



EMATEM

European Metrology Association
for Thermal Energy Measurement

Evaluation of the Flow Disturbance Test in EN 1434

Results and Perspective

1

Motivation

Status of the flow disturbance test in EN 1434-4:7.22

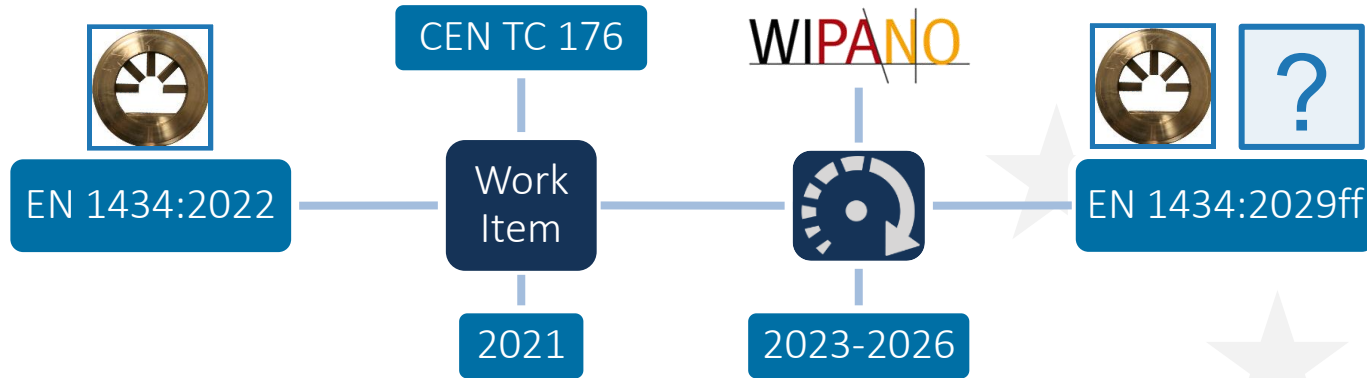


Meters receive **OD approval**,
if they pass the flow disturbance test

t in E



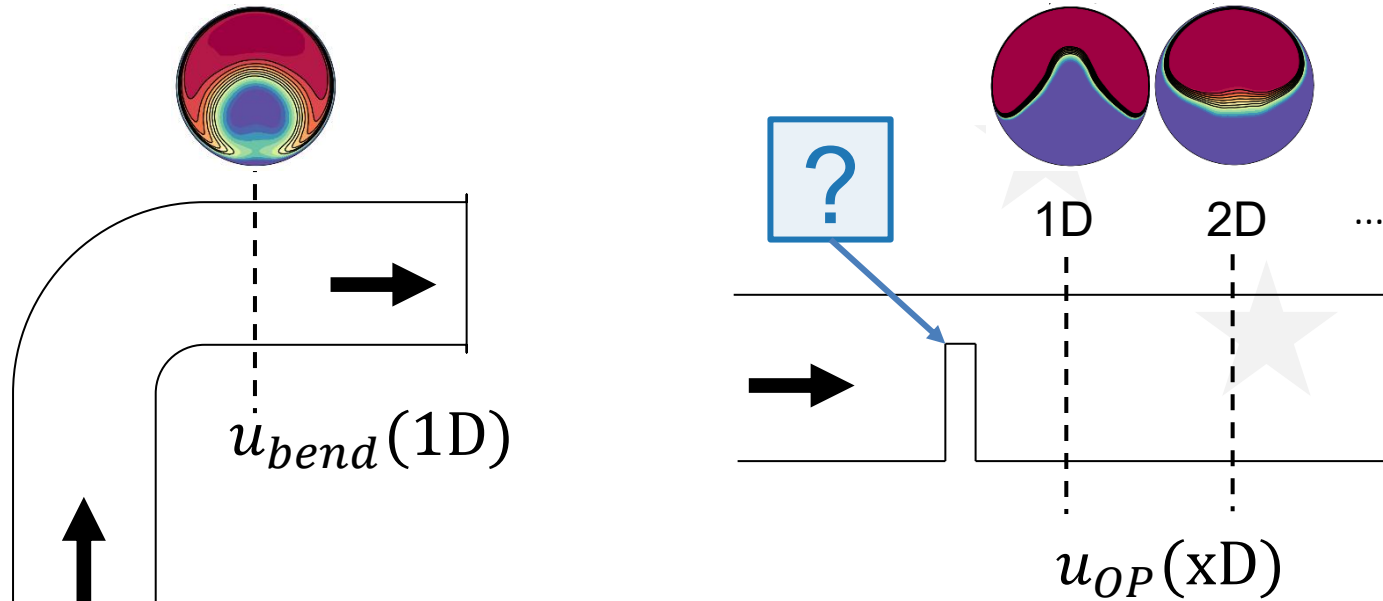
Project overview / conclusion



- **WIPANO** (BMWE) - Knowledge and technology transfer through patents and standards
- **Work item:** Flow profiles in water and water glycol solution networks, e.g. 90° bend and double bend out of plane
- **Duration:** September 2023 – April 2026
