Einbaustelle des Vorlauffühlers als auch die Einbaustelle des Rücklauffühlers gleichen sich (direkt/direkt oder Tauchhülse/Tauchhülse). Damit werden Wärmeableitfehler zwischen den Einbausituationen minimiert.

Hinweis: Für den Fall, dass die symmetrischen Einbaustellen im Vor- und Rücklauf konstruktiv voneinander abweichen, kann ein unterschiedlicher Fehlerbeitrag auf die Temperaturdifferenzmessung vorliegen. Daher ist dieser Beitrag wie für asymmetrische Einbausituationen nach 2.7.2 im Rahmen der Baumuster-/Entwurfsprüfung zu untersuchen und zu bewerten.

Voneinander abweichende symmetrische Einbaustellen der Temperaturfühler sind zum Beispiel:

- Direkteinbau im Durchflusssensor / Direkteinbau im Kugelventil
- Direkteinbau im Durchflusssensor / Direkteinbau im T-Stück
- Direkte Einbaustelle im Vorlauf gedämmt / direkte Einbaustelle im Rücklauf nicht gedämmt.

2.7.2 Asymmetrischer Einbau

Der asymmetrische Einbaufall beschreibt die Kombination aus beiden Einbausituationen (direkt/Tauchhülse oder Tauchhülse/direkt). Die Eignung asymmetrischer Einbaubedingungen ist im Rahmen der Baumuster-/Entwurfsprüfung mittels messtechnischer Nachweise zur Einhaltung der Fehlergrenzen der Temperaturdifferenz zu erbringen.



Physikalisch-Technische Bundesanstalt
Nationales Metrologieinstitut

TR-K 8

Oktober 2025
Ersatz für März 2018

Technische Richtlinien

Messgeräte für thermische Energie

**Auswahl und Einbau von Temperaturfühlern für
Messgeräte thermischer Energie (Wärme- und
Kältezähler)**

TR-K 8

Oktober 2025

Ersatz für März 2018

Herausgegeben von der Physikalisch-Technischen Bundesanstalt
Arbeitsgruppe 7.51 – „Messung thermischer Energie“

www.ptb.de



DOWNLOAD

TR-K 8

A photograph of a laboratory interior with glass-walled fume hoods and people working in white lab coats.

