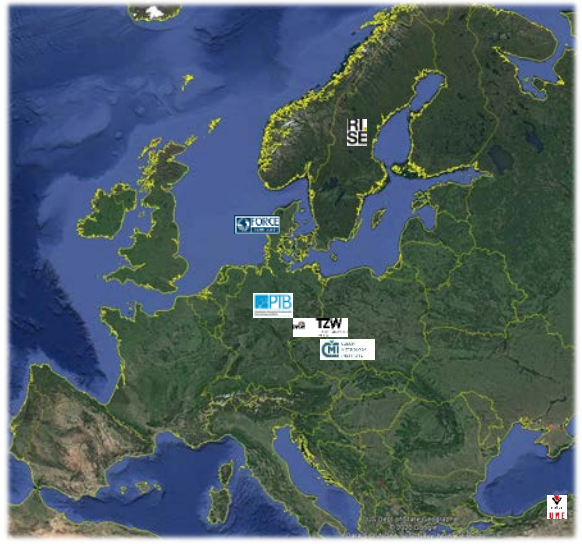
Metrology for Real-World
Domestic Water Metering

Aim

Test regime to evaluate
the performance of domestic water meters depending on water quality

- Results -



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Metrology for Real-World Domestic Water Metering

Test regimes to investigate the effect of water quality on water meter performance - Background

- Water quality can significantly affect the measurement performance of domestic water meters.
- Studies carried out in Central Europe in the last 10 years:
  no clear correlations found between water meter performance and age, total recorded volume or chemo-physical parameters of the tap water.

➢ It would be therefore extremely helpful if the field investigations could be supplemented by laboratory tests in order to be able to identify eventual problems related to water quality as promptly as possible.

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Metrology for Real-World Domestic Water Metering

Development of a water quality-related test regimes

- What conditions is a domestic water meter typically exposed to in Europe?
  - Total throughput and typical flow rates?
  - Parameter ranges of tap water (pH, hardness, particles)?

- Determination of the boundary conditions for the test regime based on
  - Surveys on consumption characteristics
    (Martin et al., 2017, Wendt et al., 2017, Kroner et al., 2019, this project)
  - Surveys on tap water quality carried out in recent years
    (Banks et al., 2015, Gauthier et al. 1999/2001, Hutter et al. 2005, Vreeburg et al., 2008, this project)

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Development of a water quality-related test regimes

- Boundary conditions of the test regime
  - Total throughput: ~ 189 m^3 Q_3= 2.5 m^3/h

    Operating time: 6 years

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Metrology for Real-World Domestic Water Metering

Development of a water quality-related test regimes

- Boundary conditions of the test regimes
  - Total throughput: ~ 189 m^3 (Q_3= 2.5 m^3/h)
  - Typical flow rates: 700 L/h – 800 L/h

Maximum flows for the 50 % and 95 % thresholds of the cumulative distribution function derived from consumption data from different countries
(Schumann et al., 2021)

Country	50 % of flow events L/h	95 % of flow events L/h
Germany	442.8	820.8
Turkey	468.0	957.6
Denmark	230.4	619.2
Czech Republic	306.0	954.0

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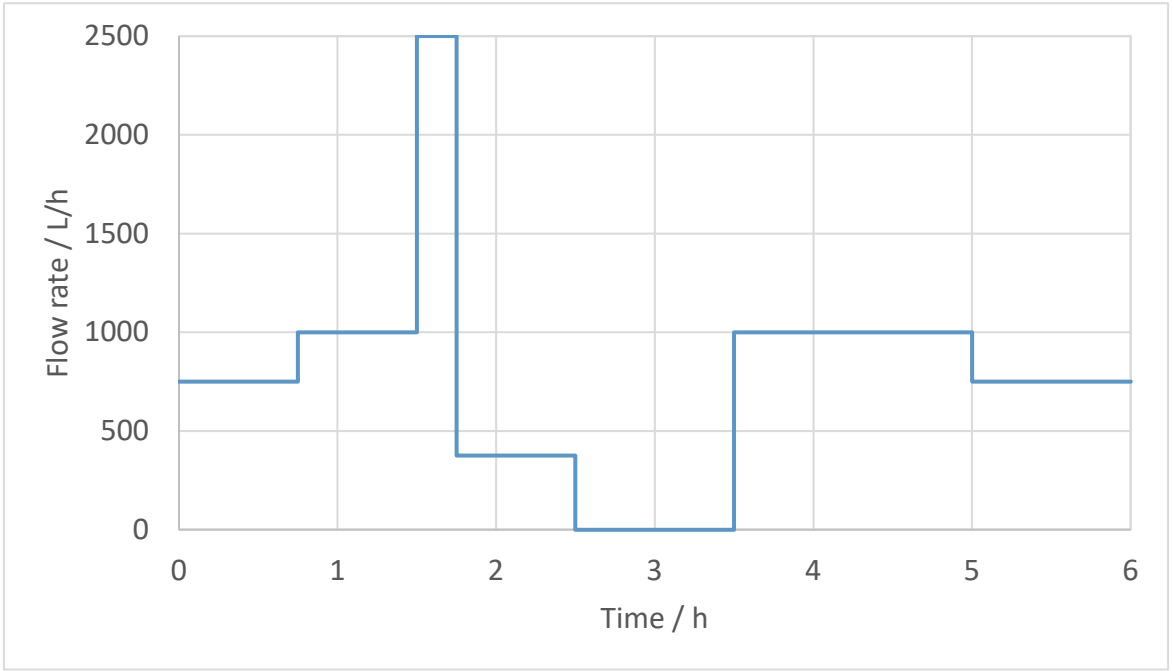
Metrology for Real-World Domestic Water Metering

