CCT member and observer Activity Report

Period: January to December 2021

Institute: National Research Council Canada

State economy: Canada

Number of persons involved in thermometry of the institute: 7

Short summary of research and development:

Reproducibility of the ITS-90

Comprehensive evaluations of subrange inconsistency for long-stem SPRT subranges [5], and Type 3 non-uniqueness, subrange inconsistency and propagation of calibration uncertainties for capsule SPRT subranges [4] have been published. The latter of these two publications shows that the CCT *Guide to the Realization of the ITS-90* overestimates several scale uncertainty components, and recommendations are given to improve the guidance given to the thermometry community regarding construction of ITS-90 uncertainty budgets [4].

Primary thermometry

A new review article on refractive index gas thermometry has been published, focusing particularly on the best values of reference data such as virial coefficients [3]. This information may also be useful for acoustic gas thermometry and dielectric-constant gas thermometry.

Emerging technologies

Work continues on the metrological evaluation and novel application of emerging thermometry technologies. In the past year, this has included publications on wavelength drift of fiber Bragg gratings at high temperatures [6, 9] and the performance of long-wavelength infrared thermal imagers mounted on aerial drones [2].

Climate

An accurate metrological investigation of the de facto standards for deep-ocean temperature measurements was published [8]. This study found deviations and irreproducibilities that were inconsistent with the manufacturer's uncertainty claims [8].

Short summary of recent comparison activity:

CCT-K7.2021 water triple point comparison

The participants' transfer cells started to arrive at NRC in July 2021 and the pilot's measurements were started in August 2021. The measurements on three of the four planned batches of cells were completed before the end of 2021. The last batch of cells will be measured in January/February 2022.

Short summary of other activities:

The CCT WG-NCTh Task Group on high-temperature fixed-point uncertainties has now published a detailed evaluation of the uncertainty profiles of two paths to realizing thermodynamic temperature by indirect primary radiometry using high-temperature fixed-point blackbody cells [7].

Link to bibliography or list of bibliography (last 5 years):

[1] A Peruzzi *et al.* 2021 **A comparison of relative humidity calibration facilities at temperatures up to 170 °C** *Measurement* in press https://doi.org/10.1016/j.measurement.2021.110435

[2] G Leblanc *et al.* 2021 **A practical validation of uncooled thermal imagers for small RPAS** *Drones* **5** 132 https://doi.org/10.3390/drones5040132

[3] P M C Rourke 2021 **Perspective on the refractive-index gas metrology data landscape** *Journal of Physical and Chemical Reference Data* **50** 033104 https://doi.org/10.1063/5.0055412

[4] P M C Rourke 2021 **ITS-90 reproducibility, xenon fixed point substitution and new interpolating equations between 13.8033 K and 273.16 K** *Metrologia* **58** 055004 https://doi.org/10.1088/1681-7575/abfd8e

[5] A Peruzzi *et al.* 2021 **Survey of subrange inconsistency of long-stem standard platinum resistance thermometers** *Metrologia* **58** 035009 https://doi.org/10.1088/1681-7575/abe8c1

[6] S Dedyulin *et al.* 2021 **Accurate measurements of a wavelength drift in high-temperature silica-fiber Bragg gratings** *Metrology* **1** 1 https://doi.org/10.3390/metrology1010001

[7] A D W Todd *et al.* 2021 **On the uncertainties in the realization of the kelvin based on thermodynamic temperatures of high-temperature fixed-point cells** *Metrologia* **58** 035007 https://doi.org/10.1088/1681-7575/abe9c5

[8] A Peruzzi *et al.* 2021 **Metrological evaluation of deep-ocean thermometers** *Journal of Marine Science and Engineering* **9** 398 https://doi.org/10.3390/jmse9040398

[9] D Grobnic *et al.* 2021 **Fiber Bragg grating wavelength drift in long-term high temperature annealing** *Sensors* **21** 1454 https://doi.org/10.3390/s21041454

[10] Y Yamada and A Todd 2021 **Special section on TEMPMEKO 2019: a feature on the XIV International Symposium on Temperature and Thermal Measurements in Industry and Science & IV International Temperature Conference, Beijing (TEMPMEKO & TEMPBEIJING 2019) and Metrology for Meteorology and Climate (MMC 2019)** *Measurement Science and Technology* **32** 020101 https://doi.org/10.1088/1361-6501/abac89

[11] S N Dedyulin *et al.* 2020 **On the long-term stability of the triple-point-of-water cells** *Metrologia* **57** 065032 https://doi.org/10.1088/1681-7575/abb52f

[12] A Merlone *et al.* 2020 **Gas-controlled heat pipes in metrology: more than 30 years of technical and scientific progresses** *Measurement* **164** 108103 https://doi.org/10.1016/j.measurement.2020.108103

[13] S Janz *et al.* 2020 **Photonic temperature and wavelength metrology by spectral pattern recognition** *Optics Express* **28** 17409 https://doi.org/10.1364/OE.394642

[14] D R White and P M C Rourke 2020 **Standard platinum resistance thermometer interpolations in a revised temperature scale** *Metrologia* **57** 035003 https://doi.org/10.1088/1681-7575/ab6b3c

[15] S Dedyulin *et al.* 2020 **Packaging and precision testing of fiber Bragg grating and silicon ring resonator based thermometers: current status and challenges** *Measurement Science and Technology* **31** 074002 https://doi.org/10.1088/1361-6501/ab7611

[16] P M C Rourke 2020 **Thermodynamic temperature of the triple point of xenon measured by refractive index gas thermometry** *Metrologia* **57** 024001 https://doi.org/10.1088/1681-7575/ab57f2

[17] S Dedyulin *et al.* 2019 **Silicon photonic chips using remote interrogation for secondary and working standards in thermometry** *2019 Photonics North* Article number 8819562 https://doi.org/10.1109/PN.2019.8819562

[18] P M C Rourke *et al.* 2019 **Refractive-index gas thermometry** *Metrologia* **56** 032001 https://doi.org/10.1088/1681-7575/ab0dbe

[19] P P M Steur, P M C Rourke and D Giraudi 2019 **Comparison of xenon triple point realizations** *Metrologia* **56** 015008 https://doi.org/10.1088/1681-7575/aaee3a

[20] D H Lowe, A D W Todd *et al.* 2017 **The equilibrium liquidus temperatures of rhenium–carbon, platinum–carbon and cobalt–carbon eutectic alloys** *Metrologia* **54** 390 https://doi.org/10.1088/1681-7575/aa6eeb

[21] P M C Rourke 2017 **NRC microwave refractive index gas thermometry implementation between 24.5 K and 84 K** *International Journal of Thermophysics* **38** 107 https://doi.org/10.1007/s10765-017-2239-1

[22] M Gotoh and S N Dedyulin 2017 **Nickel–silver monotectic in alumina crucible for use with contact thermometry** *International Journal of Thermophysics* **38** 82 https://doi.org/10.1007/s10765-017-2211-0

[23] S N Dedyulin 2017 **Sulfur hexafluoride: a novel fixed point for contact thermometry** *International Journal of Thermophysics* **38** 79 https://doi.org/10.1007/s10765-017-2216-8

[24] S N Dedyulin, M Gotoh and A D W Todd 2017 **Au fixed point development at NRC** *International Journal of Thermophysics* **38** 55 https://doi.org/10.1007/s10765-017-2186-x