Laboratory

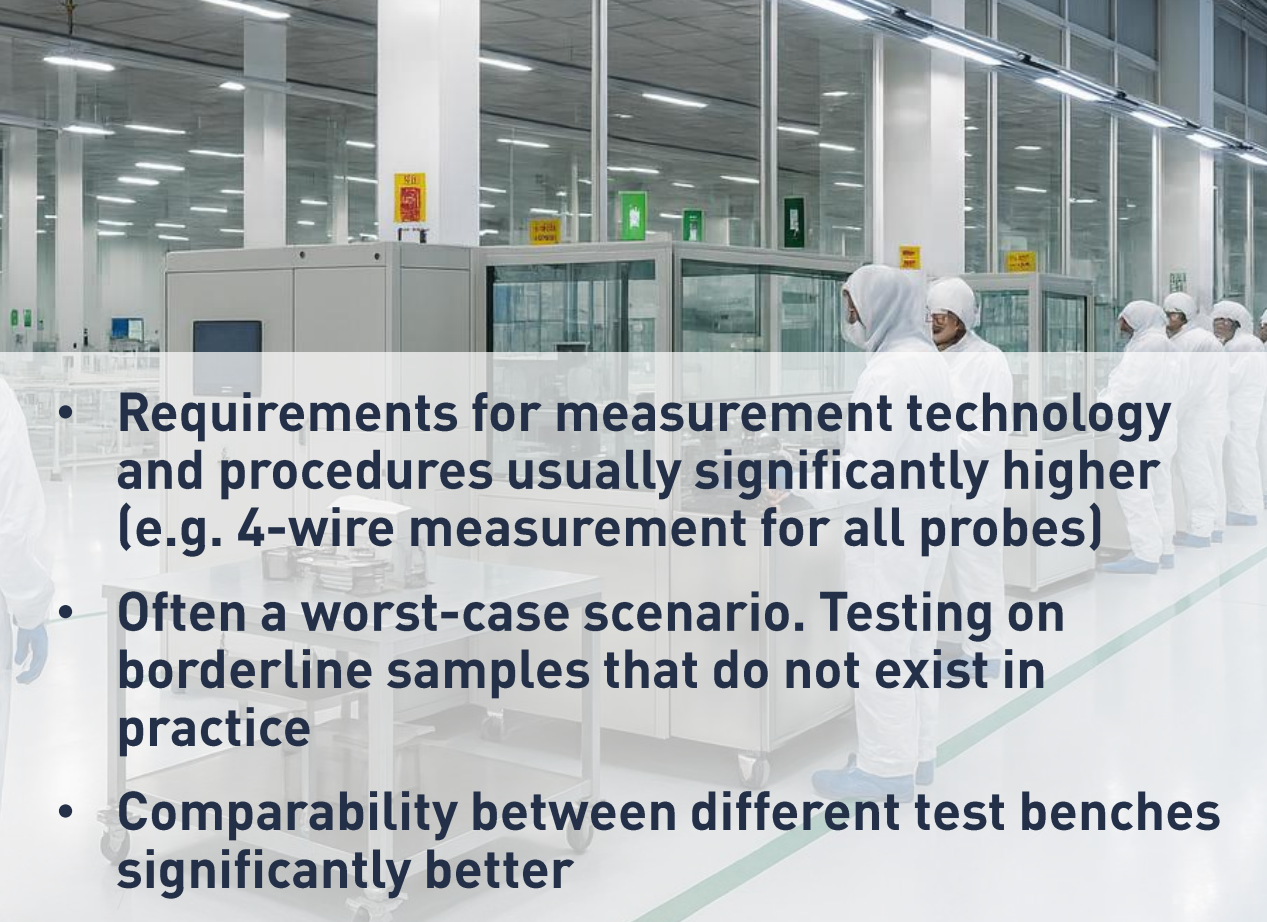
measurement

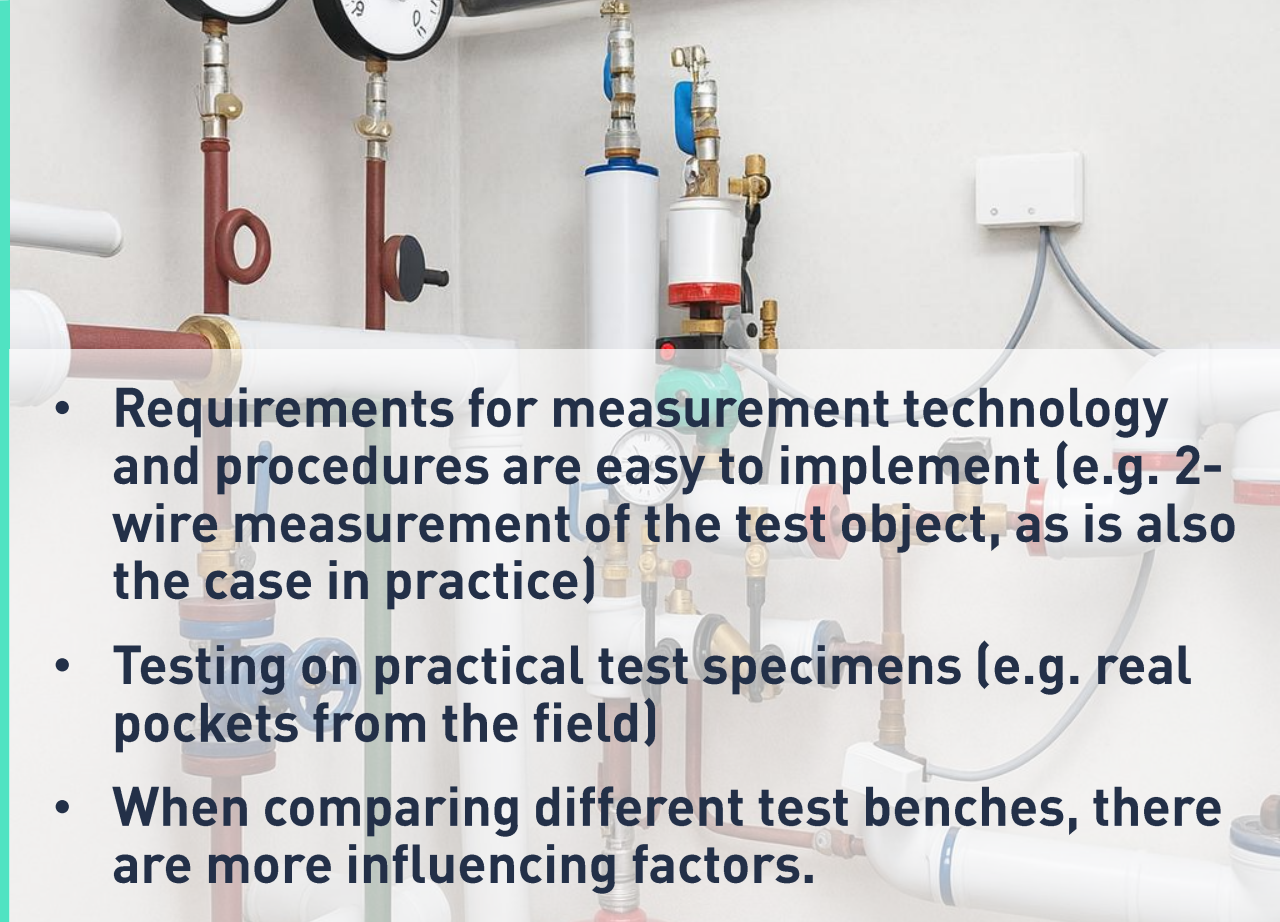
vs

A photograph of industrial piping and valves, likely for a practical measurement setup.

Practical

measurement

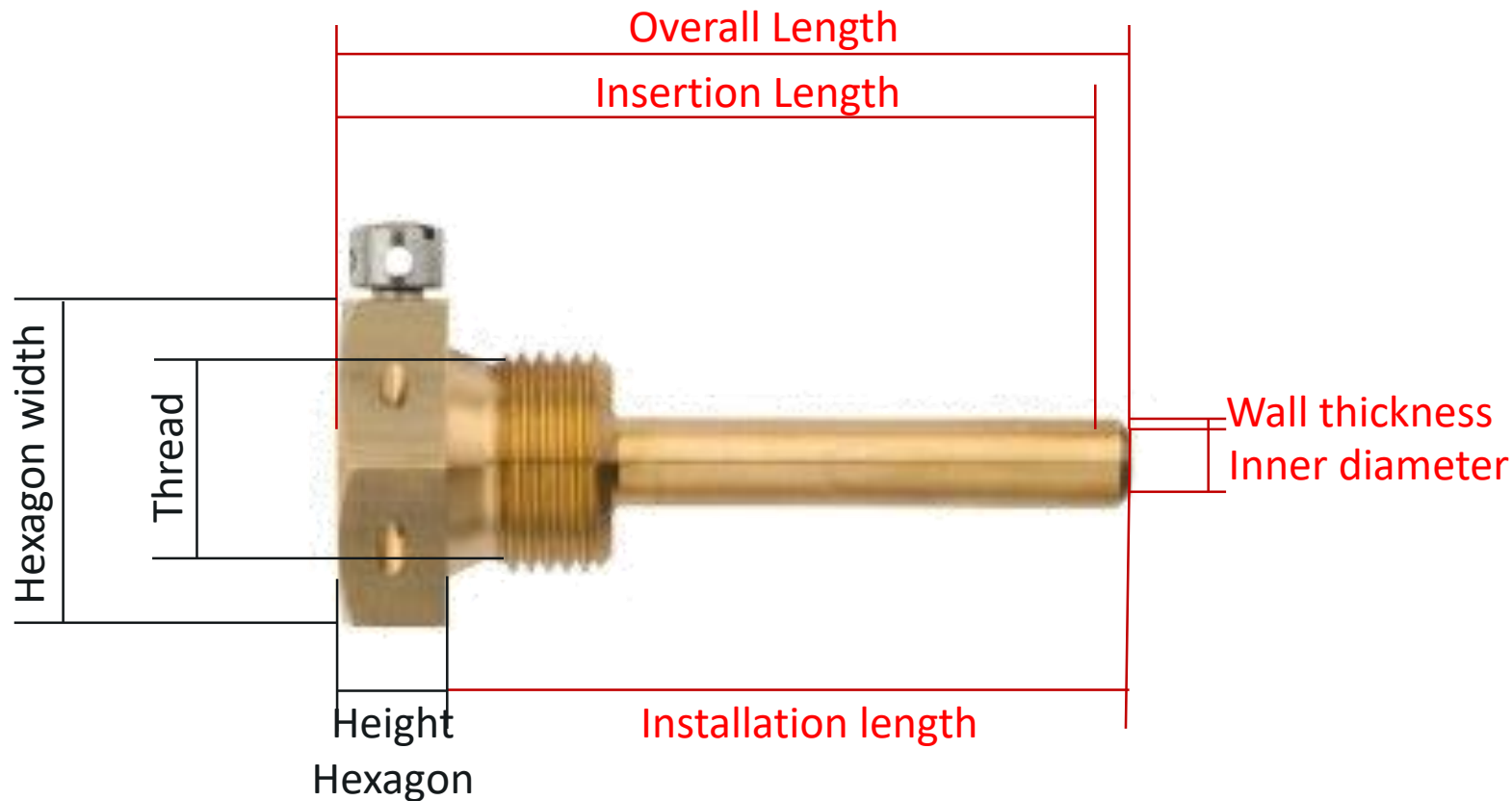
- 
- A photograph of a laboratory interior with glass-walled fume hoods and people working in white lab coats.
- Requirements for measurement technology and procedures usually significantly higher (e.g. 4-wire measurement for all probes)
 - Often a worst-case scenario. Testing on borderline samples that do not exist in practice
 - Comparability between different test benches significantly better

- 
- A photograph of industrial piping and valves, likely for a practical measurement setup.
- Requirements for measurement technology and procedures are easy to implement (e.g. 2-wire measurement of the test object, as is also the case in practice)
 - Testing on practical test specimens (e.g. real pockets from the field)
 - When comparing different test benches, there are more influencing factors.

The working group must find a good balance here

Factors Affecting a Pocket

- There are various factors that influences the heat conduction error in pockets
- Some factors have a major impact, while others have a lesser one



Major factors:

- **Length**
- **Inner diameter and**
- **Wall thickness**

Minor factors:

- **Thread**
- **Hexagon**

The principle used so far: artificial worst-case scenario

- ▶ It is not economically feasible to construct and measure individual test specimens for each of the 56 tolerated pockets.



- ▶ That is why, at that time, in collaboration with the PTB, reference boundary samples were defined for testing symmetrical installation. These are available in two different hexagon heights

56 tolerated pockets on the “Tolerance List”

In the meantime, subgroups have also been formed

High Impact
High Priority

Low impact
Low priority

1

Inst. length

2

Diameter

3

Wall thickness

4

Thread size

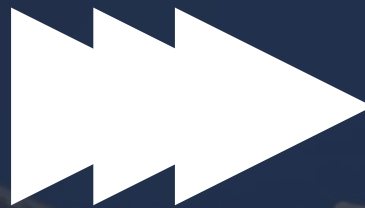
Covered pockets
with boundary sample

Registration Number TH XXX	Diameter [mm]	Installation length [mm]	Wall thickness [mm]	Thread size
Group 1	6,0	26	1,5	1/2"
TH 078	6,0	27,5	0,74	M10x1
TH 009	6,0	28	0,75	M10
TH 011	6,0	28	1	1/4
TH 027	6,0	28,5	0,75	M10x1
TH 010	6,0	33	1	3/8
TH 012	6,0	34	1	1/2
TH 028	6,0	38,3	0,75	M10x1
TH 014	6,0	43	1,0	3/8
TH 016	6,0	43	1,0	3/8
TH 019	6,0	43	1	1/2
TH 093	6,15	92,5	1,85	G1/2
TH 092	6,15	147,5	1,85	G1/2
Group 2	5,2	26	1,5	1/2"
TH 084	5,0	26,5	1	1/4"
TH 085	5,0	26,5	1	1/2"
TH 086	5,0	26,5	1	3/8"
TH 087	5,0	26,5	1	M10x1
TH 088	5,0	26,5	1	1/4"
TH 077	5,2	27,5	0,69	M10x1
TH 083	5,0	27,5	0,69	M10x1
TH 090	5,0	28,4	0,7	M10x1
TH 091	5,2	28,4	0,7	M10x1
TH 035	5,0	31	0,7	M10x1
TH 094	5,0	31	1,45	1/2"
TH 081	5,2	31,5	0,69	3/8
TH 001	5,2	32,8	0,5	1/2
TH 002	5,2	32,8	0,5	3/8
TH 029	5,0	33	1,25	M10x1
TH 004	5,2	33,3	1,1	1/2
TH 089	5,2	33,3	1,1	3/8"
Group 3	5,2	35	1,5	1/2"
TH 079	5,2	35	0,69	1/2
...	5,2	35	0,7	1/2

The new idea: “Real Case” instead of “Artificial” Worst Case



Stop creating a
pockets that
doesn't actually
exist



An existing tolerated pocket
from the list is selected as
the worst-case pocket

How do we find the “worst real-world” tolerated pocket?

