European Partnership on Metrology
Call 2022 – Digital Transformation, Health, Integrated European Metrology, Normative and Research Potential

Selected Research Topic number: **SRT-r02**
Version: 1.0

Title: Improving the realisation of the kelvin by multiple fixed-point radiation thermometry

Abstract

Highly accurate and traceable high temperature measurements are critical to a number of European industries, including metallurgical industries, glass and fertiliser production. Currently, there are regional gaps in the dissemination of the temperature scale with primary techniques at high temperatures. The *mise-en-pratique* of the new definition of the kelvin (MeP-K) offers new possibilities to realise and disseminate thermodynamic temperature using multiple high-temperature fixed points to calibrate a radiation thermometer, which is then used as an interpolating instrument. This project aims to assist emerging NMIs in radiation thermometry by providing the necessary know-how for fabrication and utilisation of high-temperature fixed points and applying the multiple fixed point scheme for the realisation of the new kelvin and linking it to the international temperature scale.

Keywords

Radiation thermometry, Mise-en-Pratique of the kelvin, high-temperature fixed points, ITS-90 fixed points

Background to the Metrological Challenges

Accurate and traceable high temperature measurements contribute to energy efficiency by enabling better control and optimisation of production processes. However, at present, few European NMIs have capabilities to disseminate the temperature scale with primary techniques at high temperatures. The new MeP-K offers the possibility for NMIs to disseminate thermodynamic temperature and to realise the international temperature scale (ITS-90) via interpolation with high-temperature fixed points with assigned thermodynamic temperatures. In its conventional realisation, the ITS-90 extrapolates Planck's law using either one fixed point of Ag, Au or Cu as the base point from which all higher temperatures are defined. The new MeP-K, however, introduces a relative primary radiation thermometry scheme where at least three fixed points, spanning the entire temperature range of interest, are used to calibrate a radiation thermometer. Using an appropriate interpolation equation, e.g., the well-known Sakuma-Hattori equation, the radiation thermometer is used as an interpolating instrument.

A new realisation of the temperature scale based on multiple fixed points will improve the services that these NMIs can offer and will connect with the recommended dissemination methods in the new MeP-K. It will also address gaps in the provision of highly accurate and traceable temperature measurements in Europe. In addition, there is a need for an intercomparison of different implementations at the participating institutes, linked to CCT-K10, in order to develop improved calibration and measurement capabilities and to determine the robustness and reliability of the relative primary thermometry scheme. Furthermore, emerging NMIs will benefit from new capabilities to fabricate high-temperature fixed points and improved knowledge on radiation thermometry from previous joint research projects funded by EMRP and EMPIR.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the development of metrological capacity through the improvement of the realisation of the Kelvin by multiple fixed point radiation thermometry.

The specific objectives are

1. To transfer knowledge to emerging NMIs on the theoretical and experimental aspects of using ITS-90 and high-temperature fixed points for radiation thermometry. The focus should be on the realisation of the ITS-90 scale by extrapolation from a single fixed-point including the determination of the base parameters (linearity, spectral responsivity, size-of-source). This incorporates progress accomplished in EMRP project SIB01 InK and EMPIR projects 15SIB05 InK 2 and 18SIB02 Real-K.
2. To construct a set of high-temperature and medium-temperature fixed-points for radiation thermometry adapted to the technical means of emerging NMIs. This includes assessment of the quality of the cells and experimental determination of the optimal thermal conditions for their implementation.
3. To realise the MeP-K through the application of the multi fixed point scheme using a variety of radiation thermometers and temperature ranges in accordance with the needs of emerging NMIs, and to compare at least one realisation to the ITS-90. A target uncertainty of 1 K at 2300 K to be achieved through establishment of traceability to thermodynamic temperatures via high or medium fixed points with assigned values.
4. To perform an interlaboratory comparison linked to key comparison CCT-K10 to underpin improved calibration and measurement capabilities (CMCs) for participant laboratories in the field of radiation thermometry, both in terms of thermodynamic temperature and temperature in the ITS-90.
5. To facilitate the take up and long term operation of the capabilities, technology and measurement infrastructure developed in the project by the measurement supply chain (NMIs/DIs, calibration and testing laboratories), standards developing organisations (e.g. CIPM CCT, EURAMET TC-T), and end users (e.g. metallurgical and glass industries). The approach should be discussed within the consortium and with other EURAMET NMIs/DIs, EURAMET TCs or EMNs, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed for Europe as a whole.

Joint Research Proposals submitted against this SRT should identify

- the particular metrology needs of stakeholders in the region,
- the research capabilities that should be developed (as clear technical objectives),
- the area for which the capabilities will be built (Green Deal, Digital Transformation, Health, Integrated European Metrology, Industry, Normative or Fundamental Metrology) and in which future main call the developed research capabilities are planned to be employed,
- the impact the developed research capabilities will have on the industrial competitiveness and societal needs of the region,
- how the research capability will be sustained and further developed after the project ends.

The development of the research potential should be to a level that would enable participation in other TPs.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.5 M€ and has defined an upper limit of 0.9 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 20 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the ‘end user’ community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the ‘end user’ community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,

- Provide a lasting improvement in the European metrological capability and infrastructure beyond the lifetime of the project,
- Facilitate improved industrial capability or improved quality of life for European citizens in terms of personal health or protection of the environment,
- Transfer knowledge to the industrial (e.g., metallurgy, glass, fertilisers) sector and the metrology community.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of the Partnership to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.