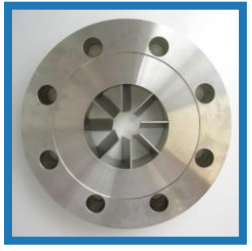

EMATEM
European Metrology Association
for Thermal Energy Measurement

Review of the EN 1434 flow disturbance test and its ongoing development

01

Motivation

New disturbance generator in EN 1434:2022



Swirl generator acc. EN 1434:2016[1], ISO 4064 [2] / OIML R 49 [3]

- generates symmetric swirl, asymmetry not reproducible

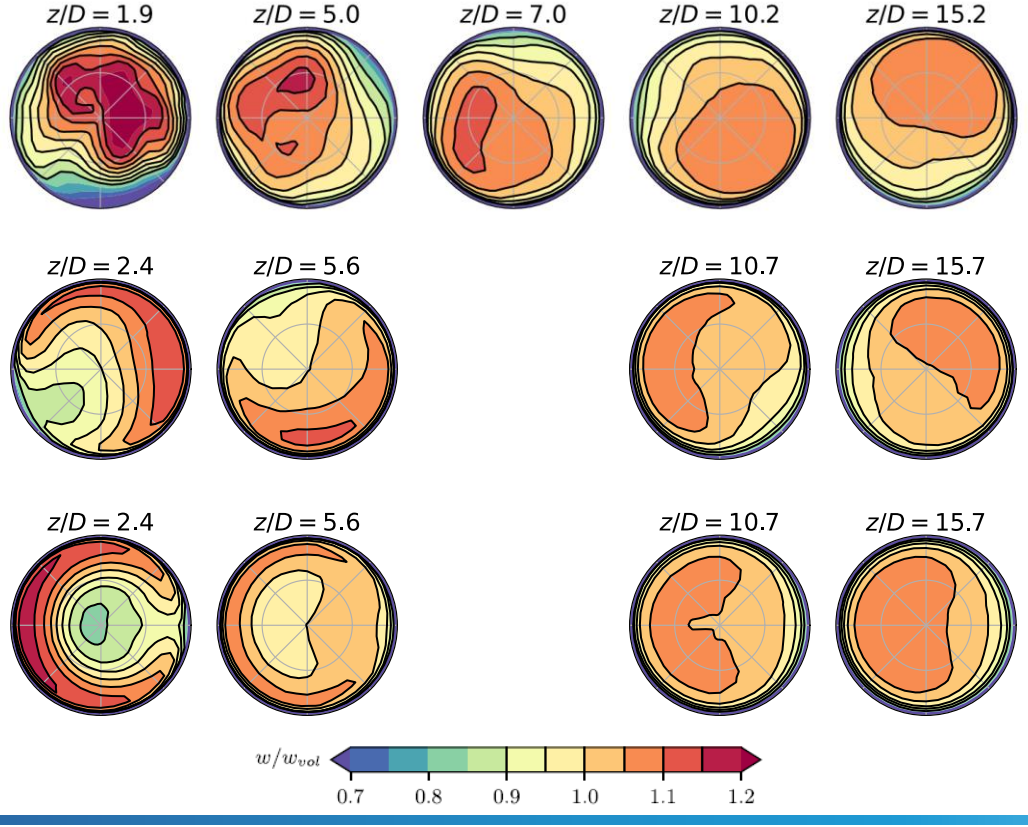
Asymmetric swirl generator (ASG) acc. Tawackolian [5]

- generates swirl and reproducible asymmetry
- representation of a double bend out-of-plane (DB) from ~15D

Modified ASG in EN 1434:2022 [9] acc. Straka et al. [10]

- increased sagitta → increased swirl and asymmetry
- representation of DB from ~5D
- significant improvement compared to swirl generator

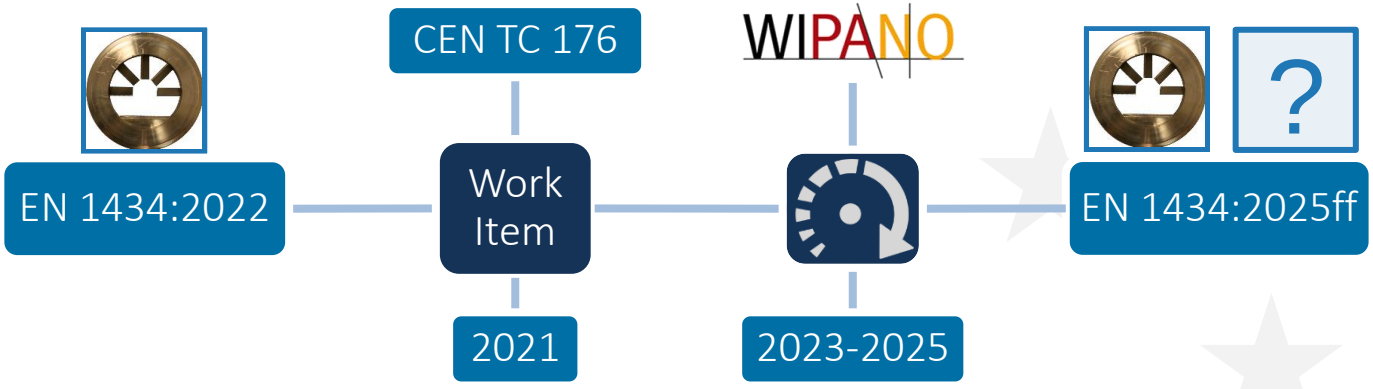
Comparison of flow profiles



Comparison of flow profiles

- matching flow characteristics between ASG 7D and DB 5D
- different flow development in the near-field range
- ASG cannot reproduce strong asymmetry downstream of DB/bend < 5D
- Dean vortices downstream of 90° bends are not represented