- **Project partners:** Physikalisch-Technische Bundesanstalt (PTB), Wärmezähler-Service-GmbH (WSG)
- **Objective**
 - Development of a disturbance generator to represent the near-field region downstream of bend configurations
 - Metrological validation of approval without inlet section (“OD approval”) in the flow disturbance test of EN 1434

2 Disturbance Generator Development

Objective



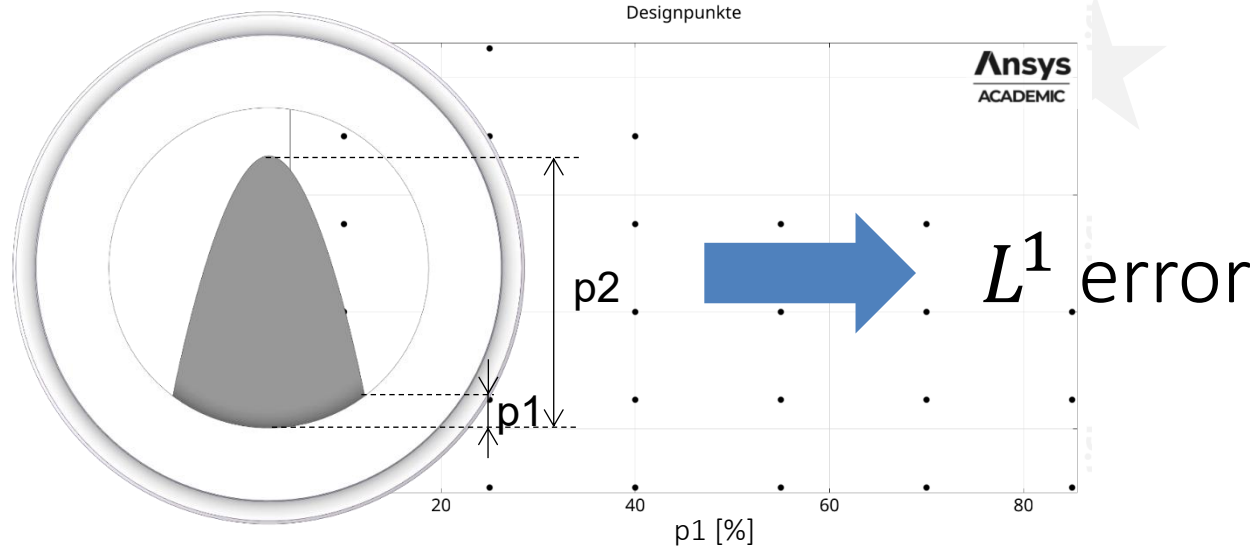
$$L^1 = \frac{4}{\pi D^2} \int_0^{2\pi} \int_0^D |u_{bend} - u_{OP}| r \, dr \, d\phi$$

Methodology

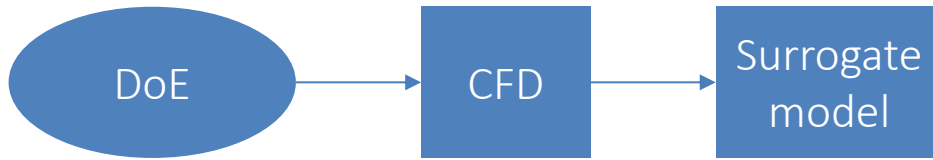
DoE

Design of Experiment (DoE)

A systematic method for deliberately varying parameters and analysing their effect on an outcome.