Development of a water quality-related test regimes

- Boundary conditions of the test regimes
  - Total throughput: ~ 189 m³ (Q_3= 2.5 m³/h)
  - Typical flow rates: 700 L/h – 800 L/h
  - Representative flow profile derived from consumption data



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Development of a water quality-related test regimes

- Boundary conditions regarding water quality
  - 25 %-, 50 %- and 75 %-quantiles for the pH and total hardness taken from survey about inorganic chemical quality of European tap-water
  - Information on particle load rather sparse
    - Quartz sand with a grain size of 0-63 µm and 60 µm-300 µm used

Total hardness	pH	Particle load concentrations
1 mmol/L	6.5	2.8 mg/L
2 mmol/L	7.7	6.2 mg/L
3 mmol/L	9.5	20 mg/L

  - Additional experiments carried out with increased total hardness value, doubling of exposition time, combination of effects and repetition of experiments

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Development of a water quality-related test regimes

- Preparation of test waters of a given quality
  - Development of “cooking recipes”
  - ➢ Ensure the comparability and repeatability of the test water properties

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Test infrastructure

- Design of experiments
  - Two types of infrastructure and test regimes

Test rig (as used for stress tests)	Model network
	
Constant flow rate between 700 L/h and 800 L/h	Changing flow rates according to profile
Duration: 10 days – 14 days	Duration: 10 days – 14 days

  - Monitoring of pH and hardness during the experiments
  - Measurement of the water meters before and after the experiments on a test rig (3 – 5 repetitions)

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Experiments

- Range of domestic water meters investigated, size Q_3= 2.5 m³/h

Company	Single-Jet R80	Single-jet R160	Multi-jet R100	Multi-jet R160	Piston R160	Piston R400	Magn.-ind. R160	Ultrasonic R100	Ultrasonic R160	Ultrasonic R250	Ultrasonic R400
A	11										
B	4		4		4				4		15
C		18		18						18	
D				3							
E				19							
F				18							
G					3						
H				3	16	3	14				
I								18		3	

Total: 196

9 different manufacturers

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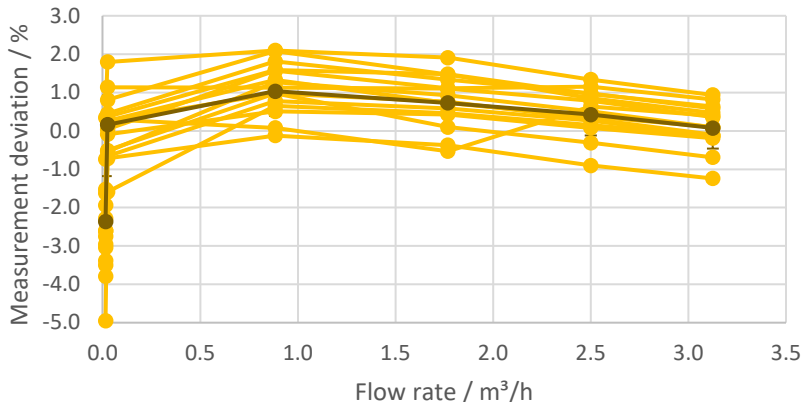
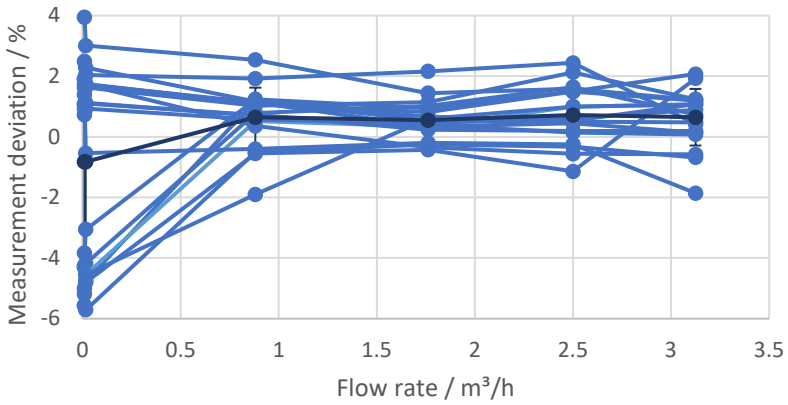
Results

