



# EMATEM

European Metrology Association  
for Thermal Energy Measurement

---

# Evaluating the flow disturbance test in EN 1434

## A comparative study

---

# 01

## Motivation

# New disturbance generator in EN 1434:2022



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

- generates symmetric swirl, asymmetry not reproducible



Asymmetric swirl generator (ASG) acc. Tawackolian<sup>[5]</sup>

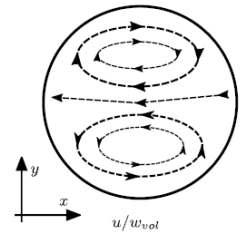
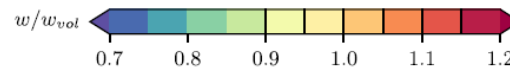
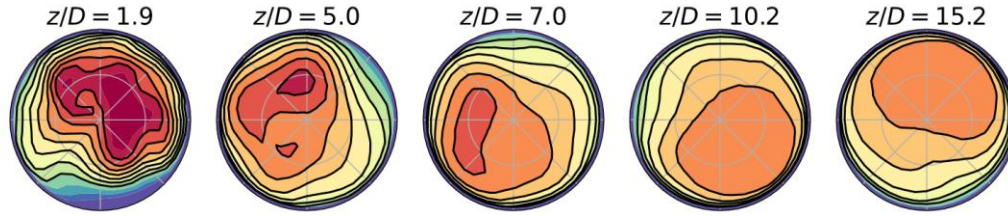
- generates swirl and reproducible asymmetry
- representation of a double bend out-of-plane (DB) from ~15D



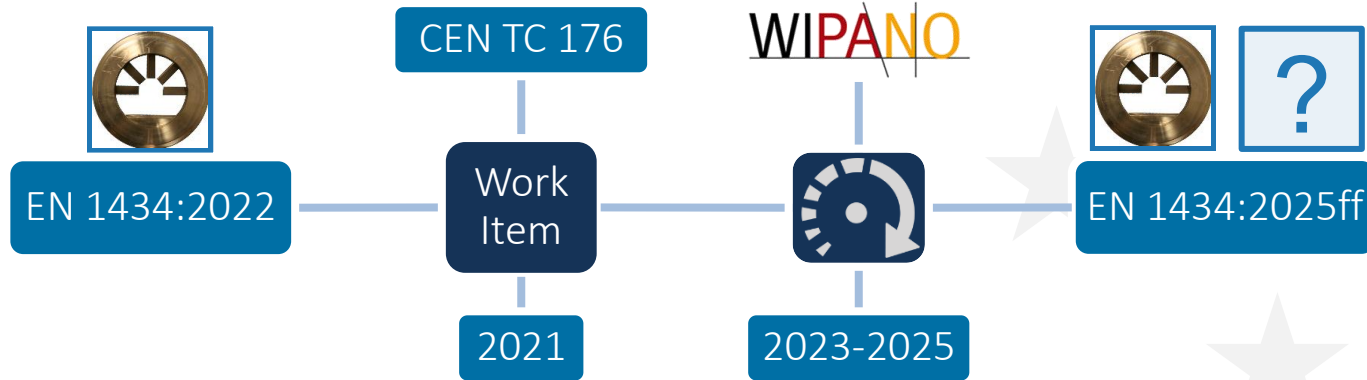
Modified ASG in EN 1434:2022<sup>[9]</sup> acc. Straka et al.<sup>[10]</sup>

