

## Report on the RISE activities in mass-related quantities for the CCM 2023

The main activities of RISE related to CCM is listed below.

### Flow:

#### Focus areas:

Hydrogen flow, nano flows, predictive maintenance and digitalisation for water and district heating

#### Comparisons:

Euramet project 1479, Intercomparison of 1000 L proving tank, Started December 2019 and finished June 2022. RISE measurements were made August 2020.

EURAMET project No. 1506 EURAMET Pilot study, Validation of standards for liquid flow rate under dynamic flows, Started September 2020 and finished February 2021. RISE measurements were made November 2020.

EURAMET project No. 1507 EURAMET Supplementary comparison, Comparisons of standards for liquid flow rates under static load changes. Started September 2020 and finished June 2021. RISE measurements were made January 2021.

EURAMET Project 1508 Pilot study intercomparison of ultra-low liquid flow rates in range below 100 nL/min. Ongoing

EURAMET 1533 Comparison of piston-operated volumetric instruments. Started January 2022 and planned to be finished June 2022.

EURAMET 1553 Comparison of two sets of one 500 mL and one 5000 mL volume flasks. Planned to start September 2023.

#### Articles:

G. Jönsson et al: Gas flow measurement of evaporated liquid nanoflows, Measurement 2023-07

A. Koustrup Niemann et al: Assessment of drug delivery devices working at microflow rates, Biomedical Engineering / Biomedizinische Technik 2023-02-23

C. Mills et al: Calibration methods for flow rates down to 5 nL/min and validation methodology, Biomedical Engineering / Biomedizinische Technik 2023-02-23

H. Bissig et al: Calibration of insulin pumps based on discrete doses at given cycle times, Biomedical Engineering / Biomedizinische Technik 2023-02-23

H. Bissig et al: In-line measurements of the physical and thermodynamic properties of single and multicomponent liquids, Biomedical Engineering / Biomedizinische Technik 2023-02-23

O. Büker et al; RISE Test Facilities for the Measurement of Ultra-Low Flow Rates and Volumes with a Focus on Medical Applications, Applied Sciences 2022-08-20

- C Kroner et al: Evaluation of the measurement performance of water meters depending on water quality, Water Supply 2022-04-01
- H. Warnecke et al: New metrological capabilities for measurements of dynamic liquid flows Metrologia, 2022-04-01
- K. Arrhenius et al: Sampling methods for renewable gases and related gases: challenges and current limitations, Analytical and Bioanalytical Chemistry 2022-02-07
- N Furuichi et al: Final report "Key comparison CCM.FF-K1.2015 - water flow: 30 m3/h ... 200 m3/h", Metrologia 2022-01-01
- M. MacDonald et al: Calibration of hydrogen Coriolis flow meters using nitrogen and air and investigation of the influence of temperature on measurement accuracy, Flow Measurement and Instrumentation 2021
- K. Arrhenius et al: Comparison of different models to calculate the viscosity of biogas and biomethane in order to accurately measure flow rates for conformity assessment, Scientific Reports 2021
- O. Büker et al: Investigations on the Influence of Total Water Hardness and pH Value on the Measurement Accuracy of Domestic Cold Water Meters, Water 2021-09
- O. Penttinen et al: Towards flow measurement with passive accelerometers, Flow Measurement and Instrumentation 2021-08
- O. Büker et al: A unique test facility for calibration of domestic flow meters under dynamic flow conditions, Flow Measurement and Instrumentation 2021-06
- C. Kroner et al: Metrology for reliable fuel consumption measurements in the maritime sector. Measurement (Special Issue: Selected papers FLOMEKO 2022) 2023
- H.-B. Böckler et al: Metrology infrastructure for high-pressure gas and liquified hydrogen flows, Measurement (Special Issue: Selected papers FLOMEKO 2022) 2023
- O. Büker et al: Characterisation of flow meters for fuel consumption measurements in realistic drive cycle tests, Flow Measurement and Instrumentation 2023
- K. Arrhenius et al: Comparison of Optical Feedback Cavity Enhanced Absorption Spectroscopy and Gas Chromatography for the measurement of the main components and impurities in biogas, landfill gas, biomethane and carbon dioxide streams, Measurement Science and Technology 2023

## **Mass**

### **Focus research areas:**

Participation in the development of the NPL Kibble balance.

### **Comparisons:**

None

### **Articles:**

None

## **Force and Torque**

### **Focus research areas:**

Dynamic force, Dynamic rotating torque

**Comparisons:**

None in the relevant period

Articles:

**Pressure****Focus research areas:**

Dynamic pressure, Optical realisations of pressure

**Comparisons:**

EURAMET.M.P-K4.2020 / (1 Pa to 15 kPa (gauge and absolute) [Gas]), ongoing, Draft A in preparation

EURAMET.M.P-K8 / (15,1 kPa to 175,1 kPa (gauge) [Gas]), ongoing

**Articles:**

A. Svete et al: A method for correcting the high-frequency mechanical vibration effects in the dynamic calibration of pressure measurement systems using a shock tube, MSSP 2023,

T. Rubin et al: Thermodynamic effects in a gas modulated Invar-based dual Fabry–Pérot cavity refractometer. Metrologia 2022.

I. Silander: In situ determination of the penetration depth of mirrors in Fabry-Perot refractometers and its influence on assessment of refractivity and pressure. Optics Express 2022

C. Forssén et al; An optical pascal in Sweden. Journal of Optics 2022

I. Silander et al: Optical realization of the pascal—Characterization of two gas modulated refractometers, Journal of Vacuum Science & Technology B 2021.

C. Forssén et al; The short-term performances of two independent gas modulated refractometers for pressure assessments. Sensors 2021

O. Axner et al: Assessment of gas molar density by gas modulation refractometry: A review of its basic operating principles and extraordinary performance. Spectrochimica Acta Part B 2021

O. Axner et al: Ability of gas modulation to reduce the pickup of drifts in refractometry. JOSA B 2021

E. Amer et al: Towards traceable dynamic pressure calibration using a shock tube with an optical probe for accurate phase determination, Metrologia 2022

E. Amer et al: Evaluation of Shock Tube Retrofitted with Fast-Opening Valve for Dynamic Pressure Calibration, Sensors 2021