National Research Council of Canada
Main Research and Development Activities

Density

The main research activity in density at NRC since the meeting of the CCM in 2021 has been the investigation of the seasonal dependence of the isotopic concentrations in the NRC reference water. The aim of this work is to correct for seasonal variations, if they exist, and reduce the uncertainty contribution of the isotopic ratio for our primary liquid density reference system. We have also undertaken a project to modernize the NRC's hydrometer calibration system. This project is currently in progress and is upgrading the environmental monitoring systems, and control systems in support of the digitization of the process.

Mass

In support of the SIM Kilogram Dissemination Project exploring mass stability across the RMO, a measurement campaign was performed in which masses from participating NMIs were returned to NIST or NRC for recalibration. The artefacts were monitored for mass change while at the participating institutes, during transport and while at the institute performing the recalibration. This is the first time the masses have been returned since their initial characterization and distribution in 2018. The artefacts have since been returned to the participating institutes. Results are being aggregated from NIST, NRC and participating institutes and a report is being drafted.

With the aim to improve measurements of gas density/pressure using a mass balance we have designed and modeled a new internal enclosure to reduce temperature gradients and increase thermal stability inside the NRC vacuum balance. The method uses buoyancy artefacts to measure gas density from which pressure can be realized through gas laws to the Boltzmann constant.

NRC performed measurements on the Kibble Balance as part of our participation in CCM M.K8, new travelling standards were successfully used due to travel restrictions which prevented the shipping of PtIr, including a tungsten mass manufactured at NRC. Realization measurements were performed with a partially new team due to retirements. Additional team members have been brought on to the project and are in training to perform the upcoming 2023 key comparison CCM.M-K8. Operational improvements are being investigated and new low TC resistors are being procured to determine whether their stability is sufficient to allow them to be transported for calibration, resistors are presently calibrated in-situ by transporting QHR and CCC instruments.

Other research projects include the development and characterization of novel resonant devices for detection of acceleration and mass. Continuing projects in the MRQ area arising from the NRC COVID response, are studies of the equivalence of mass based and number (count) based filtration efficiency measurements for filter media. As well, in support of Canada government health branches and their decision making we have continued the development and testing of a generalized model for the extraction of vaccine from vials, to predict the likelihood of extracting a specified number of doses of targeted volume.

Pressure

Over the past two years the NRC Pressure Laboratory has focused on expanding hydraulic calibration capabilities with an effort to tie three new hydraulic pistons into an existing piston (2 MPa/kg) that was used successfully in CCM-P.K7 (Final Report on Key Comparison CCM.P-K7 in the Range 10 MPa to 100 MPa of Hydraulic Gauge Pressure). The goal of this work is to acquire CMCs in hydraulic gauge pressure up to 100 MPa.

The NRC Pressure Laboratory had its external Peer Review of the Quality Management System supporting the Calibration and Measurement Capabilities (CMCs) at the National Research Council of Canada (NRC) with a technical review of the Pressure CMCs in April 2023 by Dr. Jay Hendricks (NIST). As part of this review the Quality Management System of our hydraulic pressure services was formally reviewed. Using as reference the *Guideline for reviewers of CMC entries in the field of the CCM WG Pressure and Vacuum: Risk based approach* this review will serve as part of our CMC application for hydraulic pressure.

A replacement laser for NRC's Schwien manometer was purchased and installed; the performance of the system using the new optical source is currently being investigated.

Select Publications:

Stock, Michael & Conceição, P & Fang, H & Bielsa, F & Kiss, A. & Nielsen, Lars & Beaudoux, F & Espel, P & Thomas, Matthieu & Ziane, Djamel & Baumann, Henri & Eichenberger, Ali & Marti, K & Bai, Yang & Hu, M & Li, Z & Lu, Y & Peng, C & Wang, J & Ahmedov, H. (2023*). Final report on the CCM key comparison of kilogram realizations CCM.M-K8.2021.* Metrologia. 60. 07003. 10.1088/0026-1394/60/1A/07003.

Bouchard, Alexandre & Hodges, Timothy & Stephan, Michel & Wu, Lixue & Koukoulas, Triantafillos & Green, Richard & St-Gelais, Raphael. (2023). *Localized Thermal Gradients On-Chip by Radiative Cooling of Silicon Nitride Nanomechanical Resonators*. Applied Thermal Engineering. 229. 120561. 10.1016/j.applthermaleng.2023.120561.

Sipkens, Timothy & Corbin, Joel & Koukoulas, Triantafillos & Oldershaw, Andrew & Lavoie, Thierry & Oliaee, Jalal & Liu, Fengshan & Leroux, Ian & Smallwood, Greg & Lobo, Prem & Green, Richard. (2022). *Comparison of measurement systems for assessing number- and mass-based particle filtration efficiency*. Journal of Occupational and Environmental Hygiene. 19. 1-22. 10.1080/15459624.2022.2114596.

Hodges, Timothy & Wu, Lixue & Mu, Gengyang & Snell, Nikaya & Bouchard, Alexandre & Stephan, Michel & Huang, Huan & Koukoulas, Triantafillos & Green, Richard & St-Gelais, Raphael. (2022). *Characterization of Mass-Loaded Silicon Nitride On-Chip Resonators for Traceable Sensing of Low Amplitude Acceleration*. 1-4. 10.1109/INERTIAL 53425.2022.9787524.

Comparison Participation

CCM.M-K8: Kilogram realizations, SIM.M.M-K6: Stainless steel mass (50 kg), CCM.D-K1: Density measurements of a silicon sphere (1kg) by hydrostatic weighing, CCM.D-K5: Comparison on density determination of liquid samples using oscillation-type density meters, CCM.G-K2.2023: Comparison of Absolute Gravimeters