Project introduction



- **WIPANO** (BMWK) - Wissens- und Technologietransfer durch Patente und Normen
- **Work item**: Flow profiles in water and water glycol solution networks, e.g. 90° bend and double bend out of plane
- **Duration**: September 2023 – August 2025 (2 years)
- **Project partners**: Physikalisch-Technische Bundesanstalt (PTB), Wärmezähler-Service-GmbH (WSG)
- **Objectives**
  - Metrological validation of type approval without inlet section (“0D approval”) in the flow disturbance test of EN 1434
  - Development of a disturbance generator to represent the near-field range downstream of bend configurations
  - If necessary, extension of the flow disturbance test to include new disturbance generator

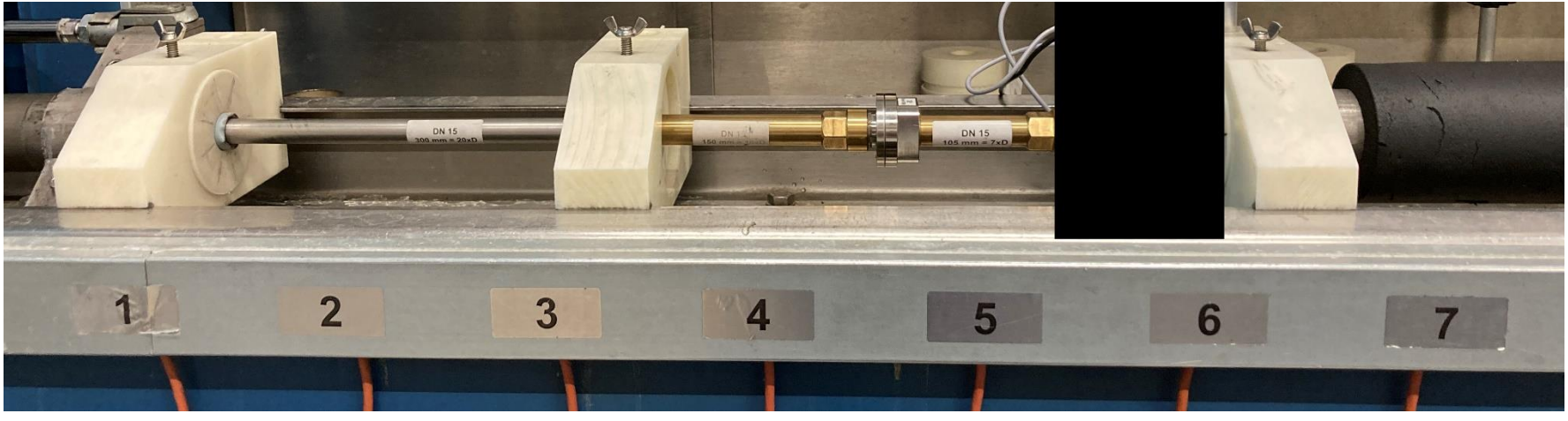
PTB WSG Wärmezähler-Service

02

Methods

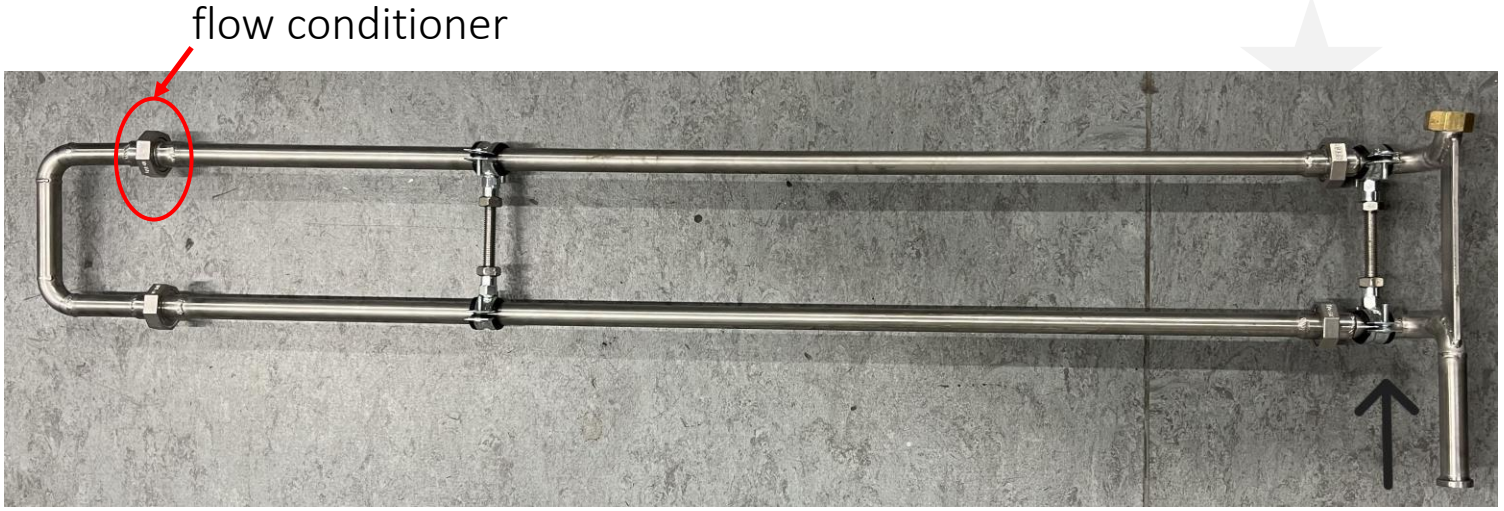
Experimental setup

- Gravimetric test rig at WSG
- 15 heat meters in DN15 and DN25
- fully developed, ASG, 90° bend, DB

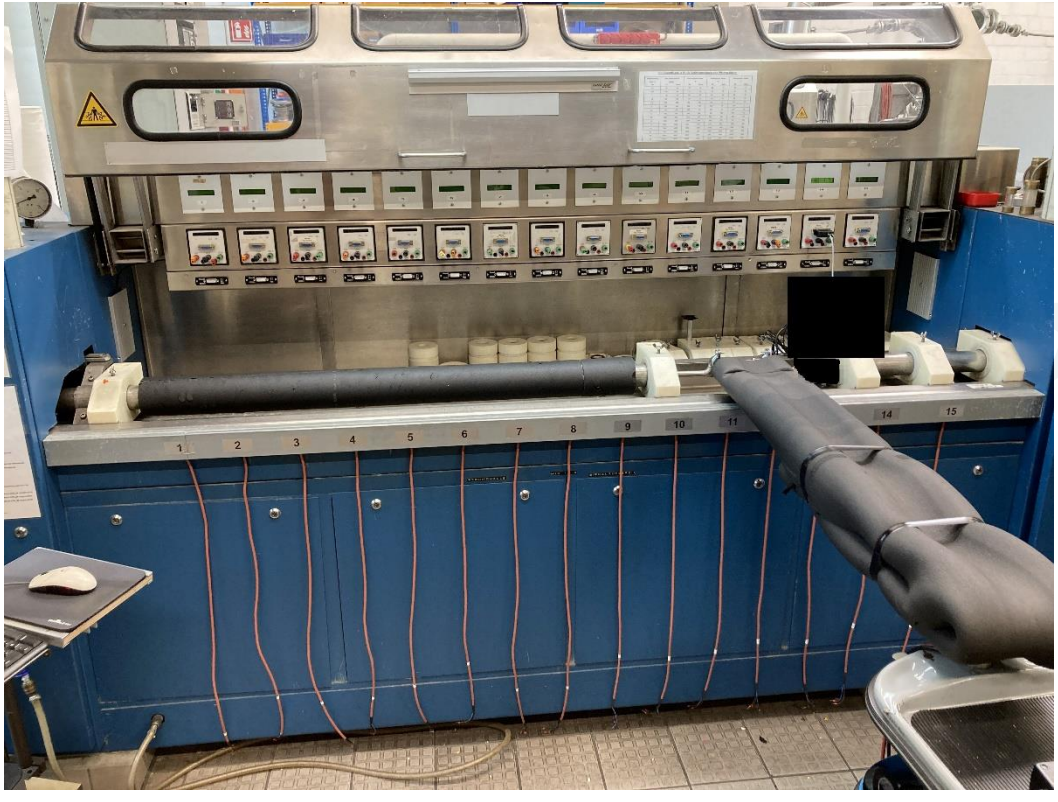


Setup of bend unit

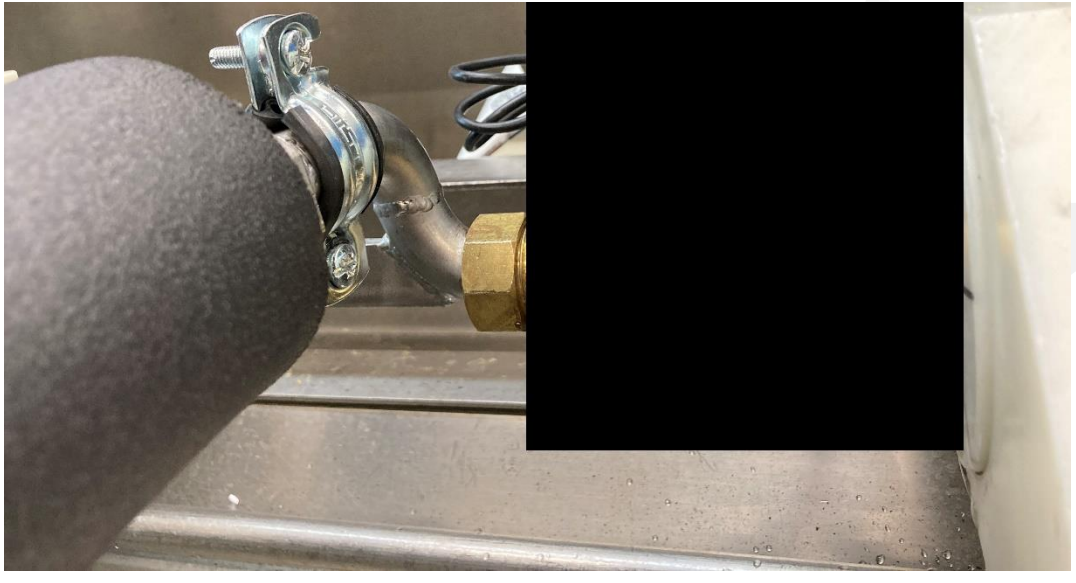
- Inlet section upstream of bend/DB: 65D (DN15) resp. 40D (DN25) downstream of flow conditioner



