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Development of new traceable European capabilities in thermal metrology

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Résumé. Cet article traite d'un nouveau projet européen dont l'objectif global est d'améliorer la disponibilité d'installations dans le domaine de la métrologie thermique (par exemple : pour les hautes températures en thermométrie par contact, en pyrométrie et pour la caractérisation des propriétés thermo-physiques des matériaux), dans les Instituts Nationaux ou Laboratoires associés de Métrologie européens émergents (INM, LA), où l'accès à ces types d'installations est actuellement limité.

1 Introduction

A number of thermal related areas have been identified where metrology capacity building would be beneficial. Development in these areas is driven by the grand challenges such as energy environment and health, and also by specific traceability requirements to support industrial production.

Thermal metrology appears as a key factor for improving the efficiency and environmental impact of industrial processes and also for other needs or applications including population health.

This paper deals with the description of a plan for improving the measurement capabilities of metrological infrastructures in European NMIs/DIs, mainly in Ireland and from Central and South-East of Europe in that field, with the

scientific and technical support of more experienced NMIs.

The primary needs identified up to now with the assistance of potential industrial or public stakeholders are:

- developing measurement capabilities to a satisfactory level of quality and beneficial to industries working in the temperature range from 300 °C to 2000 °C (e.g. metallurgy industry)

- establishing traceability in the field of thermo-physical properties measurements (e.g. insulating materials for buildings) to an acceptable international level, beneficial to European and International trade.

2 Consortium overview

The consortium brings together leading European NMIs/DIs and emerging NMIs/DIs in a complementary metrology structure.

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A research institute working usually closely with this consortium and companies that bring support with their specific knowledge and experience participate also in this project.

In total, 10 NMIs/DIs (LNE-France, CMI-Czech Republic, CNAM-France, HMI/FSB -Croatia, IMBiH-Bosnia & Herzegovina, MKEH-Hungary, MoE-DMDM-Republic of Serbia, NSAI-Ireland, TÜBITAK-UME-Turkey, UL-LMK-Slovenia), one Research Institute (VINCA-Republic of Serbia) and 11 companies or public authorities (AURAS 2000, ATC, BATA, GRAMPEX, KJKP, KNAUFINSULATION, LTM, NETINVEST, SPECIALBAU, STSI, TA) are included within this project.

3 Technical topics

The project is performed within the framework of EURAMET/EMPIR (European Metrology Programme for Innovation and Research) and is divided into five work packages including, three technical and scientific work packages, and two work packages for the impact and management [1].

Table 1 summarizes the content of the different work packages.

WPi	Work Package Title
WP1	Improving measurement capabilities for high temperature contact thermometry
WP2	Improving and developing references for radiation thermometry
WP3	Improving traceability and capabilities for the measurement of thermal properties of materials
WP4	Creating Impact
WP5	Management and Coordination

Table 1: Work Packages Summary

3 Objectives overview

The project addresses the following scientific and technical objectives:

3.1. Contact Thermometry

The general objective is to improve the accuracy of high temperature measurements by contact thermometry in the range 960 °C to 1084 °C in participating NMIs with limited metrology research capacity [2] through the following activities:

- Knowledge transfer in high temperature contact thermometry via establishment of calibration procedures and uncertainty evaluation methods.
- Construction of artefacts (Ag fixed point cells) for use as standards with the objective of disseminating the temperature unit.

3.2 Radiation Thermometry

For this part of the project, mainly based on the significant experience of CNAM [3-4], the main objective is to develop references for radiation thermometry in participating NMIs seeking to establish a research capability in this field through the following activities:

- Knowledge transfer in radiation thermometry for the realisation of the ITS-90, by organising training workshops and by establishing a guide to best practice.
- Inter-laboratory comparison of radiation thermometer calibrations in order to improve calibration techniques and to assess the uncertainties of measurements.
- Provision of assistance to capacity building in radiation thermometry in the framework of technical visits of experts from the consortium.