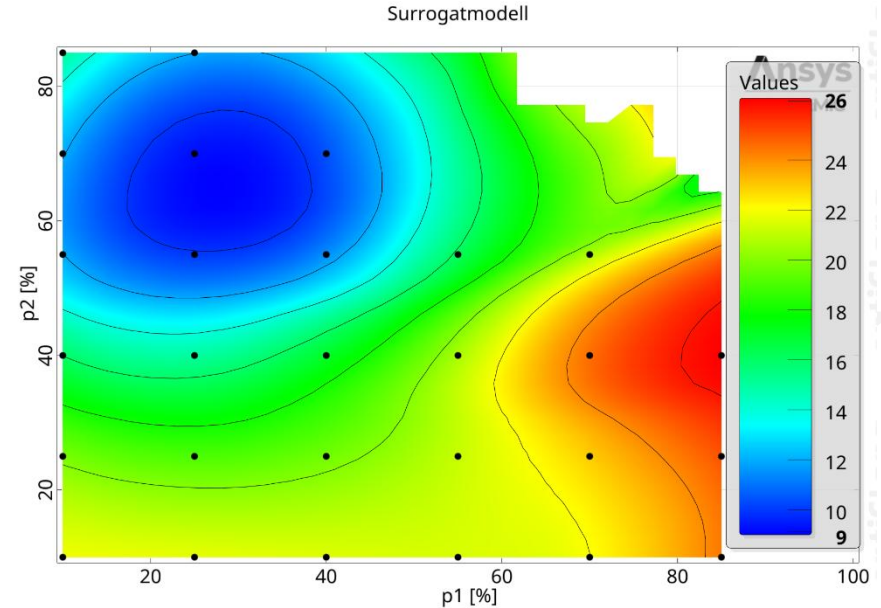


Methodology

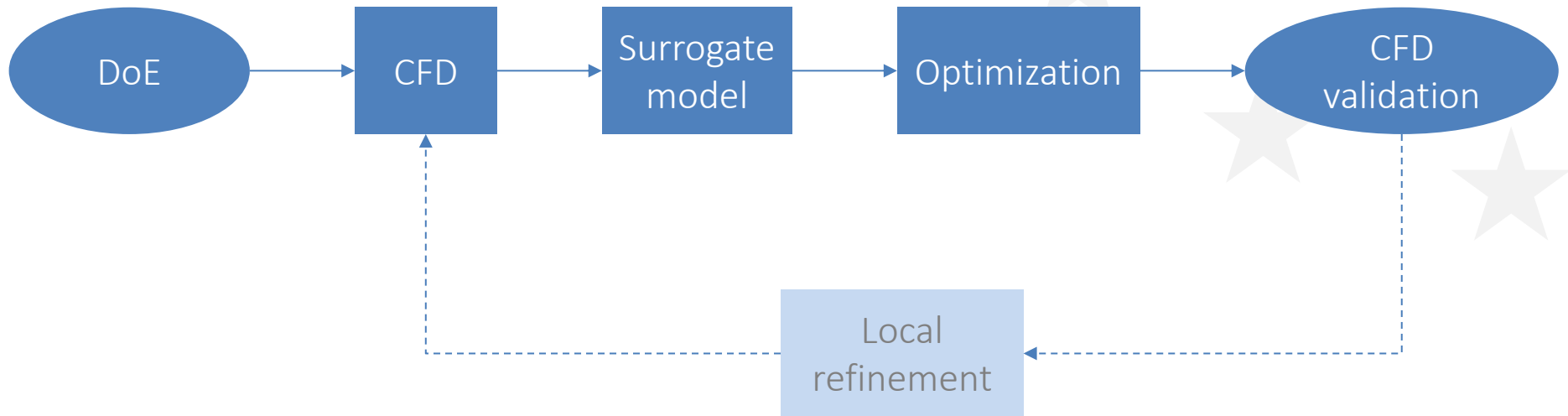


Surrogate model

A simplified, fast-to-evaluate substitute model that approximates the relationship between inputs (p_1 , p_2) and objectives (L1 error) as accurately as possible.