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

# Comparison of flow profiles



# Project introduction



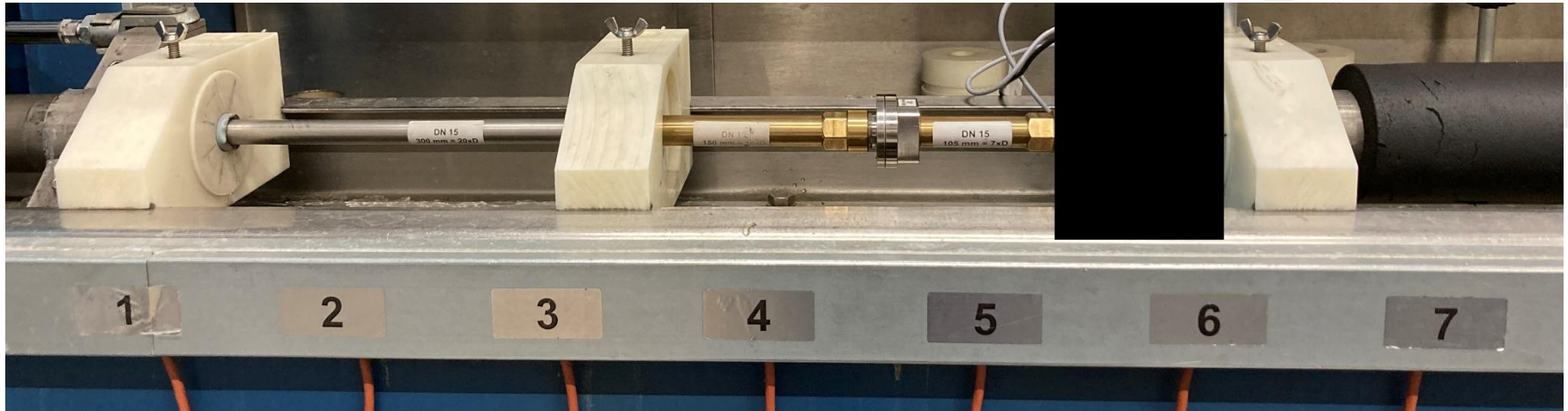
- **WIPANO** (BMWK) - Wissens- und Technologietransfer durch Patente und Normen
- **Work item:** Flow profiles in water and water glycol solution networks, e.g. 90° bend and double bend out of plane
- **Duration:** September 2023 – April 2026
- **Project partners:** Physikalisch-Technische Bundesanstalt (PTB), Wärmezähler-Service-GmbH (WSG)
- **Objectives**
  - Metrological validation of type approval without inlet section (“OD 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

# 02

## Methods

# Experimental setup

- Gravimetric test rig at WSG
- 14 heat meters
- fully developed, ASG (0D & 7D), 90° bend and DB (0D & 5D)



# Zählerauswahl

## manufacturers

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

| design  | DN     | q <sub>p</sub> | range    | classification | type of test                   |
|---------|--------|----------------|----------|----------------|--------------------------------|
| 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 (steh.<br>St./St.) |
|         |        | 3 x 6,0        |          |                |                                |