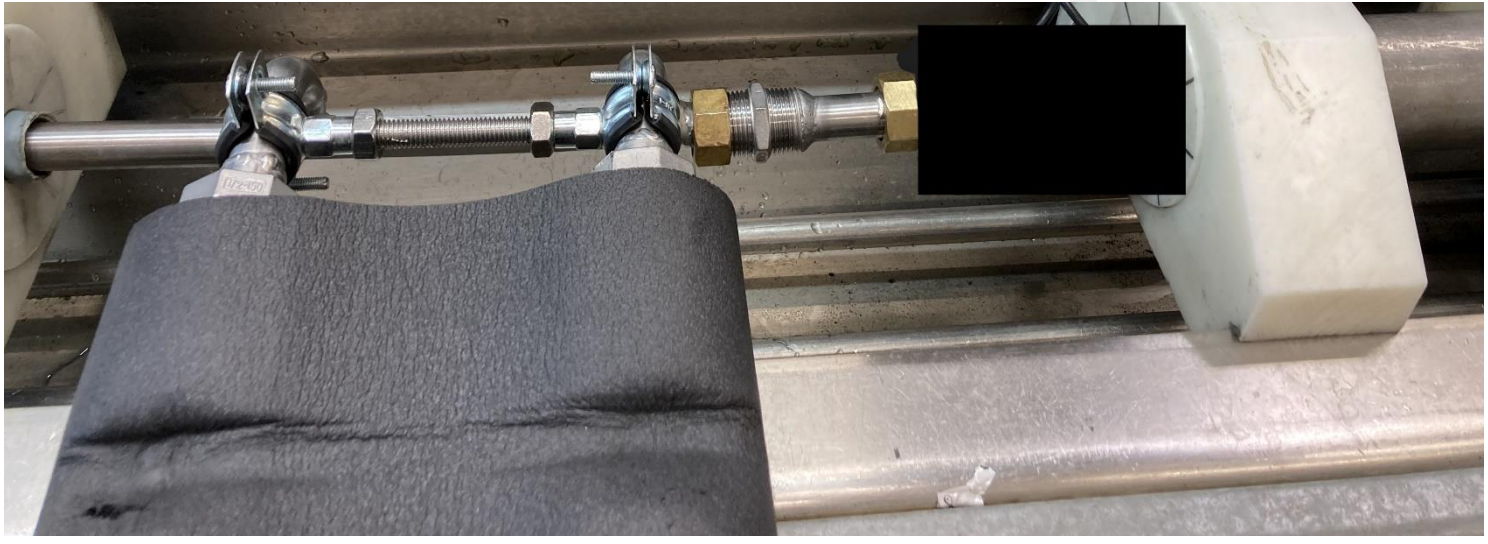
Installation of bend unit



Installation of bend unit 0D



Installation of bend unit 5D

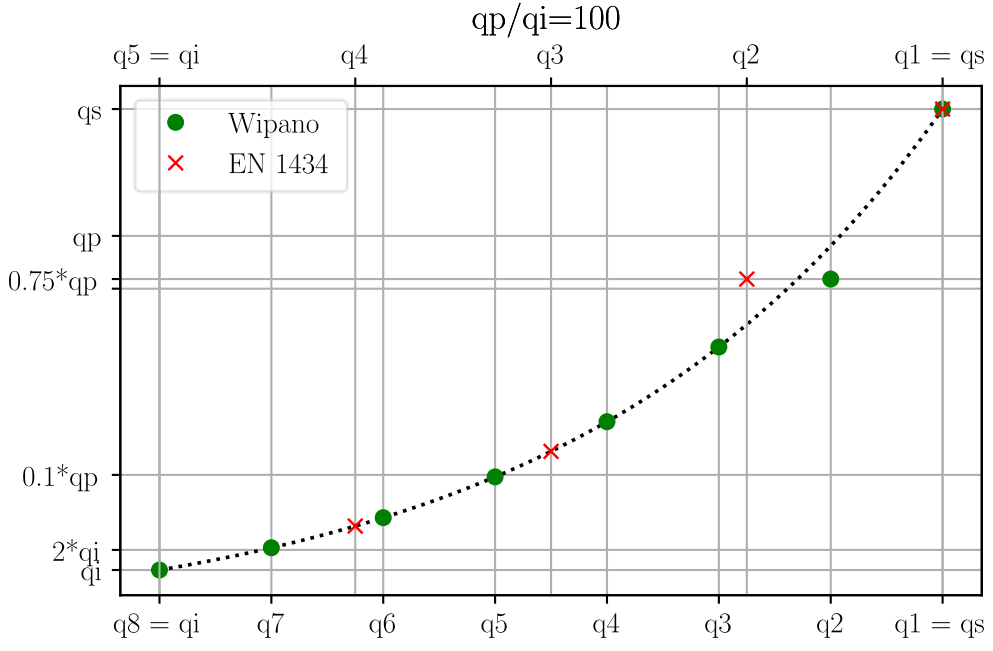


Test program

Zähler	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	DN15 - qp 0.6	DN15 - qp 1.5	DN25 - qp 6.0	DN15 - qp1.5	DN15 - qp1.5	DN25 - qp 6.0	DN25 - qp 3.5	DN15 - qp0.6	DN25 - qp6.0	DN25 - qp 3.5	DN25 - qp 6.0	DN25 - qp3.5	DN15 - qp 1.5	DN15 - qp 0.6	DN15 - qp 1.5
Basis-Messung															
ungestörter Einlauf 30xD															
ASG 0xD															
0 ° Blende oben															
45 ° gedreht															
90 ° gedreht															