Worst Pocket (from the selection):
TH 001

Select Pocket using the Filter Function

Pocket Number	Inner Diameter [mm]	Installation Length [mm]	Wall thickness [mm]	Head Volume [mm ³]	Calculated WorstCaseScore
TH 001	5,2	32,8	0,5	2245	538

Calculation Criteria

Parameter	Effect on Measurement Error	Rating Idea	Influence Ranking (1 high 4 low)
Inner diameter (di)	Larger → more material → poorer heat transfer to the sensor → worse	The bigger it is, the worse it is	2
Installation length (l)	Shorter → Faster Heat Conduction	The shorter it is, the worse it is	1
Wall thickness	Thicker wall → more material → higher heat conduction	The bigger it is, the worse it is	3
Volume of the head	Larger head → more cooling surface → worse	The bigger it is, the worse it is	4

Formula for Calculation

=WENN(UND(ISTZAHL(C4);ISTZAHL(D4);ISTZAHL(E4);ISTZAHL(F4));(55-D4)*10 + C4*8 + F4*0,1 + E4*100;NV())

Weightings that can be adjusted based on experience:

Influencing factor	Weighted by ...	Value for formula	Why?
di (column C)	×8 positive	8	Strong Influence
Length (column D)	×10 negative	10	Strongest Influence
Volume of the head (column F)	×0,1 positive	0,1	Secondary influence
Wall thickness (column E)	×100 positive	100	Moderate influence



Selection of tolerated pockets for an initial comparison

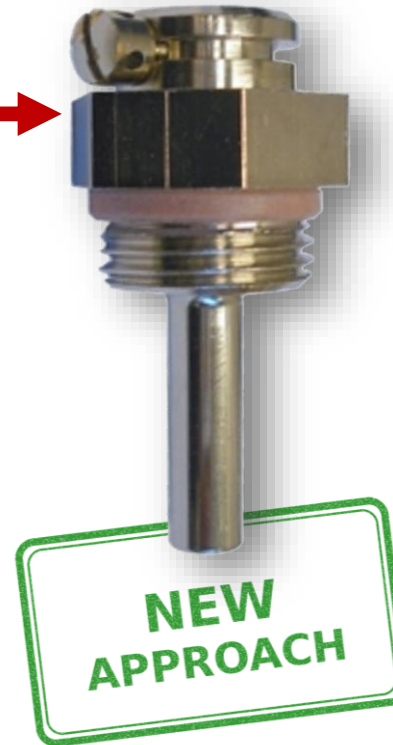
Worst Pocket (from the selection):

TH 004

Select Pocket using the Filter Function

Pocket Number	Inner Diameter [mm]	Installation Length [mm]	Wall thickness [mm]	Head Volume [mm³]
TH 001	5,2	32,8	0,5	2245
TH 002	5,2	32,8	0,5	2245
TH 003	5,2	44,3	0,85	3367
TH 004	5,2	33,3	1,1	3367
TH 005	5,2	36,5	0,3	4092
TH 013	5,0	41,5	1,0	1502
TH 015	5,0	43	1,5	3379
TH 017	5,0	43	1,5	1572
TH 020	5,0	42	1	2515
TH 021	5,0	41,5	1,0	2515
TH 029	5,0	33	1,25	1655
TH 033	5,0	43	0,7	1655
TH 035	5,2	35	0,7	2993
TH 040	5,2	35	0,7	2993
TH 043	5,2	50	0,7	2993
TH 044	5,2	50	0,7	2993
TH 046	5,2	35	0,7	1502
TH 047	5,0	35	0,7	1502
TH 048	5,2	40	0,7	1877
TH 051	5,0	40	0,7	1877
TH 054	5,2	37,5	0,7	2440
TH 055	5,0	37,5	0,7	2440
TH 067	5,2	50	0,7	1877
TH 068	5,2	60	0,7	1877
TH 077	5,2	27,5	0,69	1537
TH 079	5,2	35	0,69	2619
TH 081	5,2	31,5	0,69	1877
TH 083	5,0	27,5	0,69	1537
TH 084	5,0	26,5	1	2628
TH 087	5,0	26,5	1	2628
TH 088	5,0	26,5	1	2628
TH 089	5,2	33,3	1,1	2829
TH 090	5,0	28,4	0,7	2419
TH 091	5,2	28,4	0,7	2419
TH 095	5,0	40	1,45	2993
TH 096	5,0	60	1,45	2993
TH 097	5,0	90	1,45	2993
TH 098	5,0	120	1,45	2993
TH 099	5,0	150	1,45	2993
TH 100	5,0	210	1,45	2993