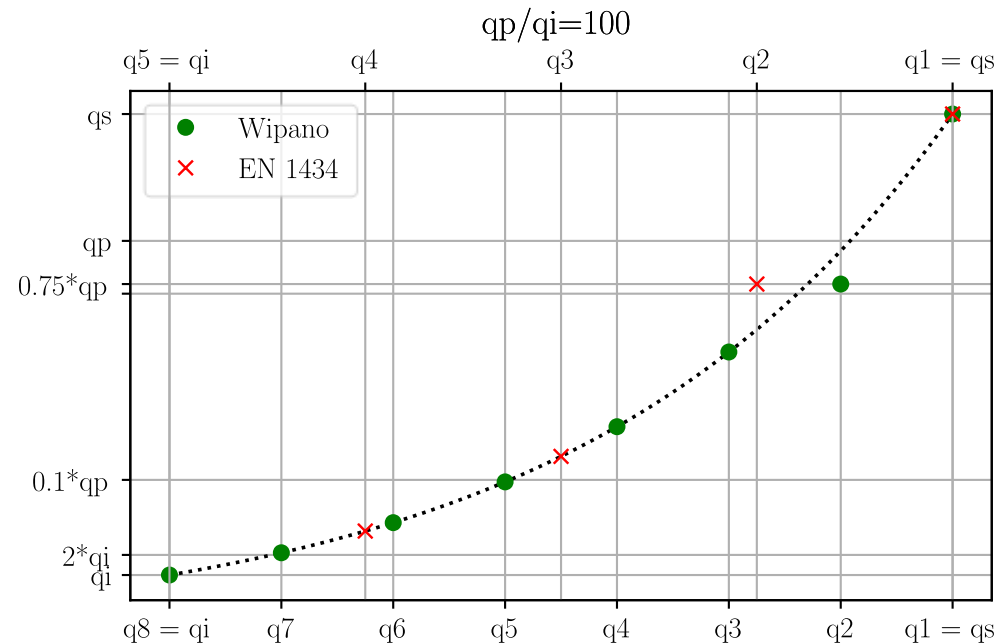
# Setup of bend unit

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



# Measurement points

| Meas. 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    |



# Test program

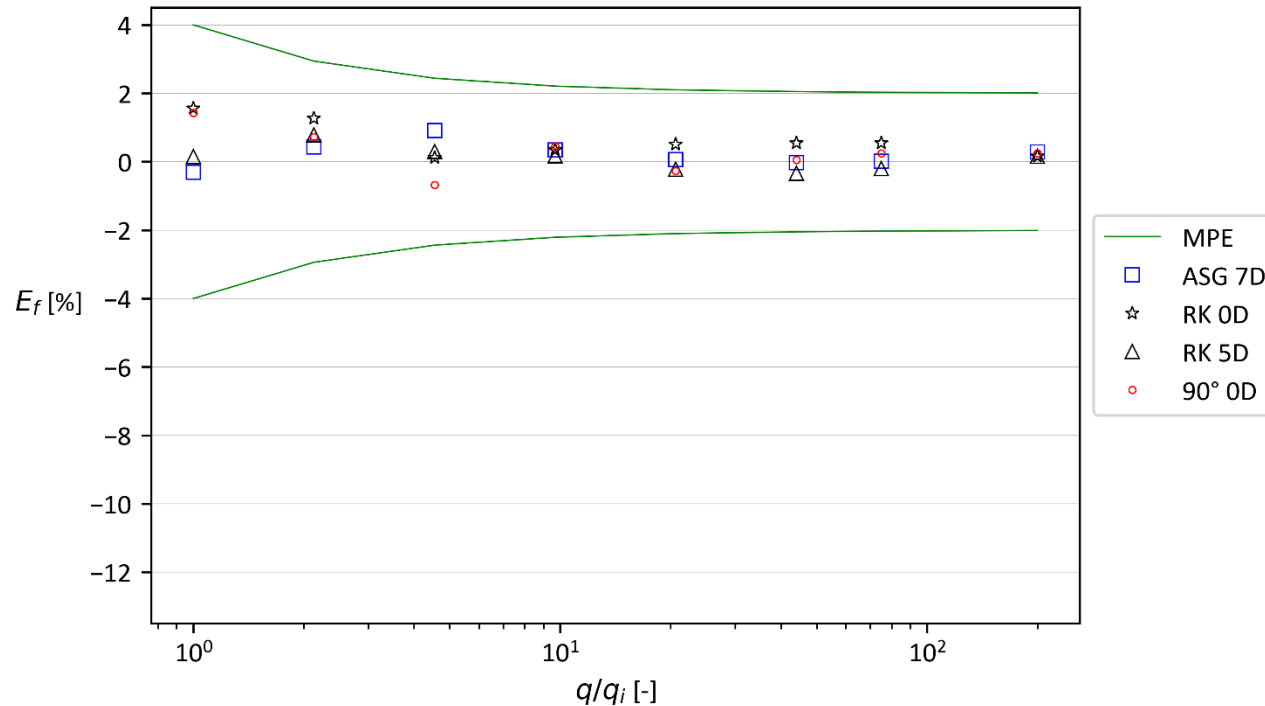


| Zähler                         | A             | B            | C             | D            | E            | F             | G             | H             | I             | J             | K             | L             | M             | N             |
|--------------------------------|---------------|--------------|---------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                                | DN15 - qp 0.6 | DN15 - qp0.6 | DN15 - qp 1.5 | DN15 - qp1.5 | DN15 - qp1.5 | DN15 - qp 1.5 | DN15 - qp 1.5 | DN15 - qp 1.5 | DN25 - qp 3.5 | DN25 - qp 3.5 | DN25 - qp 3.5 | DN25 - qp 6.0 | DN25 - qp 6.0 | DN 25 -qp 6.0 |
| <b>Basis-Messung</b>           |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| ungestörter Einlauf<br>30xD    |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| <b>ASG</b>                     |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 0xD                            |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 0 ° Blende oben                |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 45 ° gedreht                   |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 90 ° gedreht                   |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 135 ° gedreht                  |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 7xD                            |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 0 ° Blende oben                |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 45 ° gedreht                   |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 90 ° gedreht                   |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 135 ° gedreht                  |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| <b>90° - Bogen</b>             |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 0xD                            |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 5xD                            |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| <b>Raumkrümmer</b>             |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 0xD                            |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| 5xD                            |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| <b>Abschluss Basis-Messung</b> |               |              |               |              |              |               |               |               |               |               |               |               |               |               |
| ungestörter Einlauf<br>30xD    |               |              |               |              |              |               |               |               |               |               |               |               |               |               |