- Measurement deviations of domestic water meters in mint condition: Examples

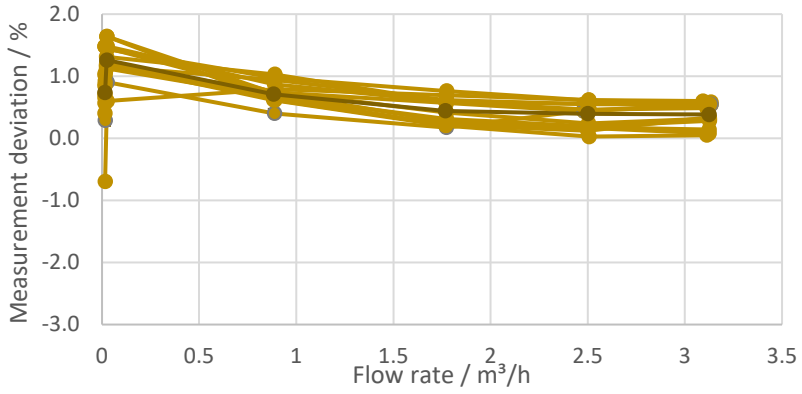
F, multi-jet, R160



C, ultrasonic, R250



H, piston, R160



„Base measurements“

Different scaling y-axes!

Dark line: mean values

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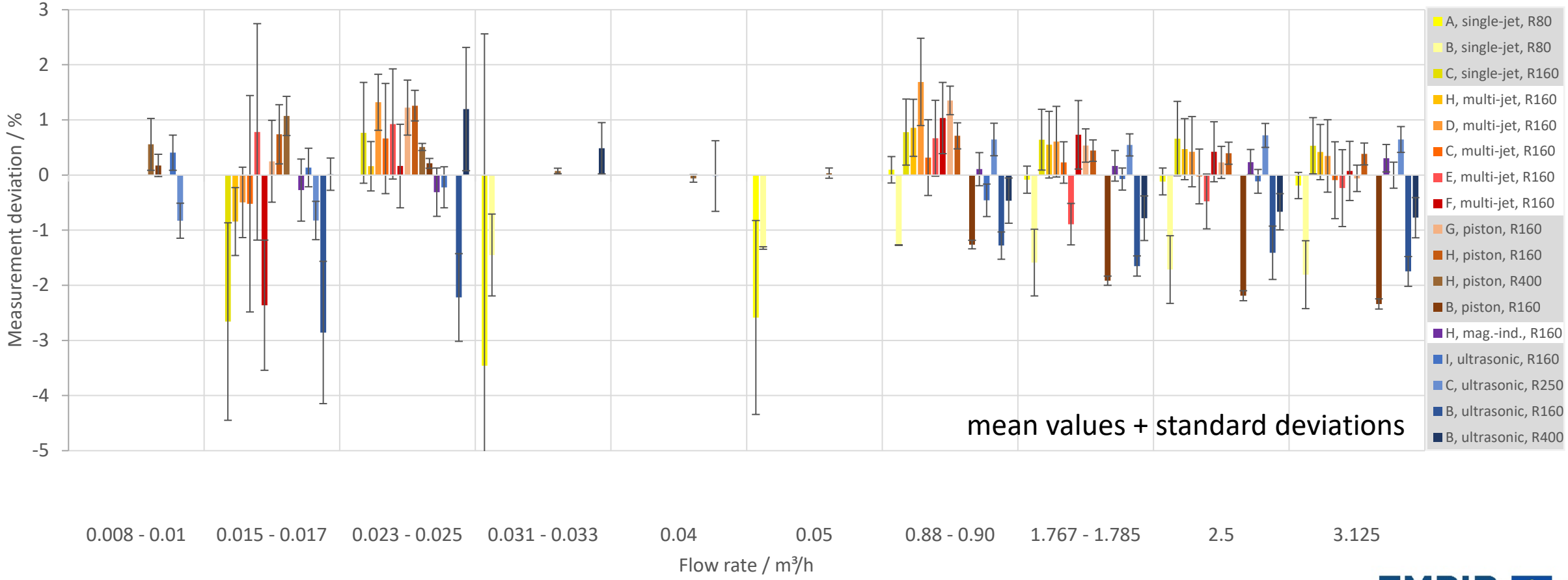
Results