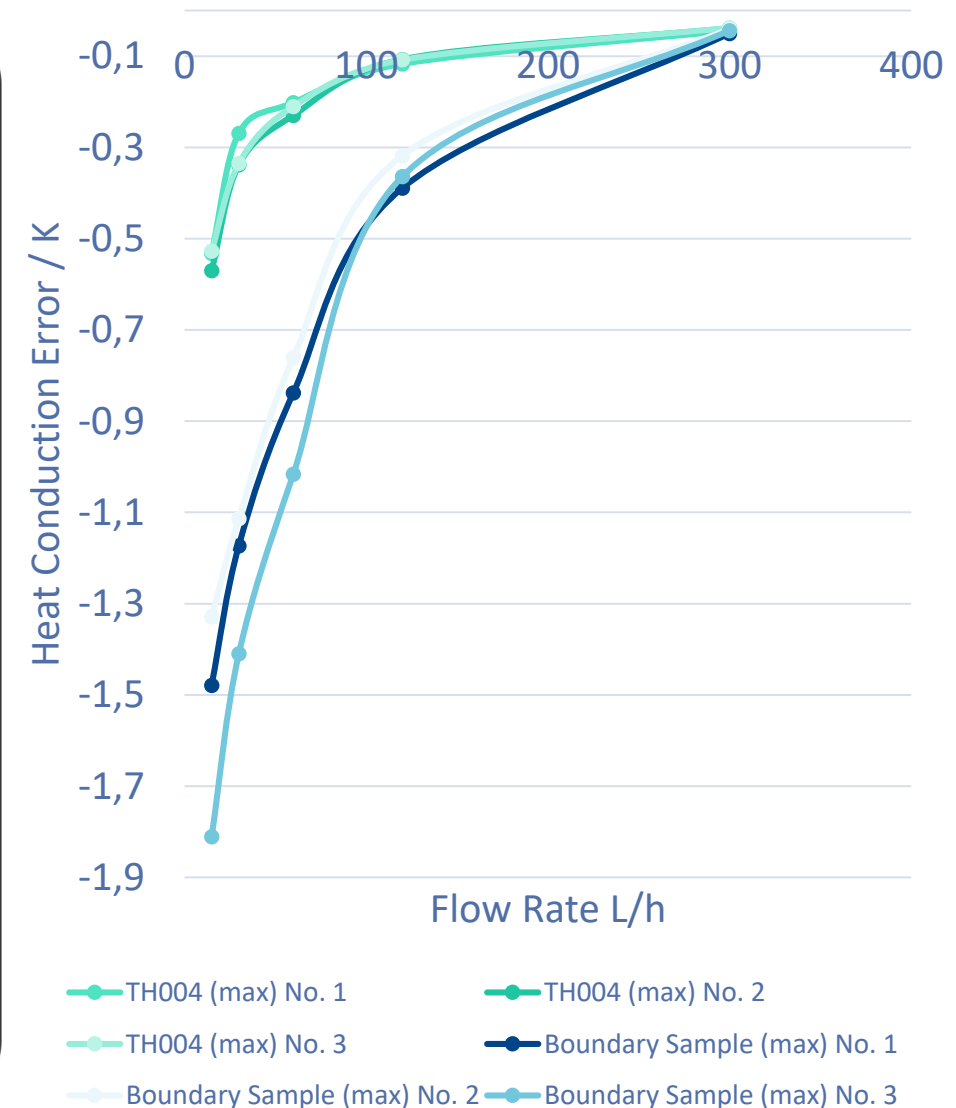
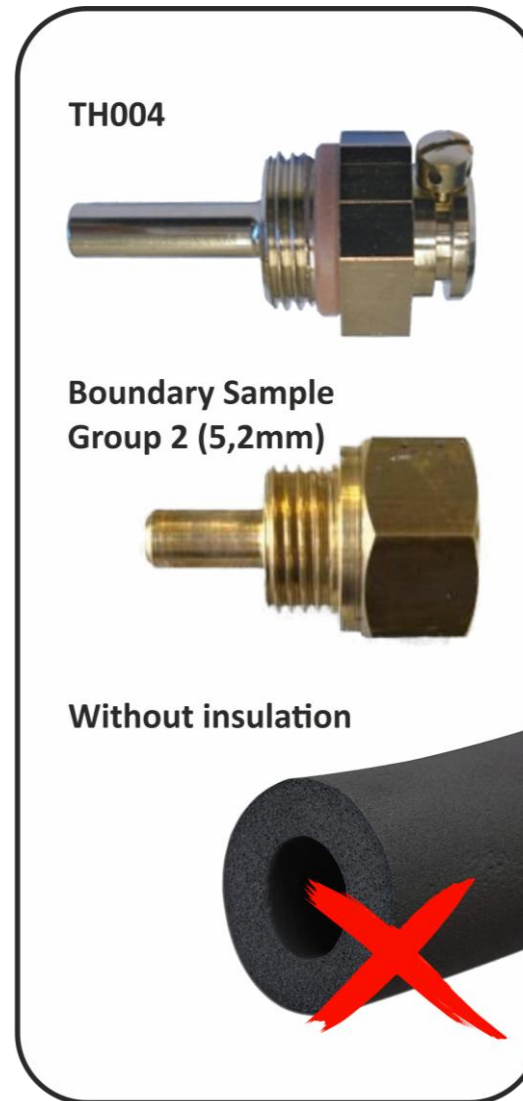
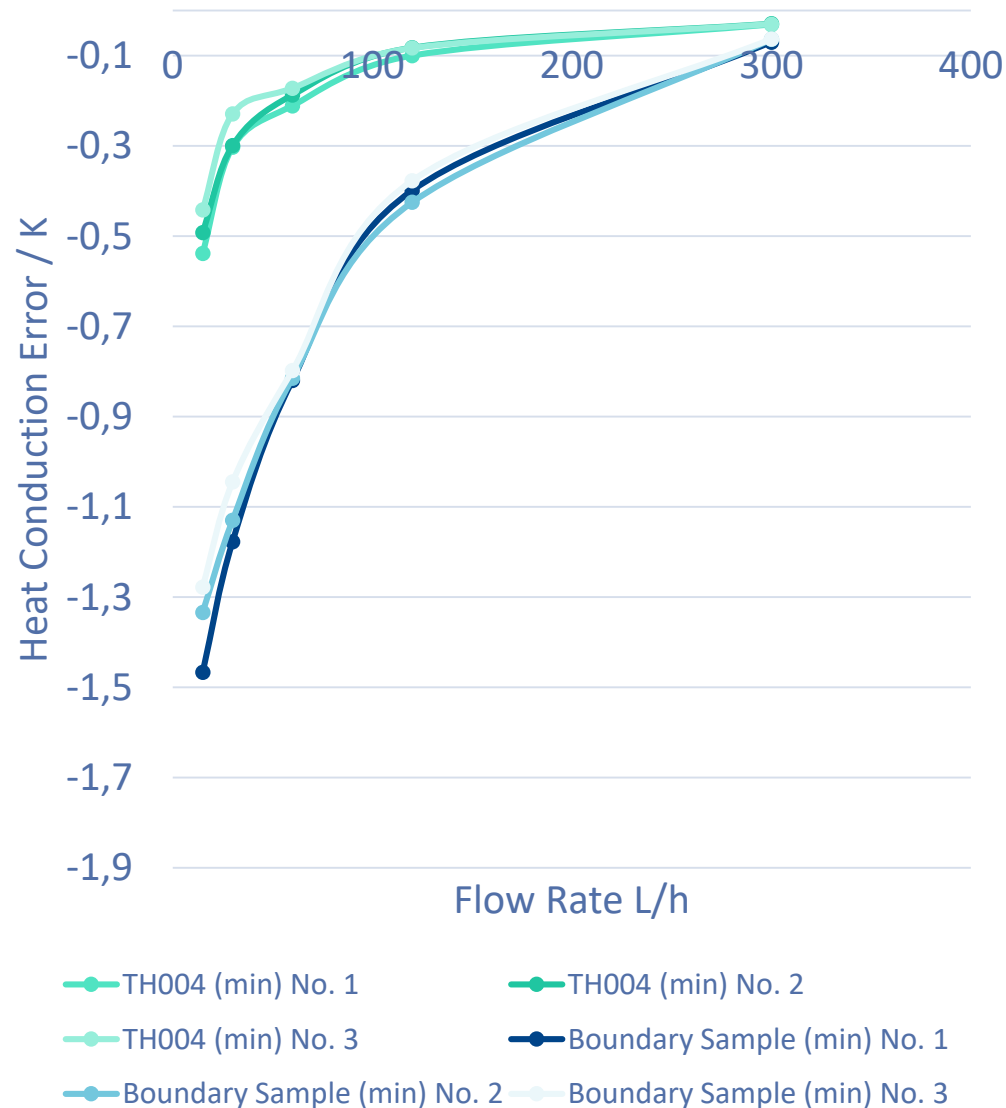
Tolerated
Pocket
TH004



Boundary
Sample for
Group 2



Comparison: “Real Case” vs. “Artificial” Worst Case



Conclusion & Open Questions for Experts



Result

Real-case pockets exhibit a lower heat conduction error than artificial boundary samples, which, however, was to be expected.



Meaning

A real-case approach could allow for a more practical assessment.



Next Step

Evaluation criteria must be validated. Discussion in the Working Group “AK Tauchhülle”, potential approval by the PTB, and, in the future, a research project involving FEM simulation of the tolerated pockets.



Open Question

Can the real-case approach establish itself as a standardizable valuation method in the future?

It's not just the probe or pocket that matters - the installation conditions also affect the measurement result.



Part 2

Installation-related measurement deviations in T-pieces



Andreas Klewer
Global Development Mechanics





“

The section of piping at the temperature probe's installation location, including any fittings, must be thermally insulated. The temperature probe must remain accessible for replacement or inspection purposes (e.g., user seal, main stamp, or markings).

”



Physikalisch-Technische Bundesanstalt
Nationales Metrologieinstitut

TR-K 8

Oktober 2025
Ersatz für März 2018

Technische Richtlinien

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**Auswahl und Einbau von Temperaturfühlern für
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Herausgegeben von der Physikalisch-Technischen Bundesanstalt
Arbeitsgruppe 7.51 – „Messung thermischer Energie“

www.ptb.de

Installation-related measurement deviations in temperature measurement – general information

calibration of the temperature sensor

VS

measurement at the installation site



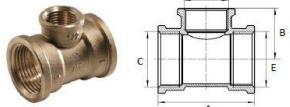
Installation-related measurement deviations in temperature measurement – influence of thermal insulation

influence of thermal insulation at the installation site



87130R

Te reducida H
F Reducing tee



TH004 in min.-
& max.-gap
dimension

CÓDIGO	MEDIDA	A	B	C-E	D
CODE	SIZE				
87130-01510	1/2" x 3/8"	130	10	42	20 1/2" 3/8"
87130-02015	3/4" x 1/2"	90	10	48	25 3/4" 1/2"
87130-02515	1" x 1/2"	60	5	52	27,5 1" 1/2"
87130-02520	1" x 3/4"	50	5	57	30 1" 3/4"
87130-03215	1 1/4" x 1/2"	40	5	56	32 1 1/4" 1/2"
87130-03220	1 1/4" x 3/4"	30	5	61	34 1 1/4" 3/4"
87130-03225	1 1/4" x 1"	30	5	66	34,5 1 1/4" 1"
87130-04015	1 1/2" x 1/2"	25	5	59	34,5 1 1/2" 1/2"
87130-04020	1 1/2" x 3/4"	25	5	63	37 1 1/2" 3/4"
87130-04025	1 1/2" x 1"	25	5	66	38 1 1/2" 1"
87130-04032	1 1/2" x 1 1/4"	20	5	74	41 1 1/2" 1 1/4"
87130-05015	2" x 1/2"	42	1	66	44 2" 1/2"
87130-05020	2" x 3/4"	42	1	69	44 2" 3/4"
87130-05025	2" x 1"	42	1	78	44 2" 1"
87130-05032	2" x 1 1/4"	36	1	85	46 2" 1 1/4"