# 03

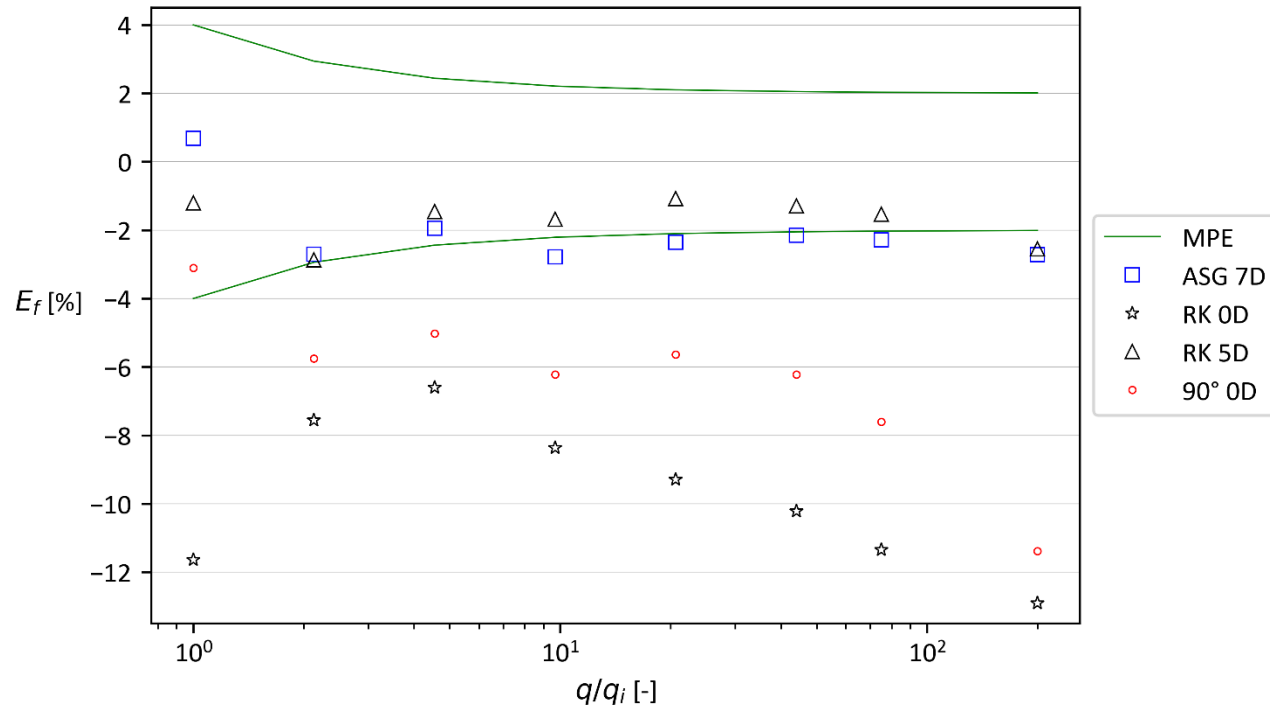
## Results

# Heat meter A – ASG 7D and disturbances



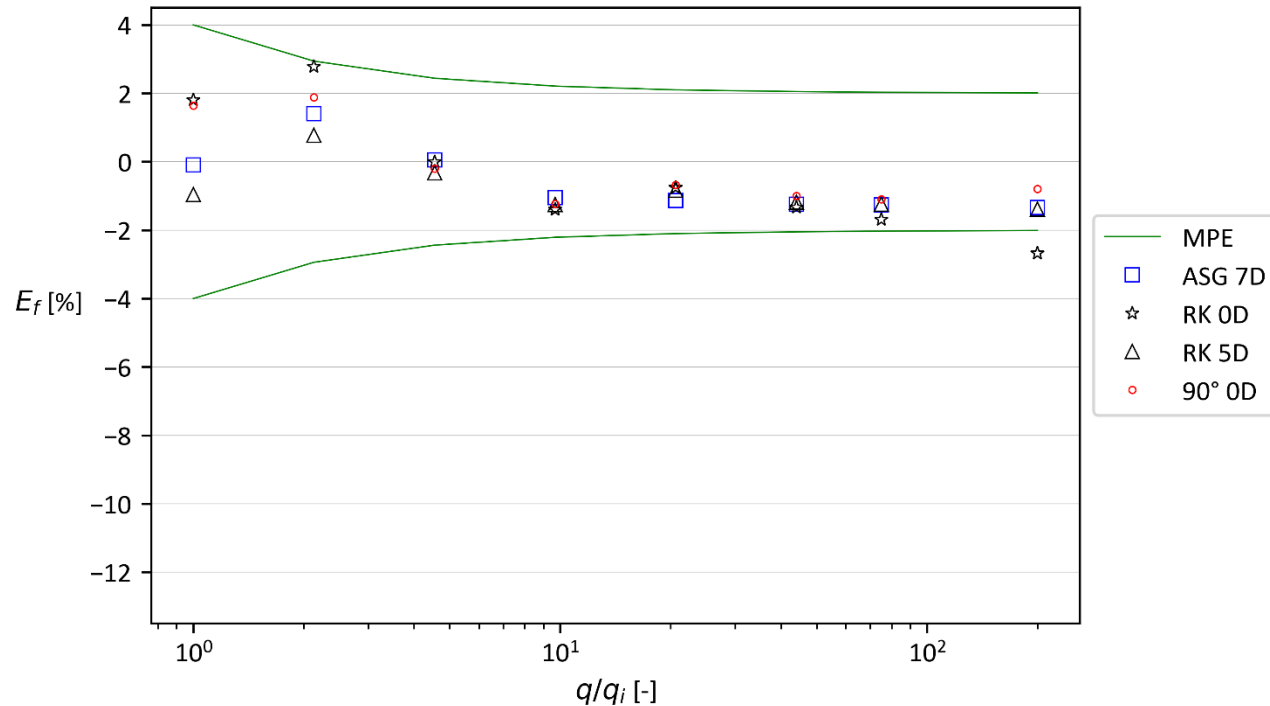
$E_f$  – difference between the error of indication and the intrinsic error of the instrument (EN 1434-1:2022 3.10.1)