- Measurement deviations of domestic water meters in mint condition (base measurement)

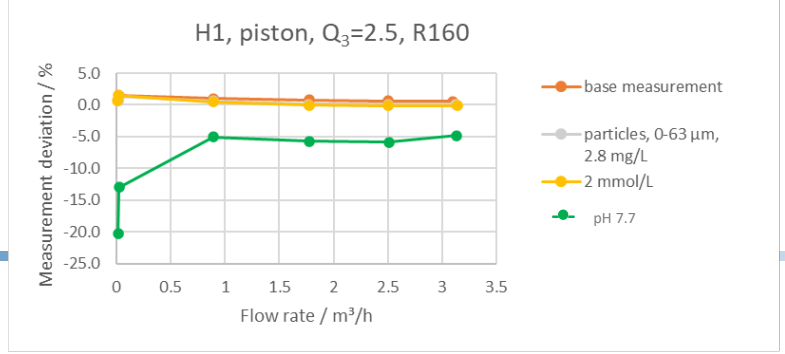


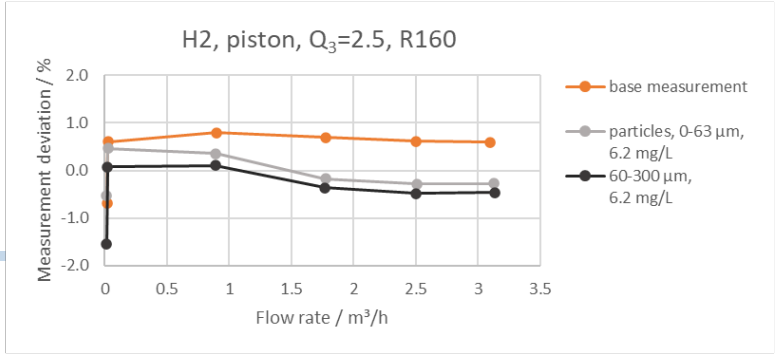
Metrology for Real-World Domestic Water Metering

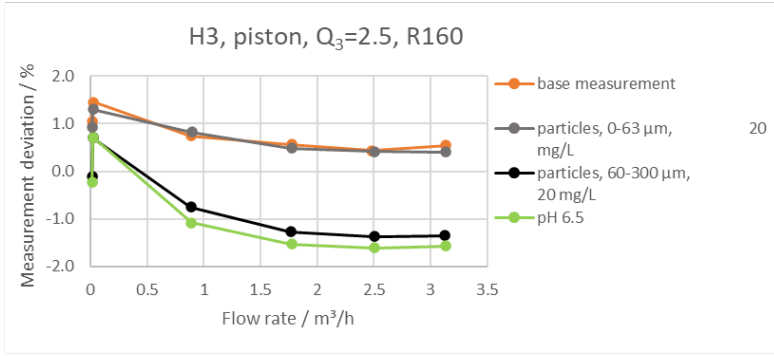
Results

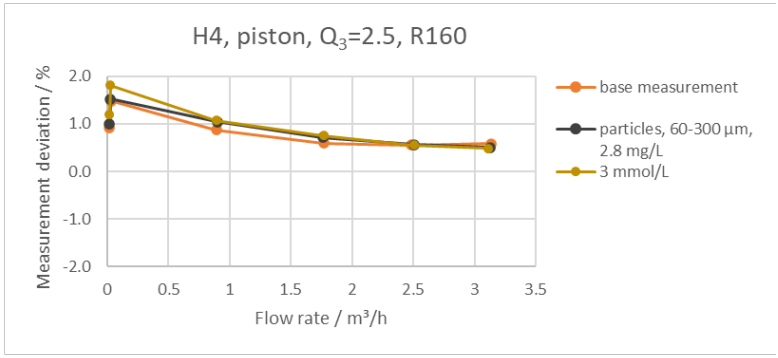
- Examples of **changes in measurement deviations** of domestic water meters after experiments with different water qualities

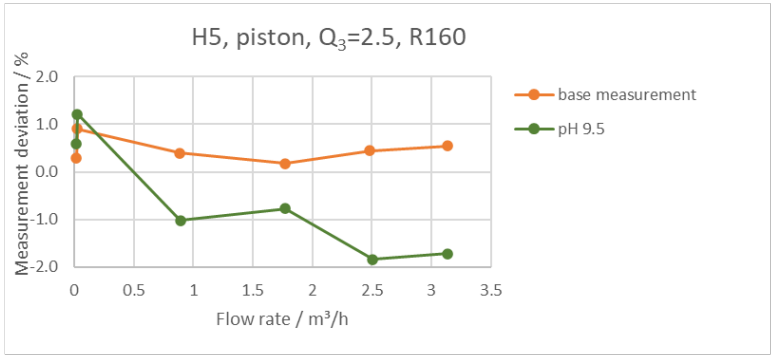
Note the partly different scaling of the y-axes!

