

Metrology for Thermal Protection Material – Project Overview

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6th November 2014

EURAMET EMRP

- EMRP supports the collaboration of European metrology institutes, industrial organisations and academia through Joint Research Projects (JRPs). It is structured around European Grand Challenges in such areas as Health, Energy, the Environment & New Technologies.
- The follow on programme is EMPIR. The last call for proposals has just closed. See www.euramet.org for more details.



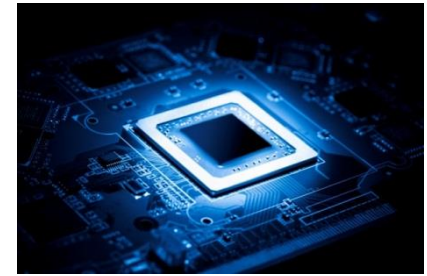
SI Units (2011 & 2012)



Environment (2010 & 2013)



Energy (2009 & 2013)



New Technologies (2011)



Health (2011)



Industry (2010 & 2012)

Presentation Outline

- The need
- Overview
- Objectives
- Work Packages
- Progress/Achievements

The need

- No reliable metrology framework available to validate the use of advanced thermal protection materials in safety critical engineering.
- Advanced manufacturing industries cannot reliably select or develop materials for applications at high temperatures - Significant level of scatter in industrial measurements, sometimes over 100%.
- Costly over-engineering or the potential for higher risk of industrial disasters/incidents.
- Requirement from the mandatory EU regulations (EU No. 305/2011) - Thermal performance measurements need to be three times better than the current level of agreement between reference laboratories.
- The cost of not being able to implement these regulations is huge and will have a significant impact on the high temperature insulation market (2.2 billion euro annually) and also on all the industrial users of these products (e.g., aerospace, power plants).

Overview

- EMRP JRP: **Metrology for Thermal Protection Materials (SIB52)**
- Project schedule: 1 June 2013 to 31 May 2016
- Funded partners:



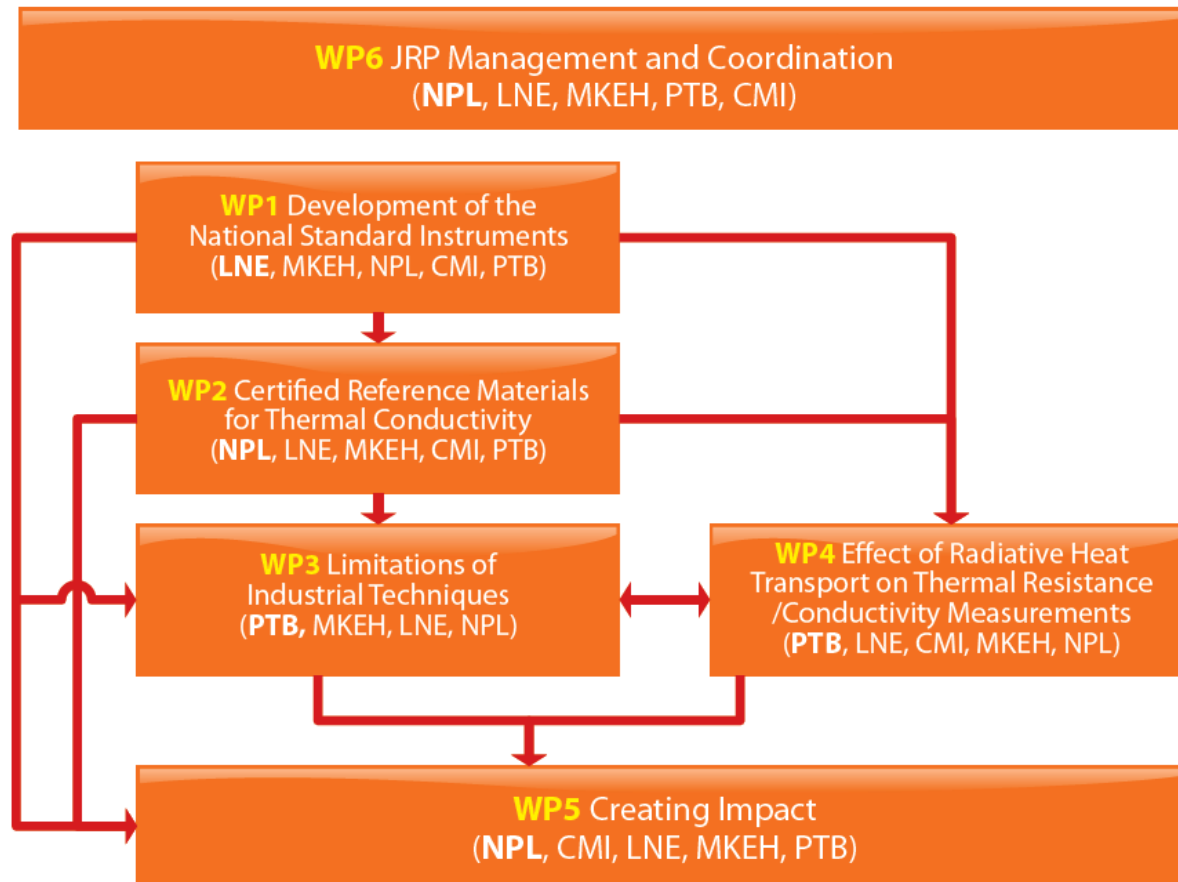
- Collaborators include:



Objectives

- Establish a complete traceability chain for characterising thermal performance of advanced thermal protection materials.
- Achieve three times better European equivalence in thermal conductivity measurements up to 800°C.
- Evaluate the viability for improving industrial measurement techniques up to 800°C.