# Heat meter N – ASG 7D and disturbances



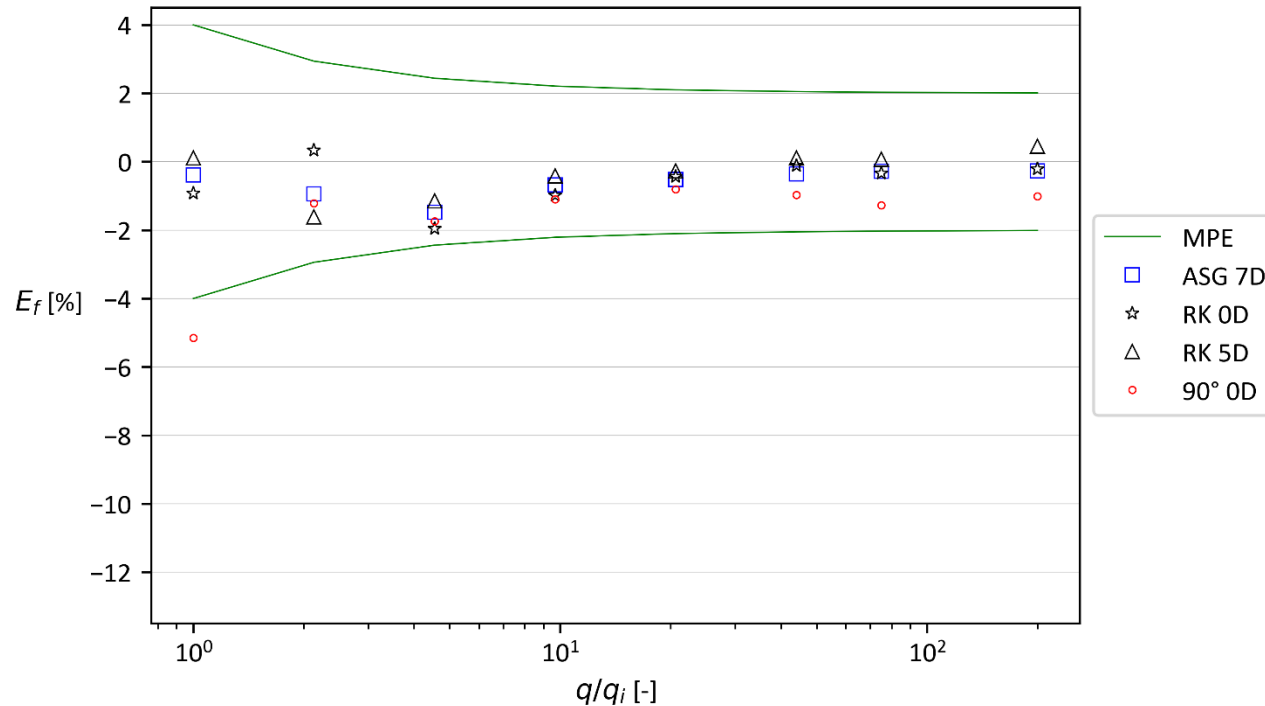
$E_f$  – difference between the error of indication and the intrinsic error of the instrument (EN 1434-1:2022 3.10.1)

# Heat meter J – ASG 7D and disturbances



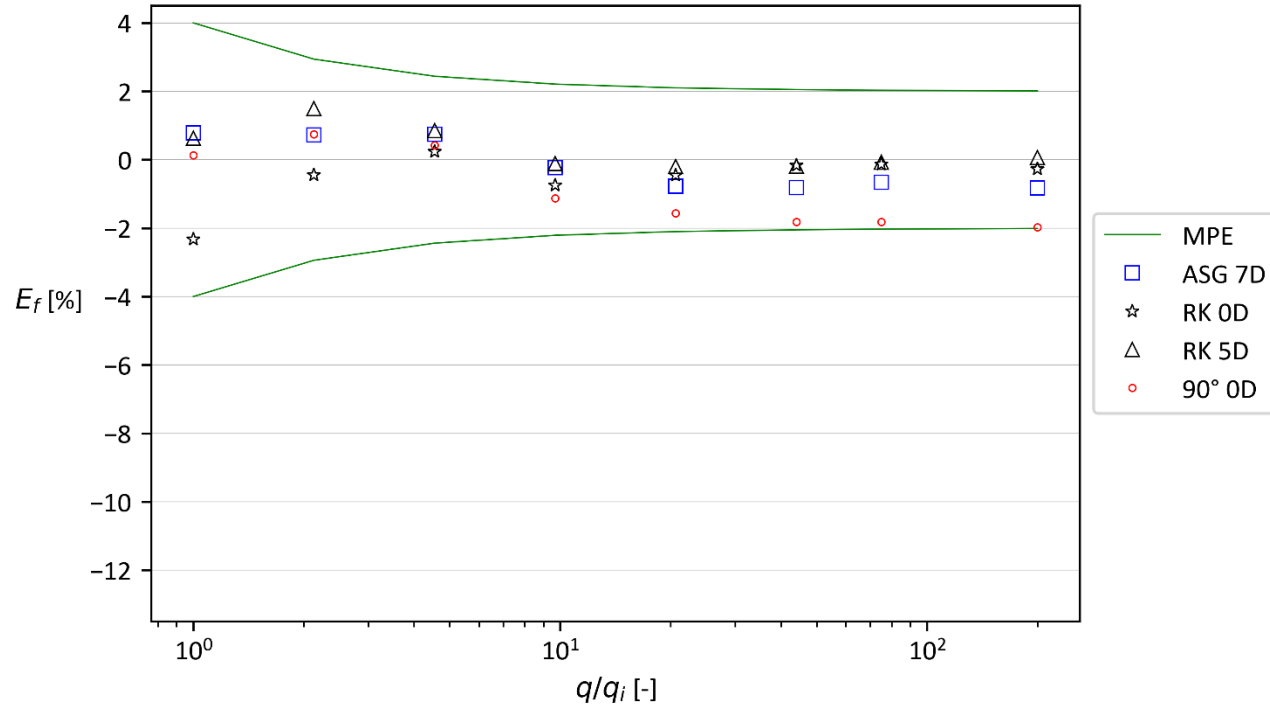
$E_f$  – difference between the error of indication and the intrinsic error of the instrument (EN 1434-1:2022 3.10.1)