135 ° gedreht															
7xD															
0 ° Blende oben															
45 ° gedreht															
90 ° gedreht															
135 ° gedreht															
90° - Bogen															
0xD															
5xD															
Raumkrümmer															
0xD															
5xD															
Abschluss Basis-Messung															
ungestörter Einlauf 30xD															

Test program: measurement points

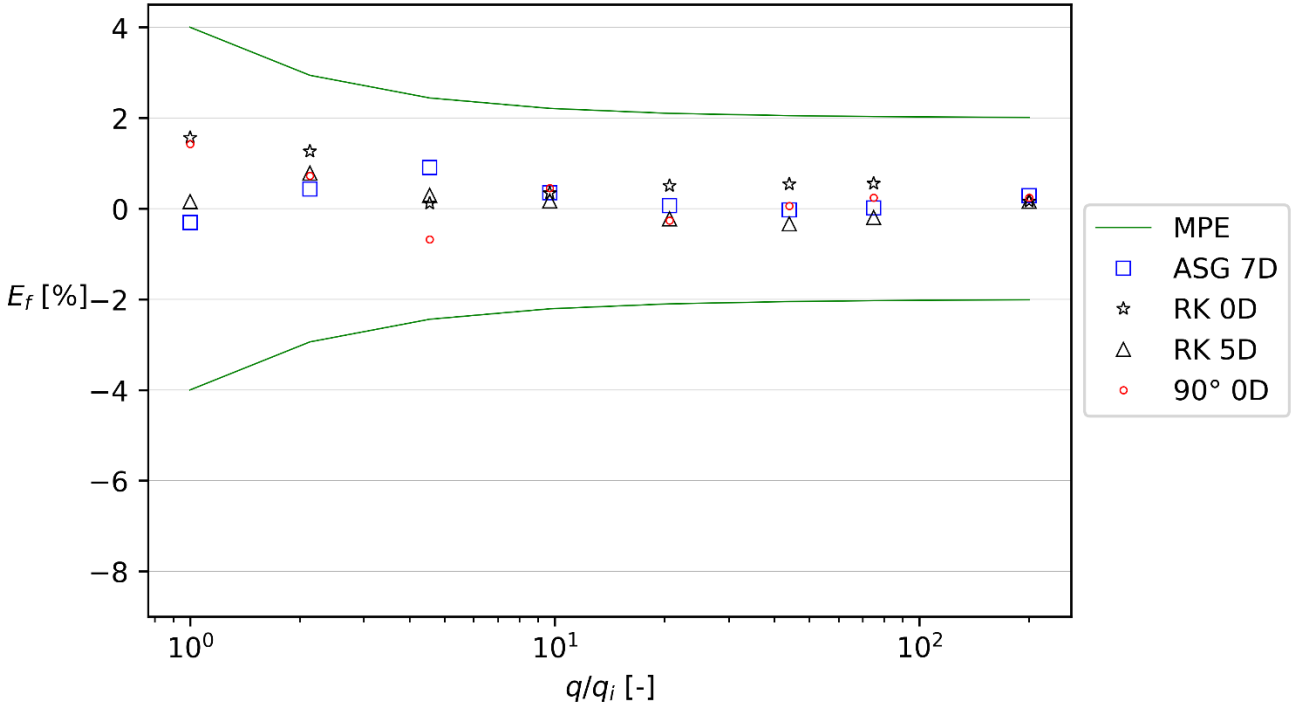
Meas. point	Multiples of q_i	
	$q_p/q_i = 100$	$q_p/q_i = 50$
q8=q_i	1	1
q7	2.132	1.931
q6	4.544	3.728
q5	9.686	7.197
q4	20.648	13.895
q3	44.014	26.827
q2	75	37.5
q1=q_s	200	100