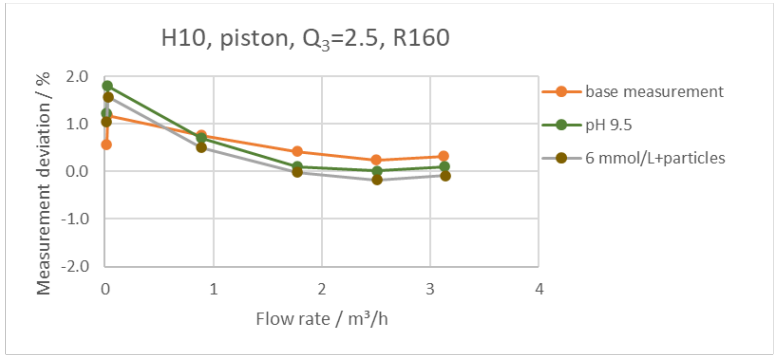


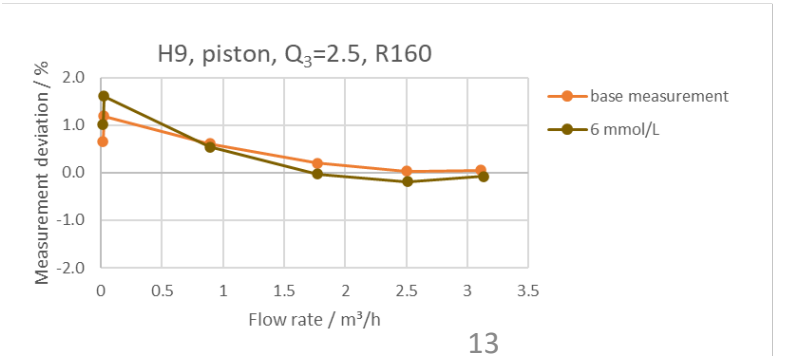


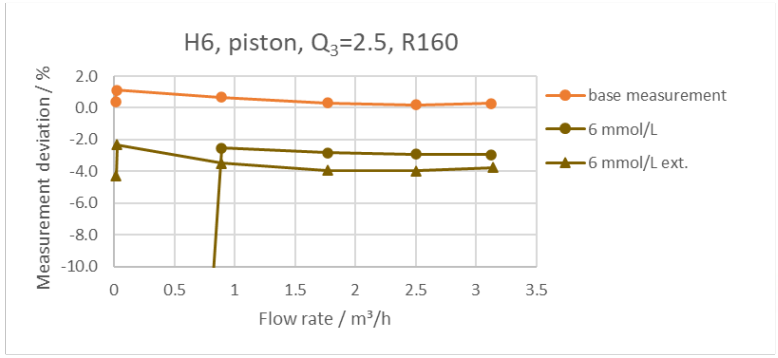








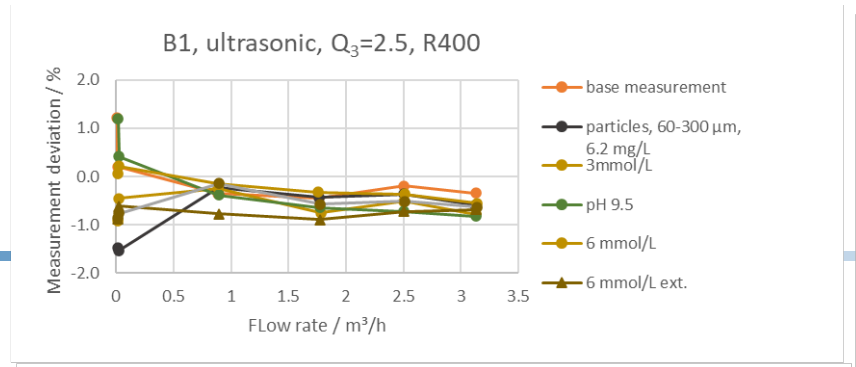


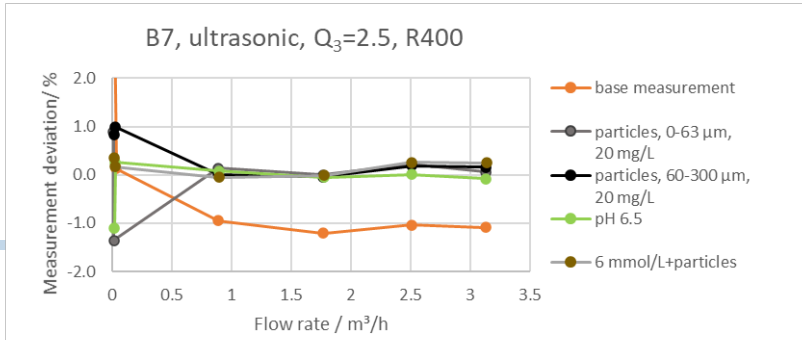


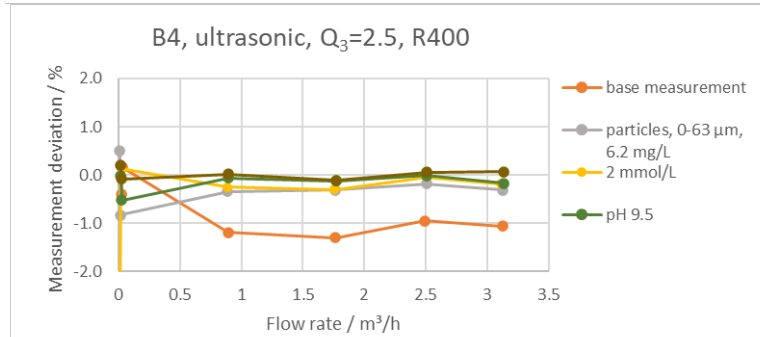
Metrology for Real-World Domestic Water Metering

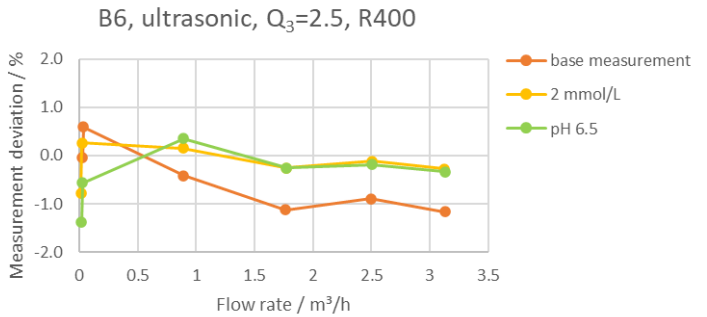
Results

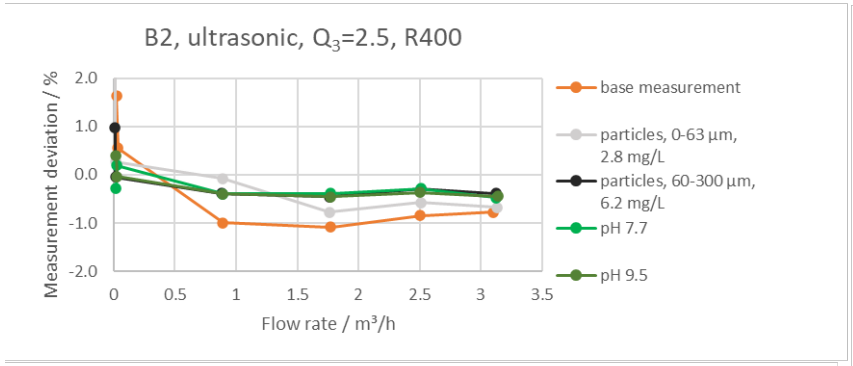
- Examples of **changes in measurement deviations** of domestic water meters after experiments with different water qualities