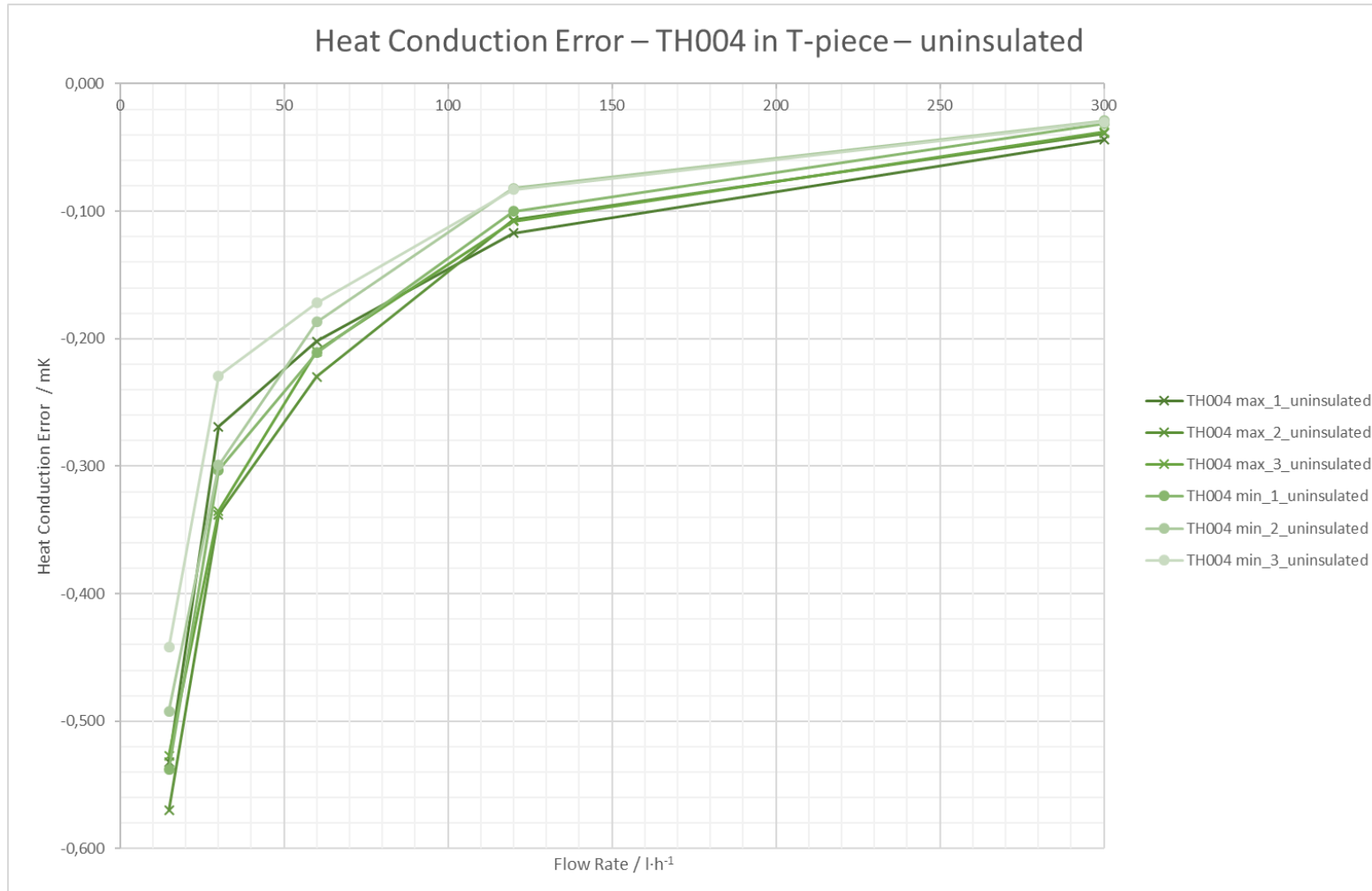


Technische Daten: Armaflex Protect (18 x 20 mm)

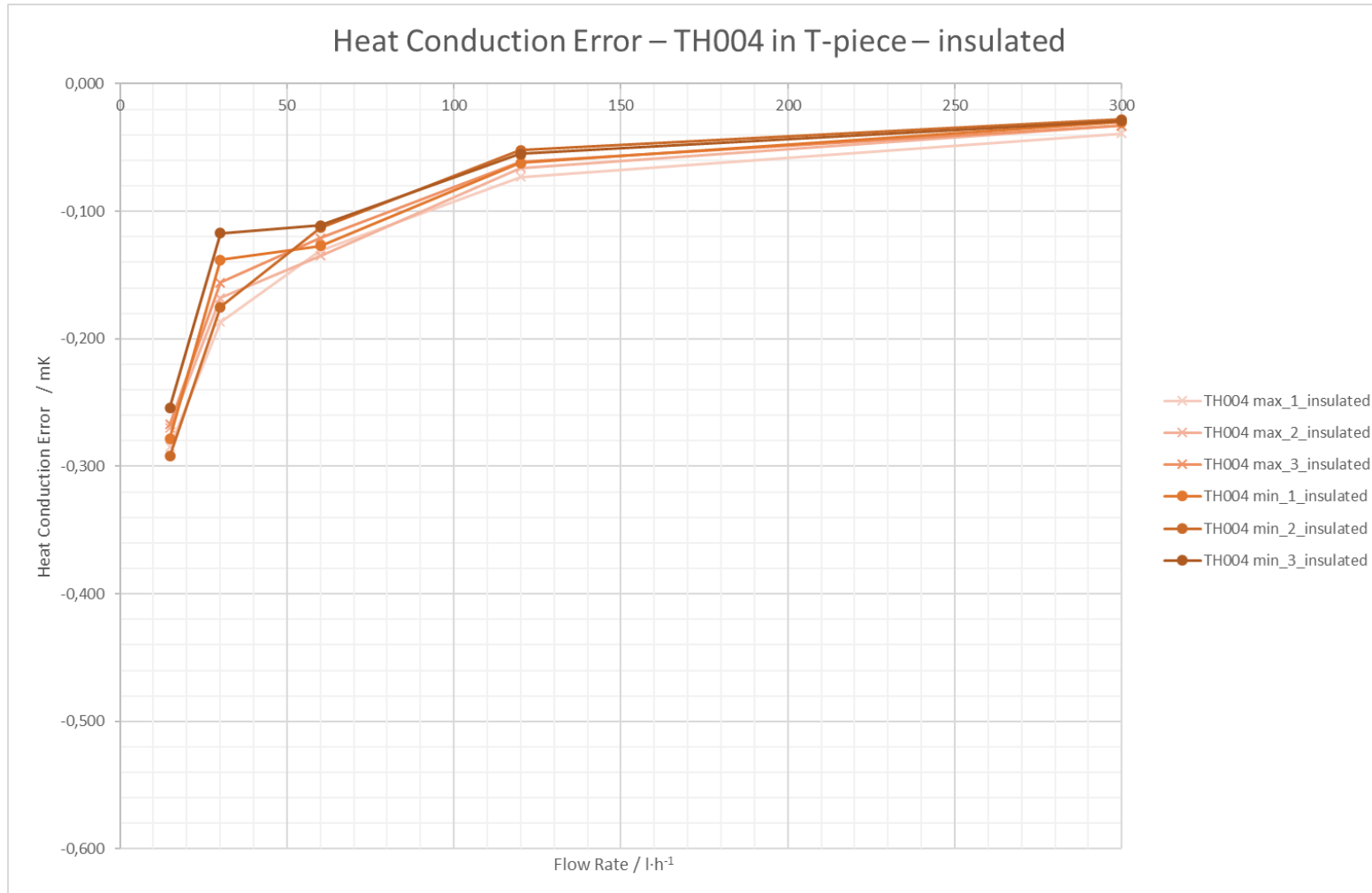
Merkmal	Spezifikation
Passend für Rohraußendurchmesser	18 mm (z. B. Kupfer, Stahl, Verbundrohr)
Dämmschichtdicke	20 mm
Feuerwiderstandsklasse	Bis zu R-90 / R-120 (nach Zulassung)
Farbe	schwarz
Wasserdampf-Diffusionswiderstand	7.000 my
Anwendungsbereich	Massivwände, Leichtbauwände und Decken