03

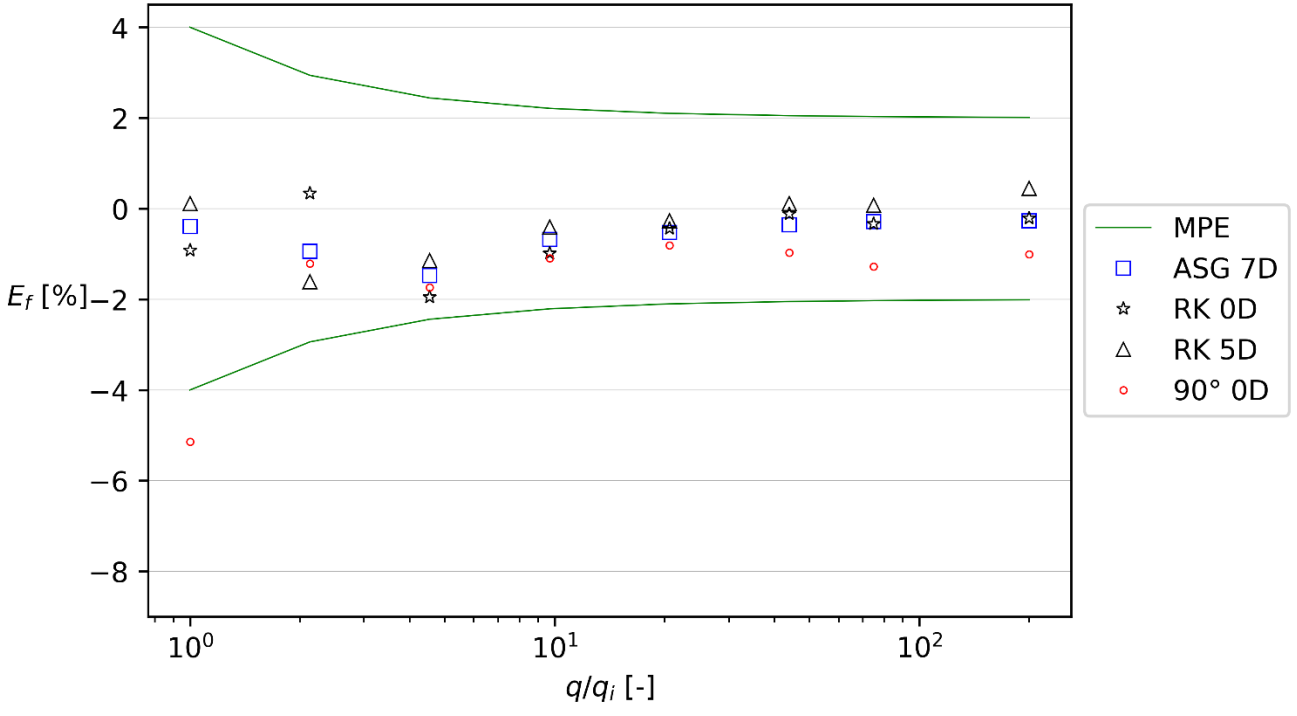
Results

Heat meter A – ASG 7D and disturbances



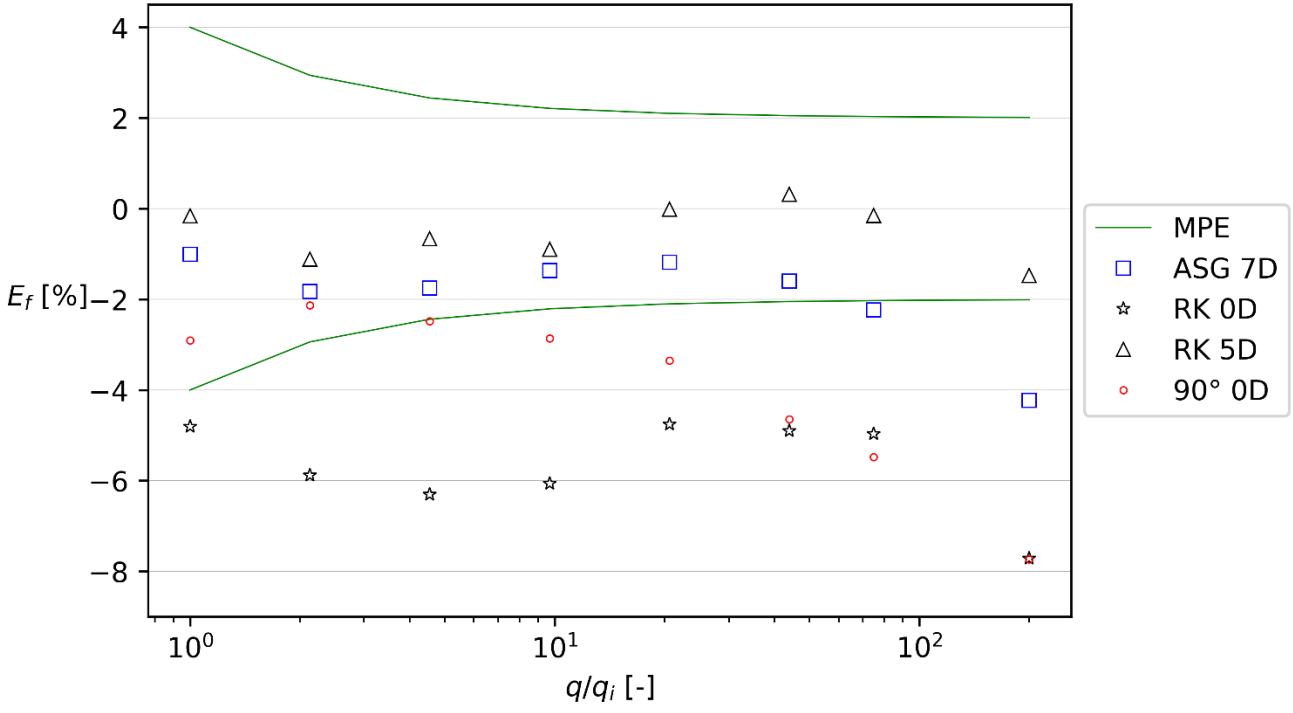
E_f – difference between the error of indication and the intrinsic error of the instrument (EN 1434-1:2022 3.10.1)

