CCT member and observer Activity Report

Period: January to December 2021

Institute: Centro Español de Metrología (CEM)

State economy: Spain

Number of persons involved in thermometry of the institute: 7

Short summary of research and development:

Fundamental thermometry and improve dissemination of the kelvin:

- Development of a micro-scale calibration system for photonic devices (EMPIR PhotoQuant project)
- Measurement of the thermodynamic temperature of fixed points for radiation thermometry (EMPIR Real-K proyect)
- Fabrication and characterization of high temperature fixed points for radiation: Cu, Fe-C and Pd-C (EMPIR Real-K project)

Enviroment:

- Development of a protocol for international comparison of Thermometer Screens/Shields and thermometers in Arctic (EMPIR Coat project)
- Study of the sources of uncertainty linked to air temperature measurements (EURAMET ATM project)
- Measurements of non-catching precipitation gauges (EMPIR Incipit project)

Industry:

- Development of traceable fibre-optic thermometry

Short summary of recent comparison activity:

CCT-K10
SIM.T-K9.1
EURAMET.T-K9
CCT-K7.2021
CCT-K9-2

Short summary of other activities:

Legal metrology and standardization of cold chain instruments.

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

1. "Improving body temperature measurement on a global basis" Graham Machin, Xiaofeng Lu, Dolores del Campo, Maria-Jose Martin, Igor Pusnik, Wang Li, *Thermology international* 2021, 31(1) 5-10

2. "Pt-40%Rh versus Pt-6%Rh thermocouples: an emf-temperature reference function for the temperature range 0 °C to 1769 °C" F. Edler, J. Bojkowski, C. Garcia-Izquierdo, M. J. Martin, D. Tucker, N. Ariifovic, S. Radek, V. Zuzek. *International Journal of Thermophysics*. 42, 150, 2021.

3. "Infrared Temperature Measurement Sensors of Overhead Power Conductors" P Castro; R Lecuna; M Mañana; M J Martin; D del Campo. MDPI *Sensors.* 20 (24), 7126, 2020.

4. "Methodologies and uncertainty estimates for $T - T_{90}$ measurements over the temperature range from 430 K to 1358 K under the auspices of the EMPIR InK2 project" H C McEvoy; D Lowe; R Underwood; M de Podesta; G Machin; M J Martin; J M Mantilla; J Campos; M Sadli; F Bourson; S Briaudeau; S G R Salim; K Anhalt; M Waehmer; D Taubert; X J Feng; J T Zhang; X F Lu; H Yoon. *Meas. Sci. Technol*.32 (3), 035001, 2020.

5. "A novel technique based in a cylindrical microwave resonator for high pressure phase equilibrium determination". Rodrigo Susial, Ángel Gómez-Hernández, Daniel Lozano-Martín, Dolores del Campo, M. Carmen Martín, José J. Segovia, *J. Chem. Thermodynamics* 135 (2019) 124–132.

6. "Report on the comparison of the calibration of noble metal thermocouples from 419 °C up to 1100 °C (EURAMET.T-S5)". Dolores del Campo, Carmen García Izquierdo, Olgica Petrusova and Juan Carlos Soto https://doi.org/10.1088/0026-1394/56/1A/03002.

7. "Evaluation of the self-heating effect in a group of thermometers used in meteorological and climate applications". Carmen García Izquierdo, Sonia Hernández, Alicia González, Laura Matias, Lenka Šindelářová, Radek Strnad, Dolores del Campo, https://doi.org/10.1002/met.1746.

8. "Traceable sea water temperature measurements performed by optical fibers". C.García Izquierdo, A.Garcia-Benadí, P.Corredera, S.Hernandez, A.Gonzalez Calvo, J.del Río Fernandez, M.Nogueres-Cervera, C.Pulido de Torres, D.del Campo. *Measurement* 127, October 2018, 124-133

9. "A systematic investigation of the thermoelectric stability of Pt–Rh thermocouples between 1300 °C and 1500 °C". J V Pearce, F Edler, C J Elliott, A Greenen, P M Harris, C Garcia Izquierdo, Y-G Kim, M J Martin, I M Smith, D Tucker. *Metrologia* 55 (2018) 558–567

10. “Evaluation of the self-heating effect in a group of thermometers used in meteorological and climate applications”. Carmen García Izquierdo, Sonia Hernández, Alicia González, Laura Matias, Lenka Šindelářová, Radek Strnad, Dolores del Campo. *Meteorological Aplications* https://doi.org/10.1002/met.1746

11. “The Bolzmann Project”. J Fischer, B Fellmuth, C Gaiser, T Zandt, L Pitre, F Sparasci, M D Plimmer, M de Podesta, R Underwood, G Sutton, G Machin, R M Gavioso, D Madonna Ripa, P P M Steur, J Qu, X J Feng, J Zhang, M R Moldover, S P Benz, D R White, L Gianfrani, A Castrillo, L Moretti, B Darquié, E Moufarej, C Daussy, S Briaudeau, O Kozlova, L Risegari, J J Segovia, M C Martín, and D del Campo *Metrologia* 55 (2018) R1–R20

12. “Updated determination of the molar gas constant R by acoustic measurements in argon at UVa-CEM”. J J Segovia, D Lozano-Martín, M C Martín, C R Chamorro, M A Villamañán, E Pérez, C García Izquierdo and D del Campo; *Metrologia* 00 (2017) 1–11

13. “Characterization of a biomethane-like synthetic gas mixture through accurate density measurements from (240 to 350) K and pressures up to 14 MPa”. R. Hernández-Gómez, T. Fernández-Vicente , D. del Campo, M. Valková , M. Chytil , C.R. Chamorro; *Fuel* 206 (2017) 420–428.

14. “Performance of Different Light Sources for the Absolute Calibration of Radiation Thermometers. M. J. Martín, J. M. Mantilla, D. del Campo, M. L. Hernanz, A. Pons, J. Campos. *Int J Thermophys* (2017) 38:138.

15. “The MeteoMet2 Project – Highlights and Results", *Measurement Science and Technology*. Merlone, Andrea, García Izquierdo, Carmen; et al, (2017), https://doi.org/10.1088/1361-6501/aa99fc.

16. “The equilibrium liquidus temperatures of rhenium-carbon, platinum-carbon and cobalt-carbon eutectic alloys” D Lowe; Andrew Todd; R Van der Bosche; P Bloemberger; K Anhalt; M Ballico; F Boursson; S Briaudeau; Joaquin Campos; M G Cox; Dolores del Campo; M Dury; V Gabrilov; I Grioryieva; Maria Luisa Hernanz; F Jahan; B Khelevnoy; V Khromchemko; X Lu; Graham Machin; Jose Manuel Mantilla; Maria Jose Martin; Helen McEvoy; B Rougie; Mohamed Sadli; S Salim; N Sasajima; D Taubert; E Van der Ham; T Wang; D Wei; A Whittam; B Whiltham; D Woods; J Woodward; E Woolliams; Y Yamada; Y Yamaguchi; H Yoon; Z Yuan. *Metrologia*. 54, 390, 2017.