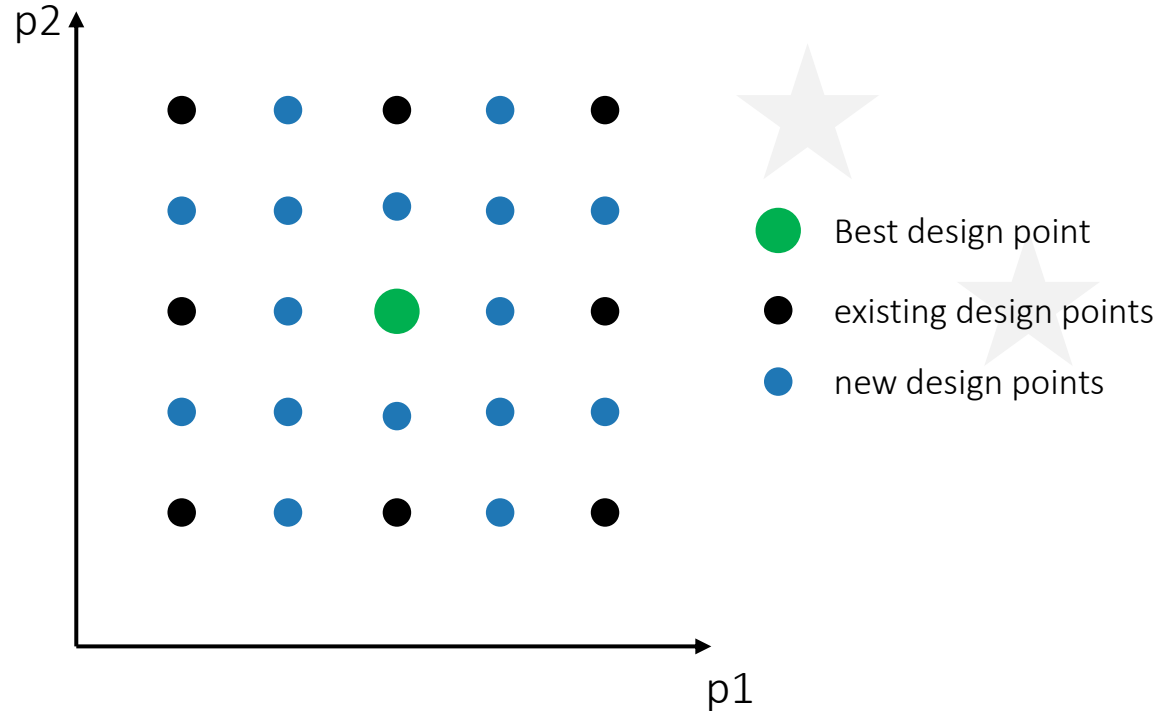


Methodology



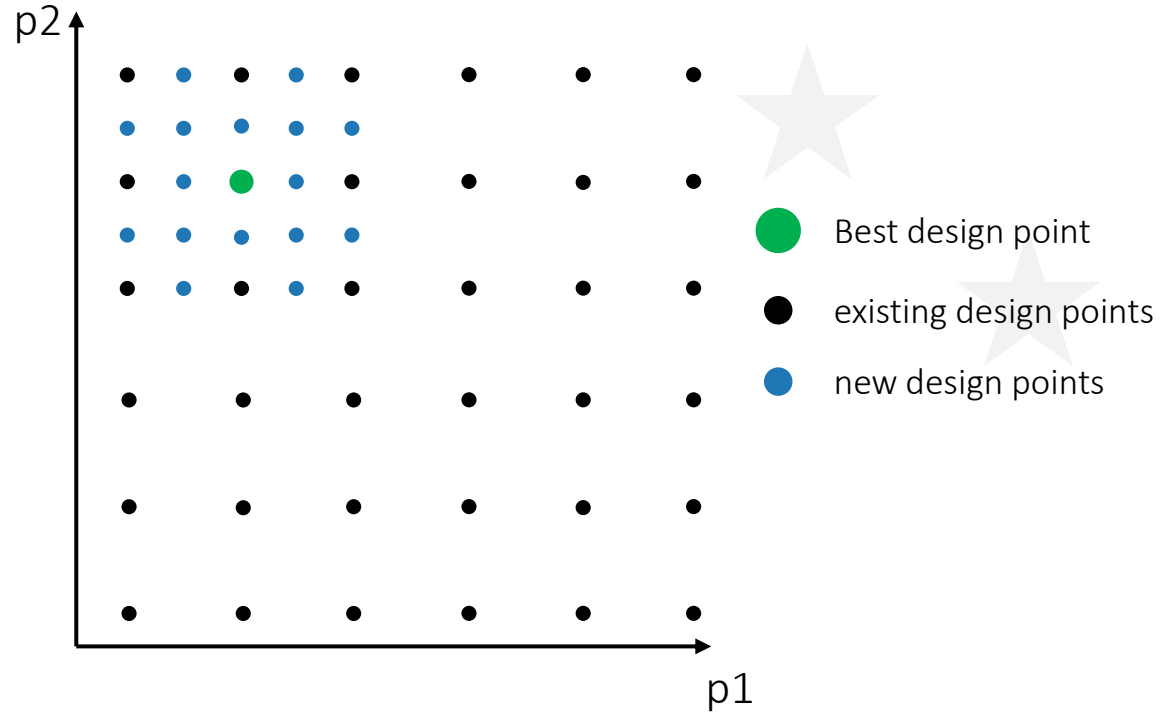
Methodology

Local
refinement

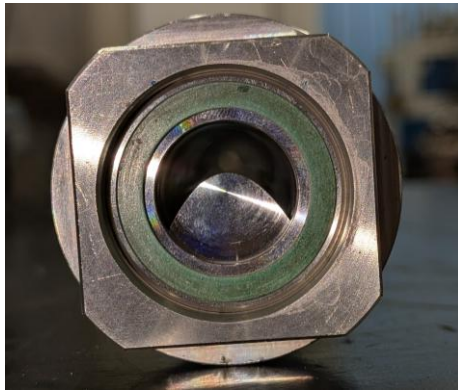


Methodology

Local
refinement



Result of the design development – 1st prototype



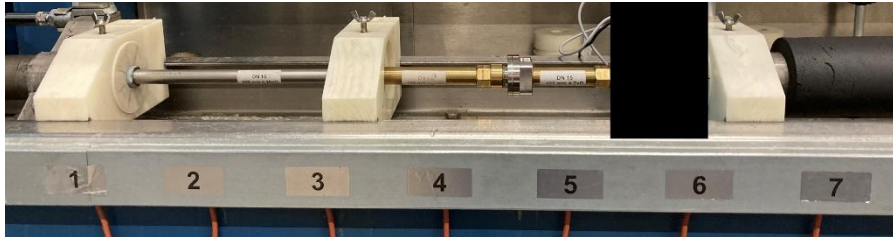
- Validation of the CFD by LDV at PTB's heat meter test rig
- Manufacturing from stainless steel in PTB workshops
- Testing of critical meters from the project measurement campaign at WSG

3

Metrological validation

Heat meter investigations

- Conducted at WSG
- 14 heat meters
- Installation situations
 - Undisturbed (before & after)
 - ASG (0D & 7D) in four orientations
 - 90° bend and double bend out of plane (0D & 5D)
 - New disturbance generator (7D)