Installation-related measurement deviations in temperature measurement – influence of thermal insulation

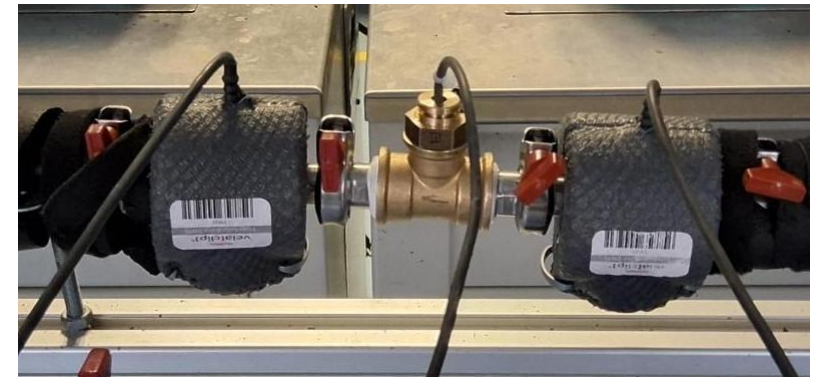
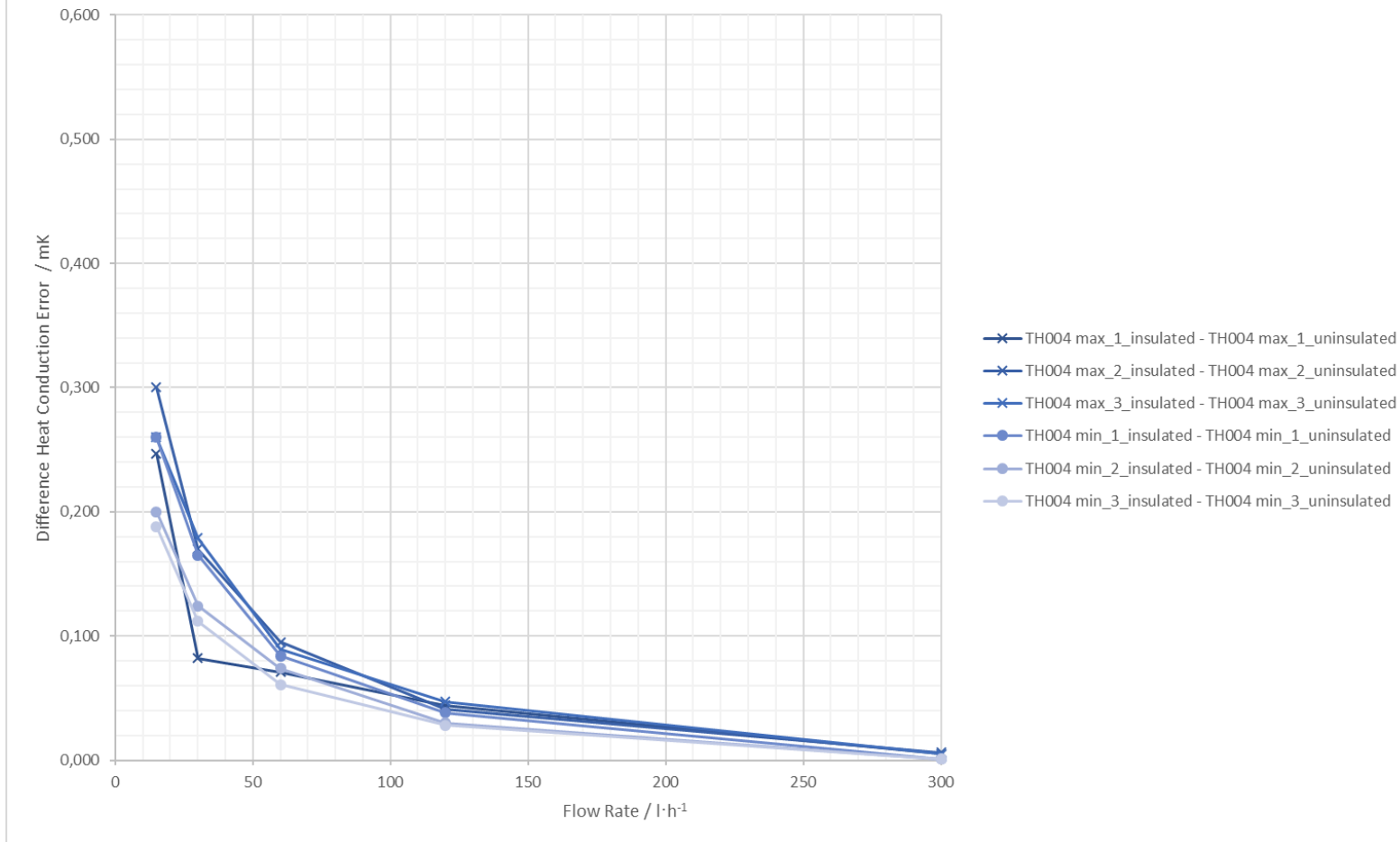


Installation-related measurement deviations in temperature measurement – influence of thermal insulation



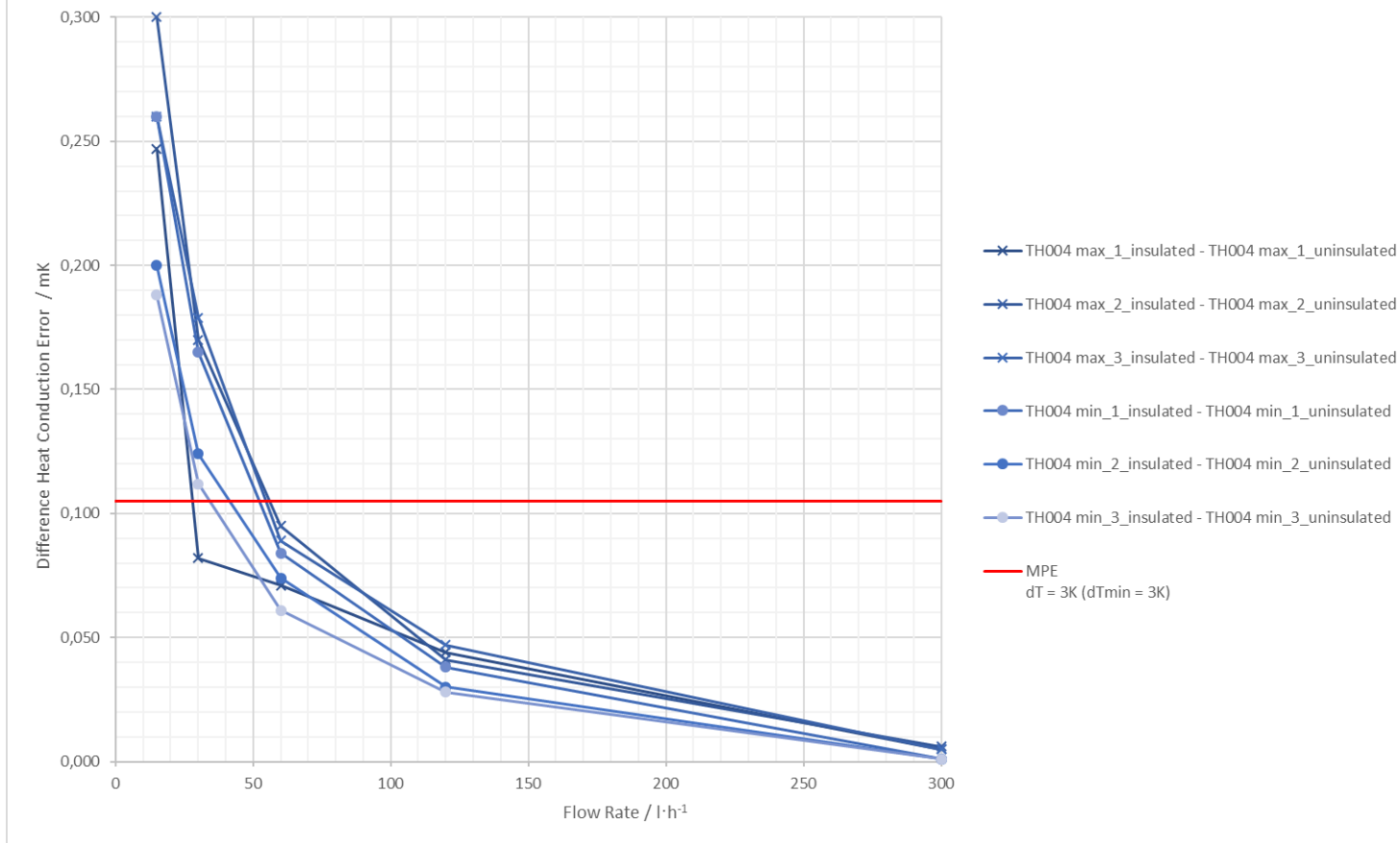
Installation-related measurement deviations in temperature measurement – influence of thermal insulation