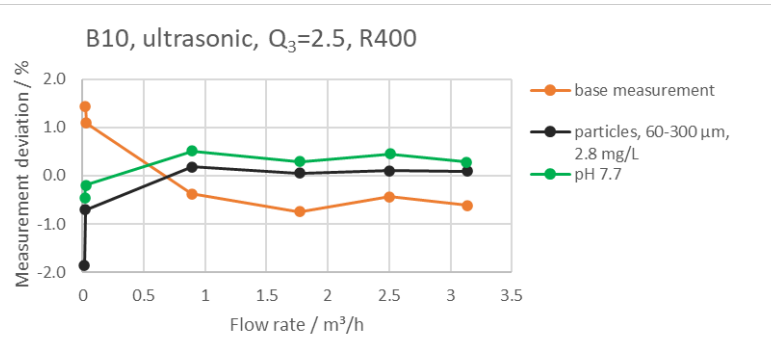


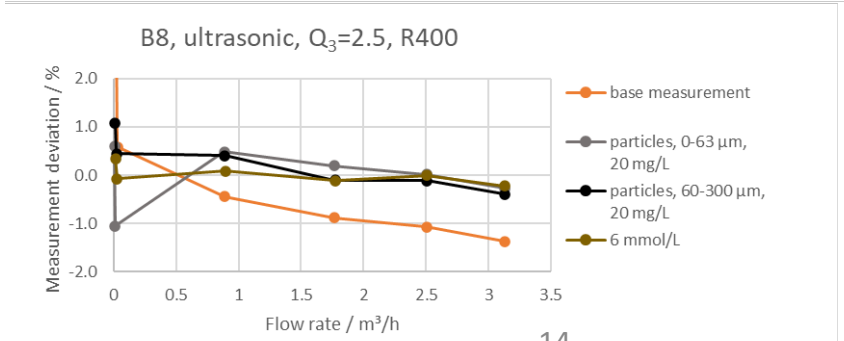


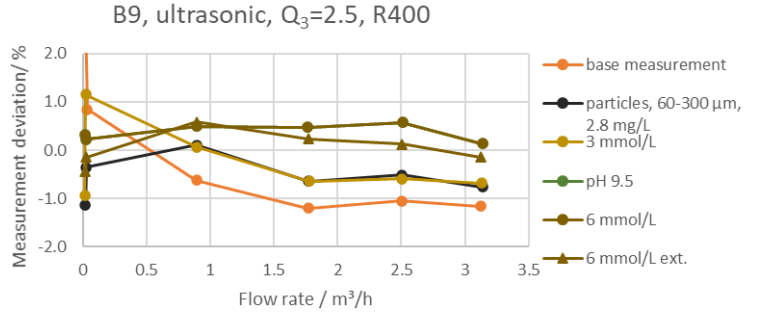












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