# 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)

# Heat meter D – 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              |
|-----------------------------|-----------------------------|--------------|---------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|----------------|
|                             | DN15 - qp 0.6               | DN15 - qp0.6 | DN15 - qp 1.5 | DN15 - qp1.5 | DN15 - qp1.5 | DN15 - qp 1.5 | DN15 - qp 1.5 | DN15 - qp 1.5 | DN25 - qp 3.5 | DN25 - qp 3.5 | DN25 - qp 3.5 | DN25 - qp 6.0 | DN25 - qp 6.0 | DN 25 – qp 6.0 |
| Basis-Messung               |                             |              |               |              |              |               |               |               |               |               |               |               |               |                |
| ungestörter Einlauf<br>30xD |                             |              |               |              |              |               |               |               |               |               |               |               |               |                |
| ASG                         | Durchflusstest nach EN 1434 |              |               |              |              |               |               |               |               |               |               |               |               |                |
| 7xD                         |                             |              |               |              |              |               |               |               |               |               |               |               |               |                |
| 0 ° Blende oben             |                             |              |               |              |              |               |               |               |               |               |               |               |               | 5              |
| 45 ° gedreht                |                             |              |               |              |              |               |               |               |               |               |               |               |               |                |
| 90 ° gedreht                |                             |              |               |              |              |               |               |               |               |               |               | 1             |               |                |
| 135 ° gedreht               |                             |              |               |              |              |               |               |               |               |               |               | 2             |               | 1              |
| 90° - Bogen                 |                             |              |               |              |              |               |               |               |               |               |               |               |               |                |
| 0xD                         |                             |              | 1             |              |              |               |               |               |               |               |               | 6             |               | 7              |
| 5xD                         |                             |              |               |              |              |               |               |               |               |               |               | 1             |               | 2              |
| Raumkrümmer                 |                             |              |               |              |              |               |               |               |               |               |               |               |               |                |
| 0xD                         |                             |              |               |              |              |               |               |               |               | 1             |               | 8             |               | 8              |
| 5xD                         |                             |              |               |              |              |               |               |               |               |               |               |               | 2             | 1              |
| Abschluss Basis-Messung     |                             |              |               |              |              |               |               |               |               |               |               |               |               |                |
| ungestörter Einlauf<br>30xD |                             |              |               |              |              |               |               |               |               |               |               |               |               |                |

|   |                                                                             |
|---|-----------------------------------------------------------------------------|
|   | liegt innerhalb der MPE                                                     |
| x | liegt mit x Messpunkten außerhalb der MPE; kein Durchflusspunkt aus EN 1434 |
| x | liegt mit x Messpunkten außerhalb der MPE; Durchflusspunkt aus EN 1434      |

# Summary

**4/14** of heat meters downstream of bend/DB not within MPE

→ **50%** do not pass flow disturbance test

→ **50%** do 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. Verif. 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.