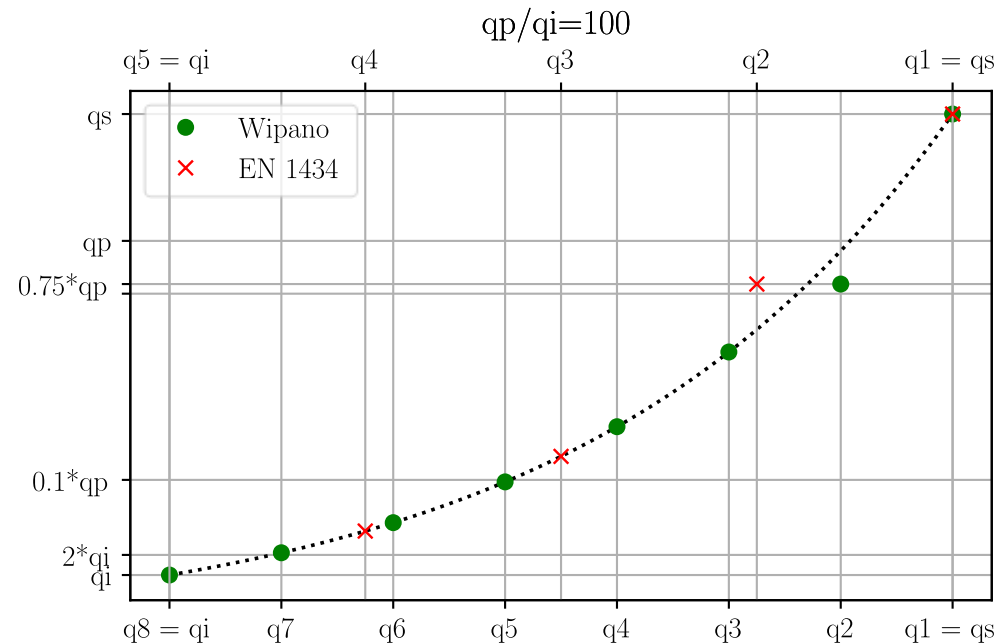
Meter selection

Manufacturers Belimo, Diehl, Ista, Itron, Kamstrup,
Landis+Gyr, Qundis, Sensus, Zenner

Meter types	DN	q _p	MB	Accuracy classes	Test types
11 x US	8 x 15	2 x 0,6	11 x 100	11 x 2	9 x NOWA
1 x MK	6 x 25	6 x 1,5	1 x 50	3 x 3	2 x Impulse
2 x ES		3 x 3,5	2 x 25		3 x Display (standing start/stop)
		3 x 6,0			

Measuring points

Measuring point	q_p/q_i		
	25	50	100
$q_8=q_i$	1	1	1
q_7	1.749	1.931	2.132
q_6	3.058	3.728	4.544
q_5	5.347	7.197	9.686
q_4	9.351	13.895	20.648
q_3	16.351	26.827	44.014
q_2	18.750	37.5	75
$q_1=q_s$	50	100	200



Results – New disturbance generator (New DG)

meter		A	B	C	D	E	F	G	H	I	J	K	L	M	N
nominal diameter (DN)		15	15	15	15	15	15	15	15	25	25	25	25	25	25
nominal flow rate [m³/h]		0.6	0.6	1.5	1.5	1.5	1.5	1.5	1.5	3.5	3.5	3.5	6.0	6.0	6.0
ASG	7xDN	0°													5
		45°													
		90°											1		
		135°											2		1
New DG	7xDN	0°													
		45°													
		90°													
		135°													
90° bend	0xDN			1									6		7
	5xDN												1		2
double bend	0xDN									1			8		8
	5xDN													2	1

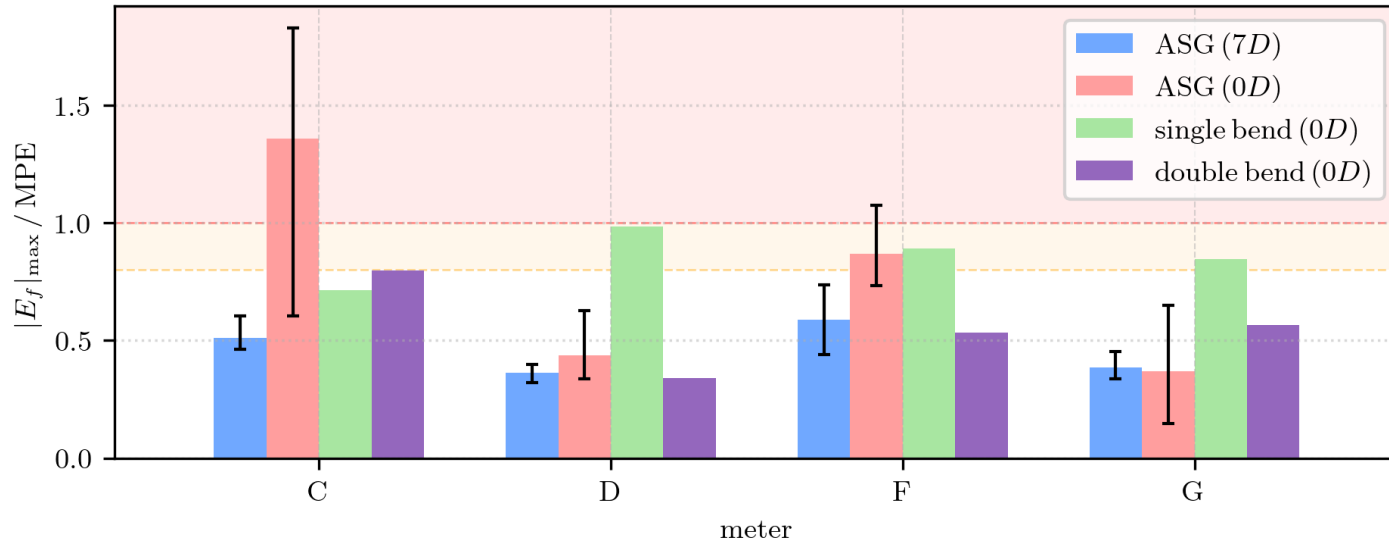
- Measurements within MPE
- x of qi/q7 outside MPE
- x of 8 points outside MPE