Heat meter B – ASG 7D and disturbances



E_f – difference between the error of indication and the intrinsic error of the instrument (EN 1434-1:2022 3.10.1)

Heat meter C – ASG 7D and disturbances



E_f – difference between the error of indication and the intrinsic error of the instrument (EN 1434-1:2022 3.10.1)

Current state

Zähler	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	DN15 - qp 0.6	DN15 - qp 1.5	DN25 - qp 6.0	DN15 - qp1.5	DN15 - qp1.5	DN25 - qp 6.0	DN25 - qp 3.5	DN15 - qp0.6	DN25 - qp6.0	DN25 - qp 3.5	DN25 - qp 6.0	DN25 - qp3.5	DN15 - qp 1.5	DN15 - qp 0.6	DN15 - qp 1.5
Basis-Messung															
ungestörter Einlauf 30xD															
ASG 0xD															
0 ° Blende oben			5			6	2								
45 ° gedreht		5	5			6									
90 ° gedreht		2	6			4									
135 ° gedreht		2	6			2									
7xD															
0 ° Blende oben															
45 ° gedreht															
90 ° gedreht			1												
135 ° gedreht			2												
90° - Bogen															
0xD		1	6												
5xD			1												
Raumkrümmer															
0xD			alle												
5xD						2									
Abschluss Basis-Messung															
ungestörter Einlauf 30xD															

	liegt innerhalb der MPE
x	liegt mit x Messpunkten außerhalb der MPE

Summary

Measurements completed with 8/15 heat meters

- So far district heating sector
- Heat meters for domestic use are still pending

3/8 heat meters downstream of bend/DB not within MPE

- 1 heat meter significantly → does not pass flow disturbance test
- 2 heat meters downstream of bend/DB → pass flow disturbance test

Literature

[1] EN 1434-4:2016. *Heat meters - Part 4: Pattern approval tests*. Standard. 2016.

[2] ISO 4064-2:2014. *Water meters for cold potable water and hot water - Part 2: Test methods*. Standard. 2014.

[3] OIML R 49-2:2013. *Water meters for cold potable water and hot water - Part 2: Test methods*. Standard. 2013.

[4] Wendt, G.: *Gegenüberstellung des Profils von Swirl-Generator und Raumkrümmer*. In: 3. EMATEM-Sommerschule, 2007.

[5] Tawackolian, K.: *Fluiddynamische Auswirkungen auf die Messabweichung von Ultraschall-Durchflussmessgeräten*. Dissertation. TU Berlin, 2013.

[6] Graner, S.; Hinz, D.F.; Breitsamter, C.: *Downstream relaxation of velocity profiles in pipe-flow with swirl disturbances*, Tech. Mess. 83. 2016.

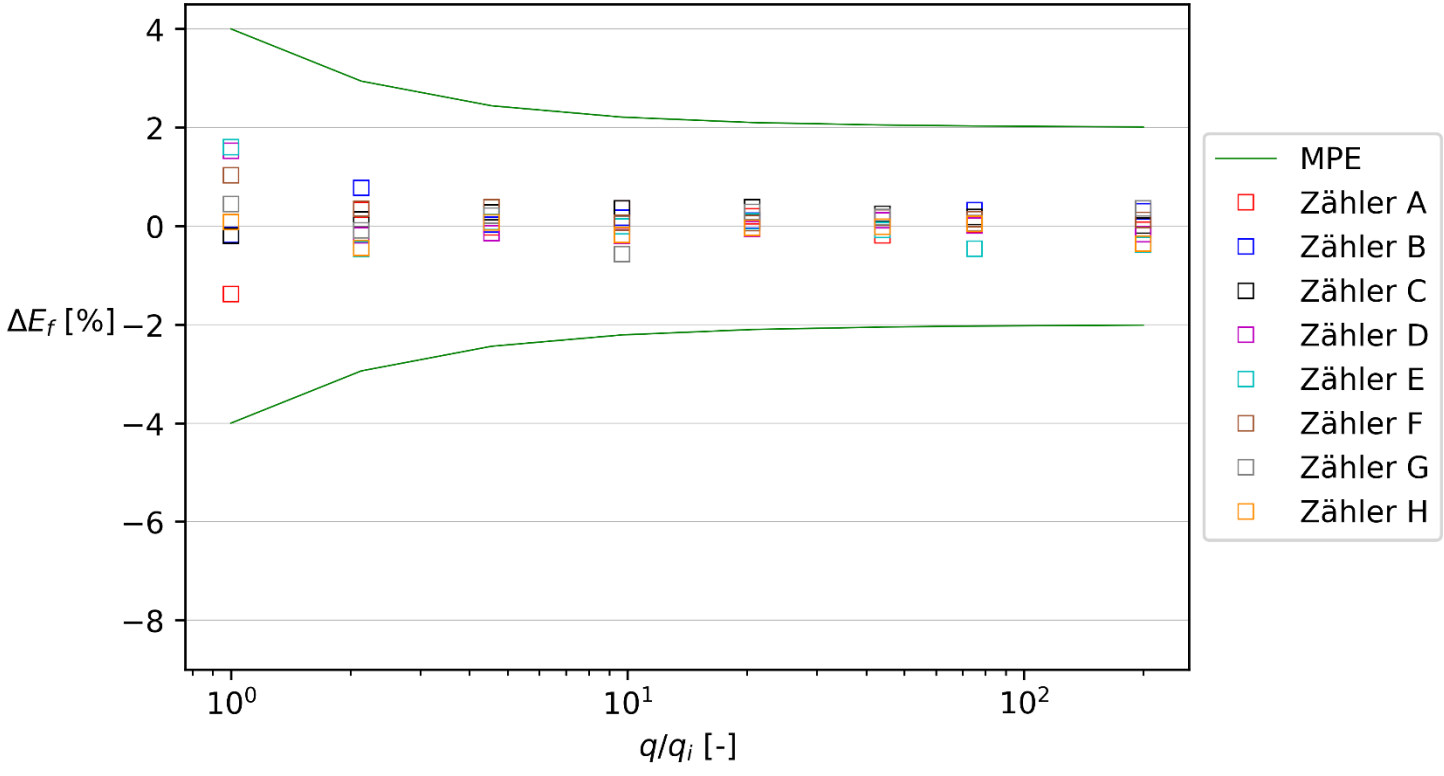
[7] Turiso, M.; Straka, M.; Rose, J.; Bombis, C.; Hinz, D.F.: *The asymmetric swirl disturbance generator: Towards a realistic and reproducible standard*. Flow Meas. Instr. 60. 2018.

