Measurement Standards Laboratory of New Zealand (MSL)

Activity report for the 18th meeting of Consultative Committee for Mass and Related Quantities (CCM)

Yin Hsien Fung

1. Main research and development activities related to CCM activities

Kibble balance

MSL mass and related quantities standards current main research focus is on the MSL Kibble balance that is based on twin pressure balances and can be operated in oscillatory moving mode, with the aim of realization of the mass unit. Few of the technologies used for this Kibble balance with distinct working principles can contribute to the development and capability extension in mass and pressure standards. The current activities in the MSL Kibble balance can be summarized as the following:

- We have completed the design and layout of modules of the Kibble balance. We have designed a mass loader with pneumatic control. The vacuum chamber for the Kibble balance is under construction.
- A measurement model is currently under development while potential methods for implementation of oscillatory measurements for the moving mode are being investigated.
- We are assembling the twin pressure balances with rotating cylinder configuration and dimensional measurements of the mechanical parts in progress. We have set up a twin pressure rig to assess the performance of the differential pressure transducer as a force comparator in the weighing mode.
- We are studying the effects of non-linearity error in oscillatory displacement measured by interferometer based on Zeeman stabilised laser. We have also acquired an Nd:YAG green laser as an option to implement an interferometer with spatially separated heterodyne beams.
- The magnet has been assembled and a prototype coil has been constructed. We have determined the uniformity of the magnetic field. We hang the coil with current under a mass comparator and use mN range forcemeters to investigate the parasitic forces arising from coil-magnet misalignment.

Mass

MSL mass standards has mainly been working on commissioning new balances and developing new apparatus to improve measurement capabilities while implementing new custom software for the laboratory.

- We have developed a novel automated weight changer system that can work on a 500 g commercial mass balance. This will enable automated calibration for weights from 200 g to 500 g.

- We are commissioning two new balances (64kg and 600kg) and several new masses to extend our large mass capability. Build up to 50 kg has been completed and we expect to continue up to 500 kg, with the aim to participate in a comparison.
- A new primary kilogram mass comparator has been commissioned and a chamber is being developed to maintain constant ambient conditions with the weight changer motor housed outside of the chamber.

Pressure

MSL pressure standards has been actively contributing to the development of the twin pressure balances system in the MSL Kibble balance and has concentrated its effort in acquiring new pressure balances as part of the ongoing equipment and capability improvement process.

- We have acquired a new hydraulic pressure balances to replace our existing Ruska units. These new standards will ensure ongoing realisation of our pressure scale in the range 0.2 MPa to 280 MPa (liquid medium) while allowing for the possibility of increasing this range to higher pressures.

2. Participation in relevant comparisons

The following is a list of comparisons either in progress or completed.

1 APMP.M.D-K4 (hydrometers): Draft B report in progress.
2 APMP.M.M-K5 (mass: 200 mg, 1 g, 50 g, 200 g and 2 kg): Final report has been published.
3 APMP.M.P-K9 (absolute gas pressure 10 kPa to 110 kPa): Final report has been published, approved for equivalence.

3. Recent publications

1 Y.H. Fung, M.T. Clarkson and F. Messerli, “Alignment in the MSL Kibble balance weighing mode”, Conference on Precision Electromagnetic Measurements (CPEM) 2020 Digest, Online Conference, August 2020.
2 R. Hawke and M. Clarkson, “Pressure control in the MSL Kibble Balance”, Asia-Pacific Measurement Forum on Mechanical Quantities (APMF), Niigata, Japan, November 2019.
3 P. McDowall, R. Hawke, Y.H. Fung and M. Clarkson, “A pressure-based Kibble balance for realizing New Zealand’s kilogram”, Metrology Society of Australasia Conference, Melbourne, Australia, March 2020.
4 Y.H. Fung, “MSL Kibble balance progress update”, Kibble Balance Technical Meeting, Teddington, UK, October 2019.
5 I. Choi, S. Woo, J. Man, M. Aldammad, W. Sabuga, Y. Jin, N.N. Thang, G. Wu, C. Sutton and M. Kojima, “APMP key comparison of absolute pressure from 10 kPa to 110 kPa (APMP.M.P-K9)”, Metrologia, 57, 07017, 2020.