3.3 Thermal Conductivity

The general objective of the technical work is to consolidate the traceability and capabilities [5-7] for the measurement of thermal conductivity by Guarded Hot Plate (GHP) in emerging European NMIs through the activities below:

- Transfer of knowledge from experienced laboratories to the NMIs of the Central and Western Balkan countries, through training courses, tutorials and workshops.
- Implementation of thermal conductivity measurements by the GHP method in emerging NMIs by participating in an inter-laboratory comparison whose main objective is to assess the coherency of measurements among the laboratories involved.

3.4. Scientific and Industrial Impacts

This task will allow a contribution to creating impact via dissemination of research outputs to end-users through conferences, papers, guidelines, etc.

4 Research Highlights

Based on a significant experience in the area of contact and radiation thermometry, especially for the realization of the ITS-90 scale and also in the metrology of thermal properties of materials for the realization of derived thermal quantity scales, the consortium is starting this cooperative scientific work according to a tight timeline. The following examples enable to highlight some research that will be done during the three year duration of the project.

4.1 Contact Thermometry

TÜBITAK as work package leader will assist selected partners (IMBiH, HMI/FSB) in the design of a batch of silver fixed point cells. In parallel, FSB-HMI will prepare a guideline for the construction of the cell including 3D models and drawings. After the construction of the batch, the Ag fixed point cells will be tested in adapted furnaces. Finally the objective will be to draw up the uncertainty budget. Uncertainties of less than 8 mK is expected.

4.2 Radiation Thermometry

CNAM, as work package leader will perform a technical audit of the capabilities and facilities developed by the partners seeking improved capabilities (namely NSAI, HMI/FSB, MoE-DMDM) in radiation thermometry over the whole temperature range (300 °C – 2000 °C).

Specific practical training will then be organised through the visit of experts from the most advanced NMIs/DIs to the laboratories in the process of developing new capabilities and methods. For instance:

- CNAM will assist HMI/FSB in developing new facilities for the calibration of radiation thermometers and the implementation of fixed-point blackbodies. Similar developments will be performed in parallel with other partners.

The objective should be in a second stage to develop capabilities, for instance to cover the temperature range 50 °C to 800 °C, with relative uncertainties less or equal to 8 % (k=2).

4.3 Thermal Conductivity

The research objective is to transfer scientific and technical knowledge from the NMIs (LNE, CMI) which have acquired relevant experience in the field of thermal conductivity measurements, to the laboratories which are developing their own metrological infrastructure (MKEH, VINCA).

The implementation of thermal conductivity measurements by the GHP method is performed by each partner in the framework of an inter-laboratory comparison.

In particular, the objective is to assess the variability and coherency of thermal conductivity measurements performed by MKEH and VINCA. Initially, suitable materials will be identified, taking into account the particular capabilities and limitations of the GHP facilities involved. Subsequently, specimens of selected materials will be machined and will circulate between all the partners during the inter-laboratory comparison piloted by LNE, the work package leader.

Again, the objective will be to draw up an uncertainty budget. For instance, the expanded relative uncertainties of less than 5% over the range 50 °C – 800 °C are expected.

4.4. Scientific and Industrial Impacts

Beyond the scientific and technical objectives described in the previous chapters, the general impact of this project is to assure an efficient knowledge transfer between the project partners and the stakeholder community which includes calibration service providers, testing laboratories, thermal equipment manufacturers and for example the metal industry and insulating materials manufacturers.

5 Conclusions - Perspectives

Thermal metrology is a key factor for improving the efficiency and environmental impact of industrial processes and also for other needs or applications including the health of populations.

In the field of thermal measurements, Europe has several National Metrology Institutes of Excellence. However to accelerate and amplify the economic growth of countries located mainly in the central and south east of Europe, this Research project aims to:

• review the existing capabilities and needs, and based on this information,

• strengthen or upgrade the consortium's metrology systems with new or better metrology capacities.

These targets will be achieved within the framework of the 3 year project managed under the umbrella of EURAMET/EMPIR, the new European Metrology Programme for Innovation and Research.

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