TH004 in T-piece – influence of thermal insulation

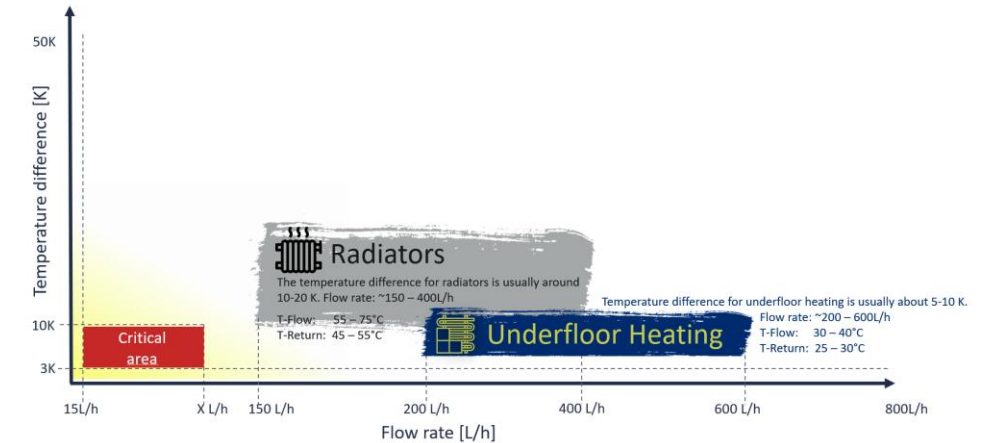


Installation-related measurement deviations in temperature measurement – influence of thermal insulation – conclusion

TH004 in T-piece – influence of thermal insulation (zoomed in)



Typical operating areas

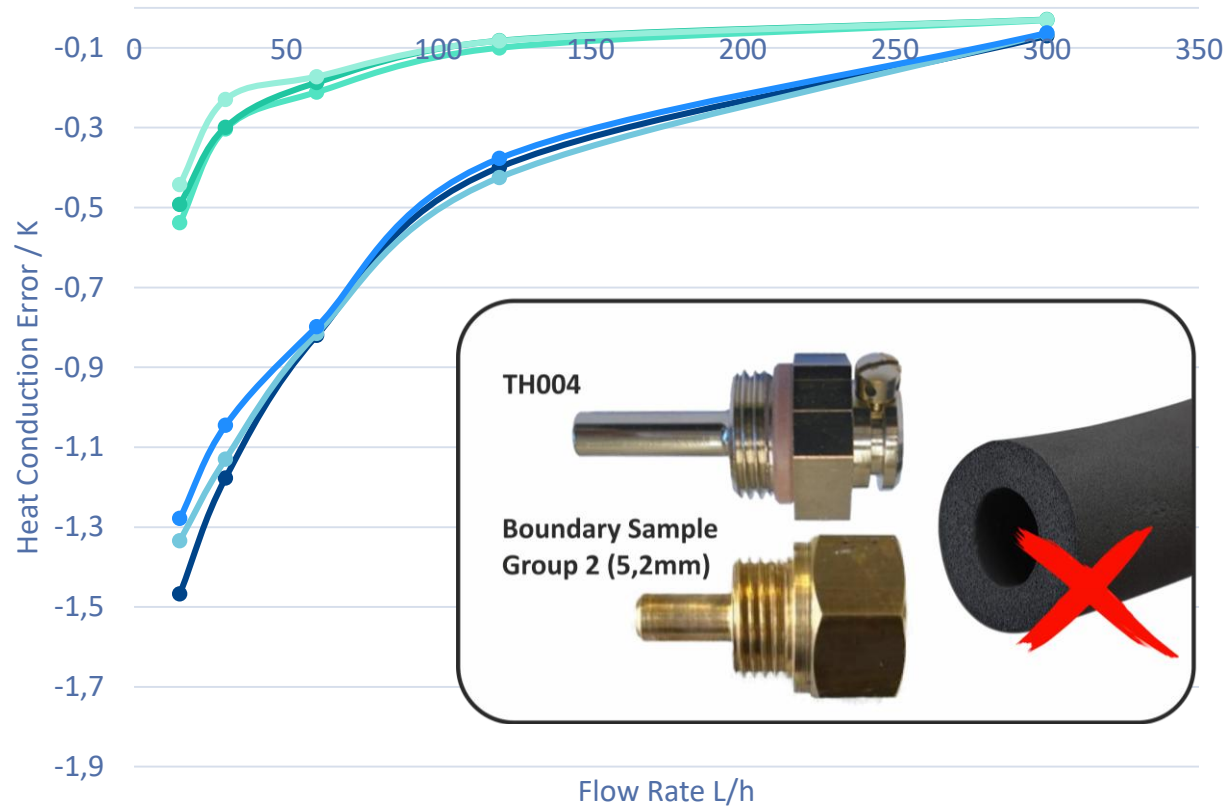


The effect of the insulation is significant.

This results in an effect on the asymmetry error, particularly in the “critical area”.

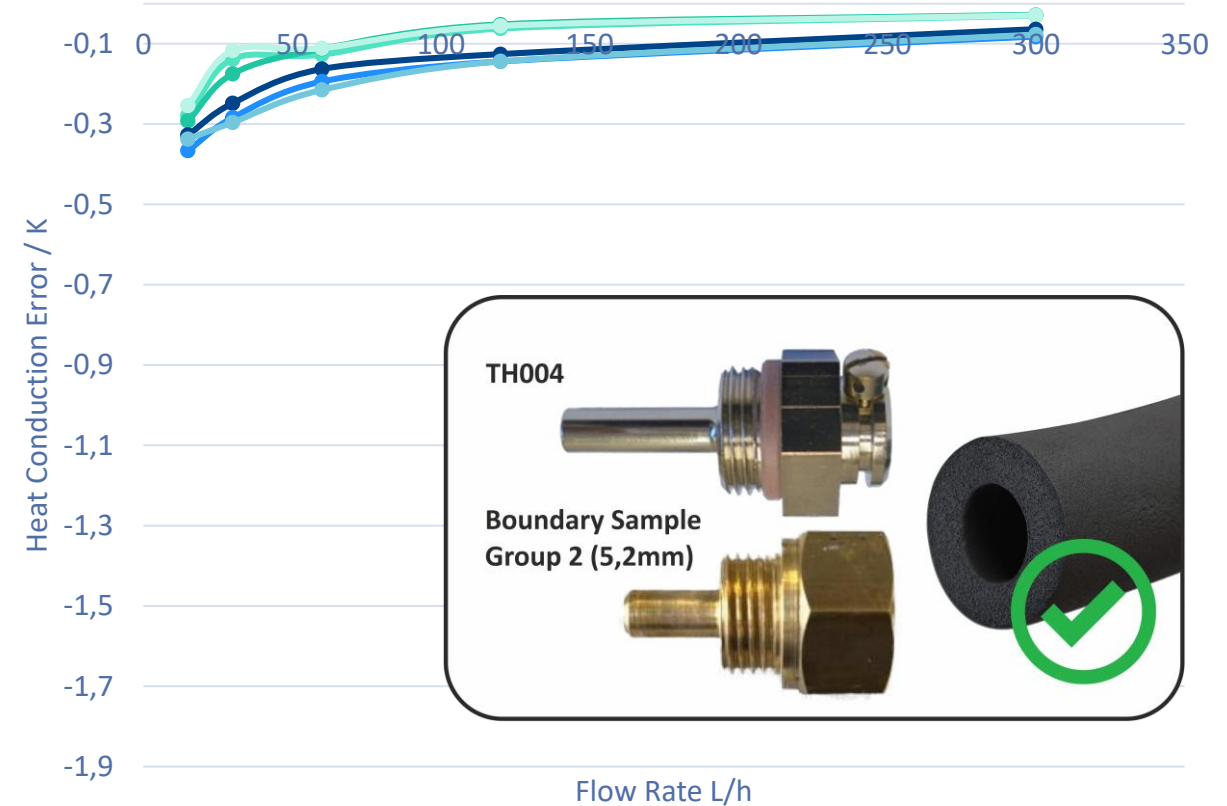
Comparison: “Real Case” vs. “Artificial” Worst Case