Work Packages



Project Website: <http://projects.npl.co.uk/thermo/>

Highlights in WP1

- LNE has designed the new hot plate and the new cold plates for updating its in-house built HTGHP.
- LNE is in the process of developing in-situ calibration of temperature sensors of its commercial HTGHP.
- MKEH has developed a new technique for measuring high temperature thermal conductivities.
- CMI is in the process of designing a HTGHP and has developed a design of an isothermal terminal block for cold junctions of thermocouples.
- NPL has designed and built a Small Guarded Hot Plate for measuring thermal conductivities of thin polymers and composites.
- NPL has instrumented a new set of heater plates to replace the existing heater plates in NPL HTGHP.
- Has identified new advanced materials and high-temperature high emissivity coatings for hot and cold plates of HTGHPs.
- PTB has carried out review of industrial HTGHPs.

Highlights in WP2

- A new method has been developed in the project, which combines both thermal metrology and material science in the assessment of candidate high temperature thermal conductivity reference materials. It enables science to go beyond what could be achieved separately.
- The initial tests stage is close to the end. We have tested aspects of material composition, microstructure, mechanical stability, chemical stability, uniformity, machining and heat treatment. The initial tests fulfilled the designed purpose of finding out potential technical, collaborative and logistic problems to ensure quality of the next stage full characterisation of reference materials.
- Two candidate reference materials have been selected for full characterisation in next stage. The procurements of the two selected candidate reference material stocks have been started.
- NPL presented a paper titled 'Provisional Assessment of Candidate High Temperature Thermal Conductivity Reference Materials in The EMRP 'Thermo' Project' at the 32nd International Thermal Conductivity Conference that was held at Purdue University, Indiana, USA. The paper is in the process of publication.

Highlights in WP3

- PTB have carried a critical review of industrial techniques for thermal conductivity measurements of thermal protection materials.
- A manuscript on the review has been submitted to a peer-reviewed journal for publication.

Highlights in WP4

- PTB has identified a theoretical model describing relatively simple analytical expressions of the complex behaviour of the combined conductive and radiative heat transfer through a highly porous semi-transparent material. Furthermore, an experimental test plan was designed.
- LNE has performed normal hemispherical spectral transmittance and quasi-normal hemispherical reflectance measurements on five thin high-temperature insulation samples at room temperature. The study has shown that it is possible to obtain experimentally radiative properties data on high temperature insulation materials.
- MKEH has developed a theoretical model to present the radiative heat transfer between the metering zone heater and the guard zone heater of its in-house built High Temperature Thermal Conductivity Measurement Apparatus (HTTCMA), based on experimental results.
- CMI has developed an algorithm/a numerical model concerning the contact of planar and imperfect horizontal plates for the investigation of the appropriate tolerance of the surface flatness of the heater plates.
- NPL has provided thermal conductivity measurement data and boundary condition data, using warped heated-cold plate, for validating CMI's numerical model.

Highlights in WP5

- Presentations:
Delivered 7 presentations at:
BIPM CCT WG9 meeting
TEMPMEKO 2013
32nd ITCC
Euramet-TCT meeting
Thermophysik 2014
ECTP
- Trainings and Workshops
Provided 4 training and held 3 workshops for JRP consortium members
Co-hosted an external workshop at ITCC32/ITEC20, Purdue University, IN, USA
- Will held a training Workshops at the end of the project
- Will publish 3 Good Practice Guides
- Feedback to the Technical Specification (PrEN/TS 15548-1)

Highlights in WP5

Peer-reviewed paper

- J. Wu, R. Morrell, T. Fry, S. Gnaniah, D. Gohil, A. Dawson, etc. Provisional Assessment of Candidate High Temperature Thermal Conductivity Reference Materials in the EMRP 'Thermo' Project, 32nd ITCC and 20th ITES, on 27 April to 1 May 2014, IN, USA (in the process of publication)
- C. Stacey, M. J. Parfitt, A. J. Simpkin, J. Wu, Design of a Guarded Hot-Plate for Measuring Thin Specimens of Polymer and Composite Materials, 32nd ITCC and 20th ITES, on 27 April to 1 May 2014, IN, USA (in the process of publication)
- U. Hammerschmidt, J. Hameury, R. Strnad, E. Turzó-Andras, J. Wu, Critical Review of Industrial Techniques for Thermal Conductivity Measurements of Thermal Protection Materials (in revision and will re-submit)

Highlights in WP6

- Contract:
Negotiate and amendment of contract documents
- Meetings:
Kick-off meeting, 6MM, 12MM and 18MM Project Meetings, Stakeholder Meeting, Teleconference Calls, Monthly Meetings with the JRP co-ordinator
Action lists
- Reporting:
6MM and 12 MM Reports sent to EMRP MSU on time
- Monitoring project delivery:
List of deliverables: tracking and recording project costs, schedules and deliverables
- Integrated risk and change control:
Share Point website;
Risk registry and active risk control
Provide direction for issue resolution
- Procurement risk management:
Co-ordinate the procurement of candidate materials, heat treatment and machining of candidate materials, according to the EMRP rules.

Q/A

6th Nov. 2014
NPL, U.K.

EMRP SIB52 Thermo
1st Stakeholder Meeting