

Report to the CCM from the National Physical Laboratory, UK
Updates covering the period since the 17th CCM (May 2019)

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Main research and development activities related to CCM activities

Mass

NPL continues to work on the development of a next-generation Kibble balance. The mechanical design has been finalised and the parts are currently being manufactured. The interferometer is being tested, and the instrumentation and software, needed for the first phase of operating the balance, is ready for testing. The aim is to take part in the third Key comparison of (kilogram) realisation experiments, scheduled for late 2023.

Two of NPL's primary kilogram standards, one of platinum-iridium and one of tungsten, have been placed in specially constructed storage vessels for long term storage in pure nitrogen. The pressure in the vessels is continuously monitored and maintained at 10% above atmospheric pressure to ensure the integrity of the storage medium. Contamination is monitored in real-time using a quartz crystal microbalance and the storage vessel also contains surface samples which can be characterised by surface analysis before and after the storage period.

Force

NPL has completed the updating of the software and control system for its 120 kN deadweight force machine and updating of the 20 kN machine is underway. The upgrade will improve the reliability and flexibility of operation of the machine and will increase the efficiency of calibration service delivery.

Torque

NPL has built and commissioned a rig for the measurement of dynamic torque and power transfer. This will initially be used for the validation of the measurements made in the field of indoor cycle trainers and similar equipment but has also been used to assess efficiency and wear improvements for chain/sprocket drives. In future the knowledge and technology developed will be applied to Net-Zero metrology areas such as electric vehicles and wind turbines.

Pressure

NPL's primary piston cylinders have been re-dimensioned and the build-up calibration of NPL's suite of pressure balances has been completed. Uncertainty budgets have been reviewed with a view to improving best measurement capability. NPL has also developed facilities for the testing of ventilators.

Density

NPL's helium pycnometer system has been upgraded. Work has been done to produce traceable density standards for its calibration and it has been used, in combination with other density determination techniques, to assess the porosity of materials as part of projects to evaluate the

quality of additively manufactured components and to characterise samples in the pharmaceutical and biotechnology areas. A comparison run by the European Commission, Joint Research Centre, Institute for Reference Materials and Measurements has been successfully completed.

General

Over the past year, as part of a Measurement for Recovery programme, the Mass area of NPL has provided consultancy to a wide range of UK companies to help overcome specific metrology issues. Projects have included;

- Measurement of the loss of nanoparticles from a coating using complimentary gravimetric and particle counting techniques
- Efficiency and wear characterisation of a new cycle sprocket design
- Measurement of impact forces for pellets and seeds as part of an industrial process using optical and dynamic force measurements
- Design of a system to give gravimetric traceability to a next generation flow calibration rig
- Design evaluation, instrumentation and uncertainty analysis for a novel on-line density meter
- Design and uncertainty evaluation for a liquid dilatometer
- Evaluation of a next-generation primary pressure standard.

Comparisons

Mass

None

Force

CCM.F-K2.a.2 force 5 kN to 200 kN – Draft A

EURAMET.M.F-S5 force 10 kN to 500 kN – Results published

Pressure

EURAMET.M.P-K1.c Effective area of piston-cylinder 0.7 MPa to 7 MPa – Draft B report

Density

CCM.D-K5 Density of liquids – Protocol agreed

EURAMET.M.D-K1.1 Solid density comparison – Results published

Publications

Mass loss of platinum-rhodium thermocouple wires at 1324°C, Jonathan Pearce, Stuart Davidson, Sivahami Uthayakumaar, Johnson Matthey Technology Review, Jan 2021

EURAMET key comparison 1031 (EURAMET.M.D-K1.1)—solid density comparison, Horst Bettin, Stuart Davidson et al. Metrologia, Volume **57**, Number 1A, 2020

Beginning of a new phase of the dissemination of the kilogram, S Davidson and M Stock, Metrologia, Volume **58**, Number 3, 2021

Report on the CCM key comparison of kilogram realizations CCM.M-K8.2019, Stock M, Davidson S et al, Metrologia Volume **57**, 07030, 2020

A μ Kibble balance for direct realisation of small-scale masses and forces, Charlie Jarvis, Emily Webster, Stuart Davidson et Ian Robinson, 19th International Congress of Metrology (CIM2019), Paris, France, September 24-26, 2019

Towards the next generation of NPL Kibble balances, Robinson, Ian et al, Conference on Precision Electromagnetic Measurements (CPEM) 2020

INTERCOMPARISON BETWEEN DEADWEIGHT MACHINES IN CHINA AND UK UP TO 1 MN, Lin Shuo, A. Knott, Chi Hui, Li Shixin, Tang Yun, ACTA IMEKO, December 2020, Volume 9, Number 5, 106 - 108

Force supplementary comparison EURAMET.M.F-S5 (10 kN to 500 kN), A J Knott and Ž Alar, Metrologia, Volume **58**, Number 1A, 2021

Dynamic characterisation of pressure transducers using shock tube methods. Knott, A J; Robinson, I A, Transactions of the Institute of Measurement and Control, 42 (4). pp. 743-748, 2020.