Heat Conduction Error Boundary Sample 2 (min. gap dimension)
/ TH004 (min. gap dimension) | uninsulated



TH004 (min) No. 1 TH004 (min) No. 2
TH004 (min) No. 3 Boundary Sample (min) No. 1
Boundary Sample (min) No. 2 Boundary Sample (min) No. 3

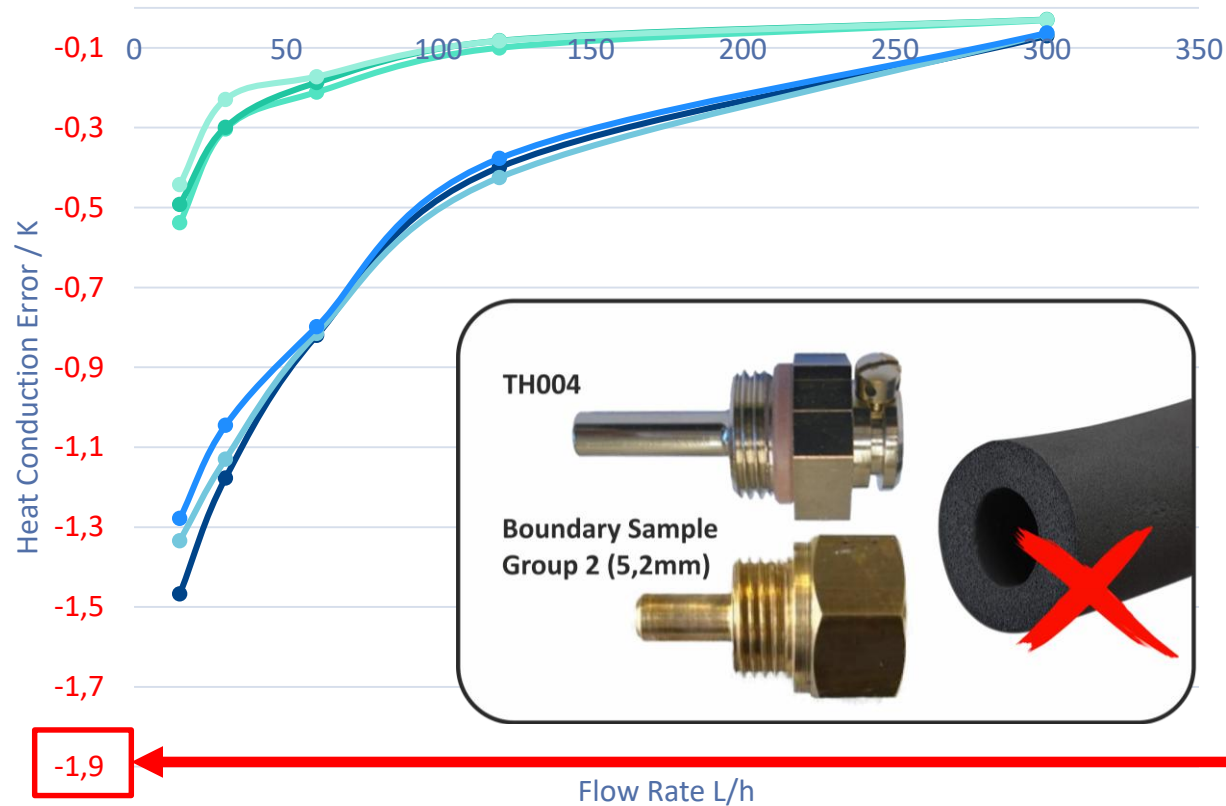
Heat Conduction Error Boundary Sample 2 (min. gap dimension)
/ TH004 (min. gap dimension) | insulated



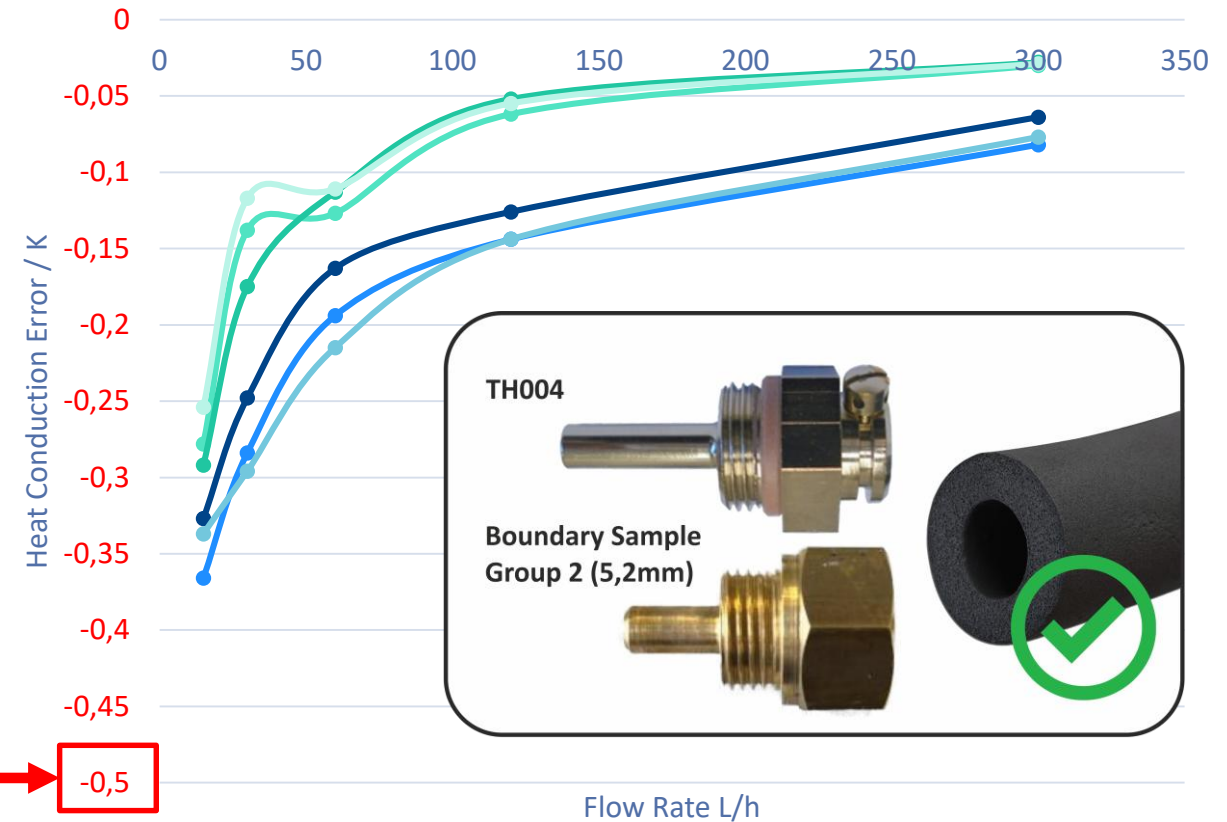
TH004 (min) No. 1 TH004 (min) No. 2
TH004 (min) No. 3 Boundary Sample (min) No. 1
Boundary Sample (min) No. 2 Boundary Sample (min) No. 3

Comparison: “Real Case” vs. “Artificial” Worst Case

Heat Conduction Error Boundary Sample 2 (min. gap dimension) / TH004 (min. gap dimension) | uninsulated



Heat Conduction Error Boundary Sample 2 (min. gap dimension) / TH004 (min. gap dimension) | insulated



-1,9

-0,5

We look forward to your questions!



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