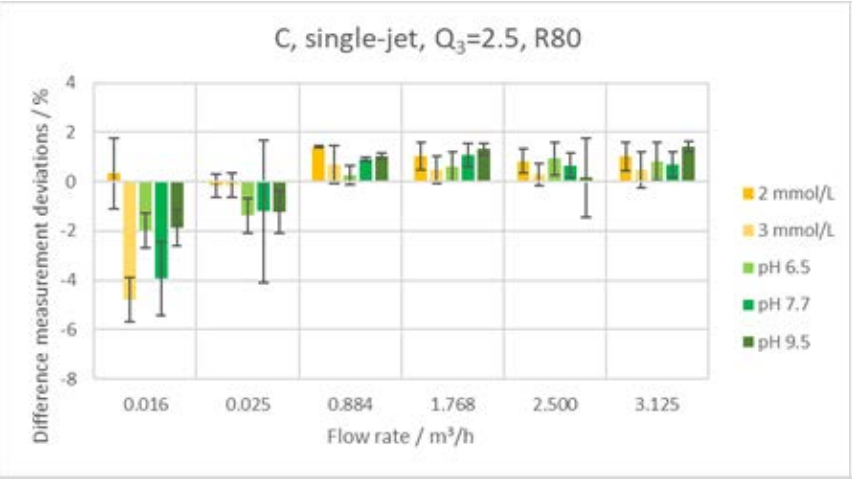
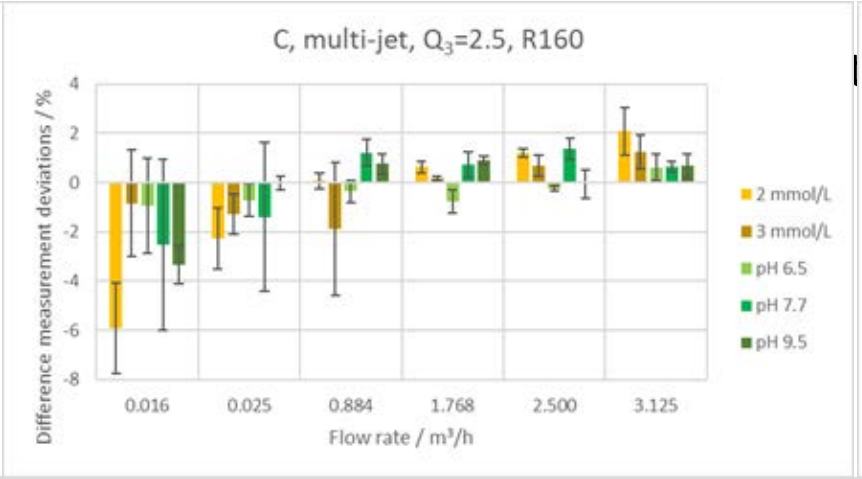
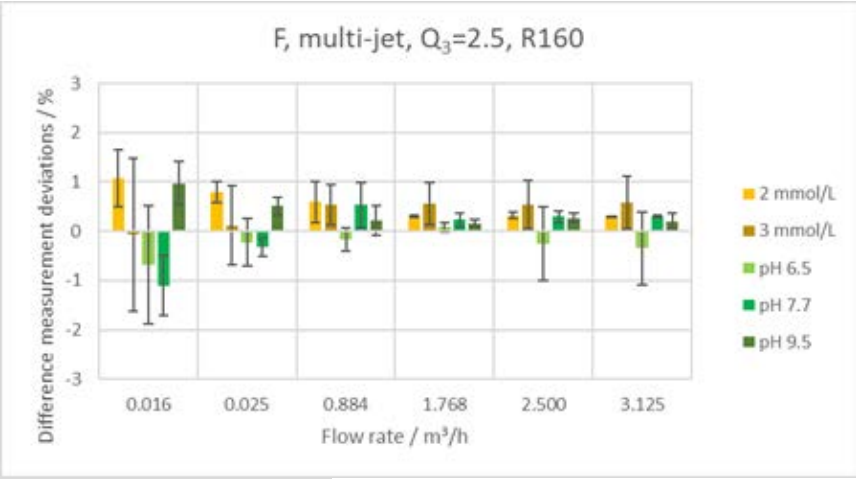
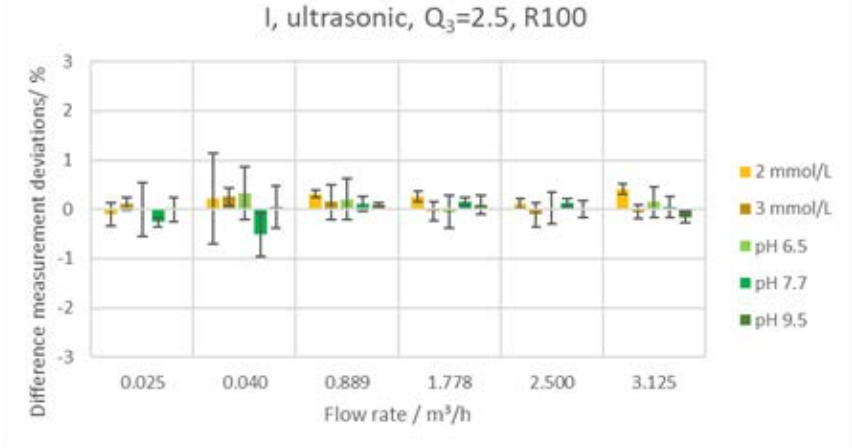
Results