→ 4/14 meters after disturbance outside the MPE

→ 2/4 detected by test with ASG @ 7D (L,N)

→ 3/4 detected by test with new disturbance generator (J,L,N)

Results – Angular dependence



[2]

- Rotation of the ASG shows angular dependence of the meters
- **Assumption:** meters C, D, F, G outside the MPE downstream of bends when rotation is considered

Findings from the measurements

- **4/14** meters outside the MPE downstream of bends
 - ASG detects 2/4, New DG detects 3/4
- **4/14** meters within $80\% \leq E_f < 100\% \cdot \text{MPE}$ (C, D, F, G)
 - Hypothesis: outside the MPE due to angular dependence
- Meters in DN25 show higher measurement errors than in DN15

4 Outlook

Objectives

- **Large nominal sizes**
 - How does the flow disturbance test scale to larger DN (DN 40/100)?
- **Angular dependence**
 - Were critical meters overlooked?
- **Water-glycol mixtures** (CEN work item)
 - What should the test look like for laminar flows?
- **disturbance generator**
 - How robust and transferable is the prototype?

Water-glycol mixtures: Laminar as a new test regime?

- For small DN and low temperatures $\rightarrow Re(q_p) < 2300 \rightarrow$ laminar flow!

Reynolds-Zahlen für DN 15, $q_p = 1.5 \text{ m}^3/\text{h}$; nach Baack

T °C	Wasser Re	Tyf. LS Re	Anti. SHT Re	Tyf. L40 Re	Anti. N40 Re
-10	—	1331	908	1645	3562
-5	—	1884	1258	2292	4537
0	—	2577	1692	3090	5666
5	23910	3422	2217	4049	6953
10	27655	4428	2840	5178	8400
20	35881	6948	4402	7958	11775

	$Re < 2300$	laminar
	$2300 \lesssim Re \lesssim 3000$	Übergang
	$Re > 3000$	turbulent

[4]

Can test concepts using water as the medium
be transferred to water-glycol mixtures?

Further information

Paper on the measurement campaign:

M. Straka, R. Kernebeck, K. Hertha-Dunkel, S. Rademacher, T. Eichler; *Heat meter performance downstream of bends and the asymmetric swirl generator; tm - Technisches Messen.* <https://doi.org/10.1515/teme-2026-0003>

CFD-supported design development:

https://ematem.org/wp-content/uploads/2025/10/10_hertha-dunkel_PTB_deutsch_final.pdf

Or during the break 😊

Literature

- [1] M. Straka, T. Eichler, C. Koglin, and J. Rose. Similarity of the asymmetric swirl generator and a double bend in the near-field range. *Flow Meas. and Instrum.*, 70:101647, 2019.
- [2] M. Straka, R. Kernebeck, K. Hertha-Dunkel, S. Rademacher, T. Eichler; *Heat meter performance downstream of bends and the asymmetric swirl generator; tm - Technisches Messen*. <https://doi.org/10.1515/teme-2026-0003>
- [3] <https://store.danfoss.com/de/de/L%C3%B6sung-f%C3%BCr-W%C3%A4rmetechnik/Energiez%C3%A4hler/Energiez%C3%A4hler/SonoMeter-40/Energiez%C3%A4hler%2C-SonoMeter-40%2C-100-mm%2C-qp-%5Bm%C2%B3-h%5D%3A-60%2C-Beheizung%2C-Batterie-%282-x-AA-Zelle%29%2C-M-Bus/p/187F2024>
- [4] Baack, S.: *Heat Metering with Glycol-Water-Mixtures*, Dissertation. TU Berlin, 2020. [10.14279/depositonce-9628](https://nbn-resolving.org/urn:nbn:de:hbz:5:1-63868-p0010-9)