[8] van Hove, A.; Skov, L.N.; Hinz, D.F.: Reproducibility of Experiments With Swirling Flow: Numerical Prediction With Polynomial Chaos. J. Verfif. Valid. Uncert 3(1). 2018.

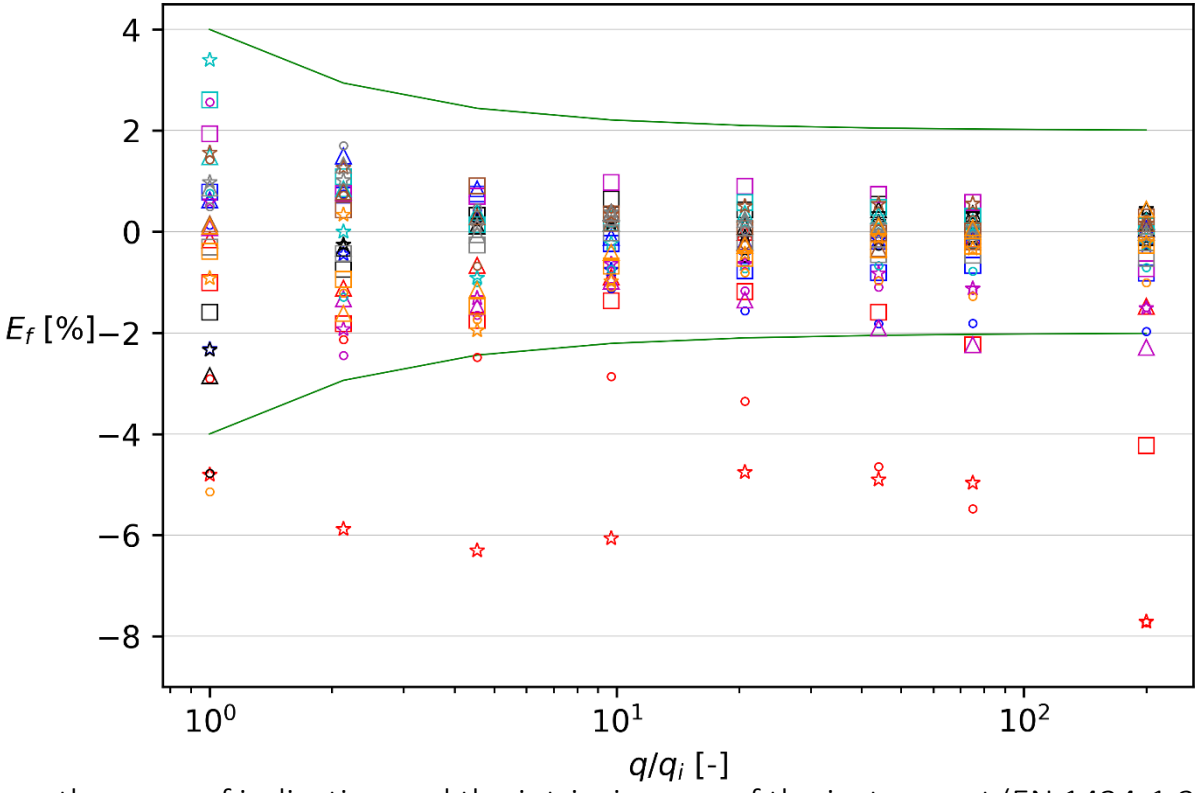
[9] EN 1434-4:2020. Heat meters - Part 4: Pattern approval tests. Standard. 2016.

[10] 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.

Differenz Eingangs- gegen Ausgangsmessung



All heat meters – ASG 7D and disturbances



E_f – difference between the error of indication and the intrinsic error of the instrument (EN 1434-1:2022 3.10.1)

Outlook: New disturbance generator