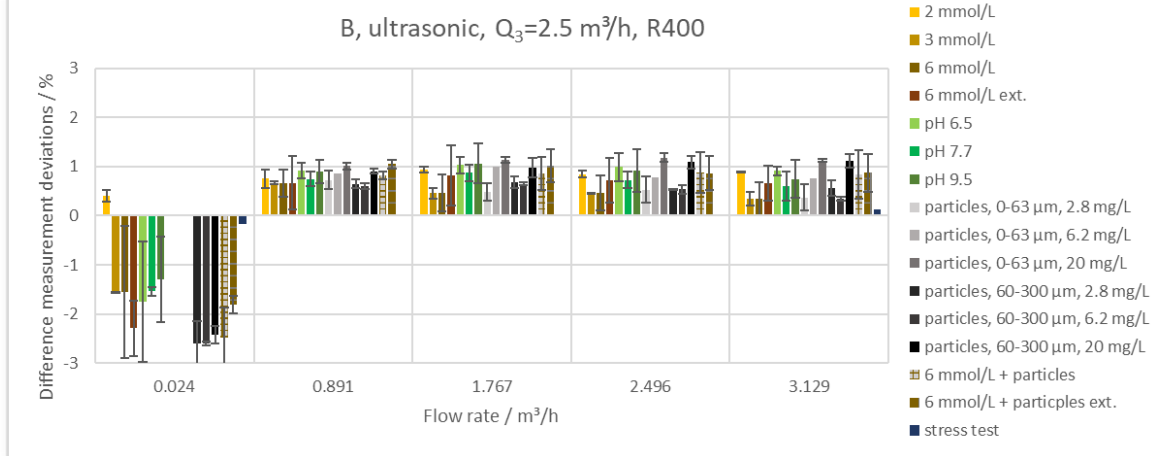
- Examples of **changes in measurement deviations** of domestic water meters after experiments with different water qualities:
  difference *[deviation after experiment] – [base measurement]*











Partly different scaling!

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Conclusions

- Test regimes proved to be fit for purpose
  - Type of test regime (steady or dynamic) does not seem to play a role
  - Test waters proved to be stable

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Conclusions

- Greatest effects not necessarily
  - with poorest water quality
  - at smallest flow rates

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Conclusions

- Indications that tests with poorer water quality tend to lead to stronger effects than conventional stress testing (100 h at Q_4)
- Indications that mechanical water meters installed vertically are more affected than water meters installed horizontally
- Results are extremely heterogeneous, strongly depend on the combination of water meter type (+batch?)+manufacturer

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Acknowledgement

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