

# Metrology for thermal protection materials

## Challenges - Step changes in metrology



**Recent developments in thermal protection systems have the potential to provide performance that is several-fold better than conventional insulation materials, but there is currently no reliable metrology framework with which to validate their use in safety critical engineering.**

- Mandatory EU regulations (EU NO. 305/2011) require thermal performance measurements that are three times better than the current level of agreement between national reference laboratories.
- Advanced manufacturing industries cannot reliably select or develop materials for applications at high temperatures, as existing industrial measurement techniques have shown a significant level of scatter, sometimes over 100 %. This leads to costly over-engineering or the potential for higher risk of industrial disasters/incidents.
- Large gaps in the underpinning scientific knowledge within European measurement standards are preventing reference laboratories from meeting ever more stringent requirements from industry. These metrological and material issues relate to complex heat transfer through porous materials; experimental validation of theoretical and numerical radiative heat transfer models; temperature sensor degradations; quantifying surface thermal contact; new advanced material and high emissivity coatings.



**Rolls-Royce**

*"In all of these applications it is critical to the design process and the reliable operation of the engine that we have high quality metrology of the thermal properties of the materials systems used. We are increasingly interested in novel emerging materials for these applications such as aerogels currently becoming available. In these cases the development and adoption of new material classes, with consequent benefits to engine systems, will only be possible through the development of suitable metrology techniques and the generation of high quality data suitable for use in design studies."*

**eurima**  
European Insulation Manufacturers Association

*"New mandatory requirements for traceability to national standards and to EU regulations for high temperature insulation products were published. These requirements will not be able to be fully met without a significant improvement in the current level of metrology within Europe and without the availability of traceable reference materials."*

## Approach - Chain of traceability to SI units

**Establish a complete traceability chain for characterising thermal performance of advanced thermal protection materials.**

**Achieve three times better European equivalence and evaluate the viability for improving industrial measurement techniques up to 800 °C.**

**Consortium:** This project combines the distinct expertise from leading national research programmes to find integrated solutions to thermal metrology and traceability challenges.

**WP1:** Development of techniques for a next generation National Standard Instruments with step-change in performance, including thin temperature sensors for surface temperature measurements, high emissivity coatings, thermal contact resistance issues and thermal guarding systems (SRT-s21 objective No. 2 and 3)

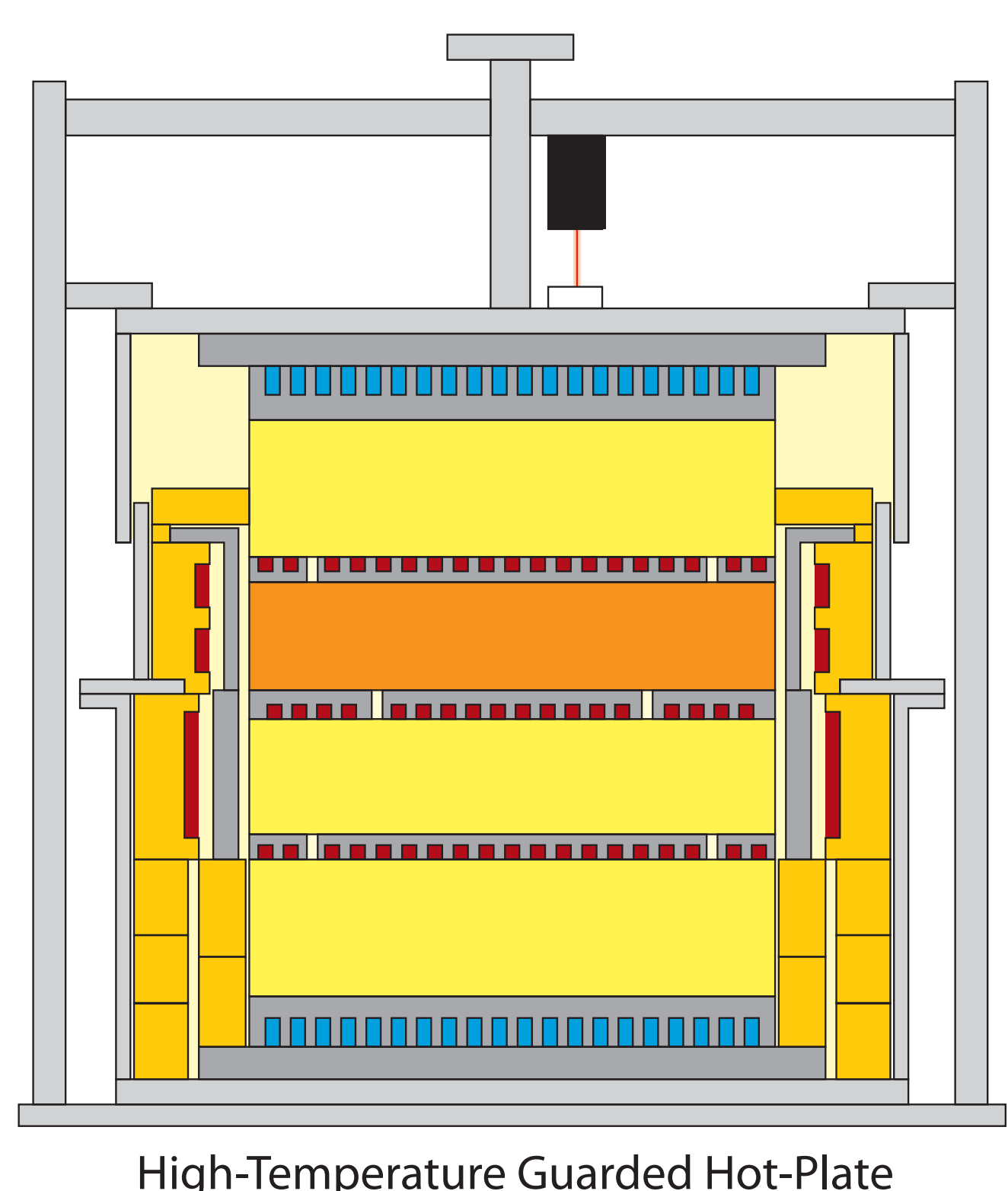
**WP2:** First reference materials with thermal conductivity in the range  $0.02 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$  to  $1 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$  and covering temperatures up to  $800 \text{ }^\circ\text{C}$ , which will be an essential tool for investigating the causes of disagreement (SRT-s21 objective No. 5)

**WP3:** The first time that world-leading experts in different thermophysical measurement techniques will work together to develop impartial recommendations on the limitations and viability of using transient and other industrial techniques (SRT-s21 objective No. 4)

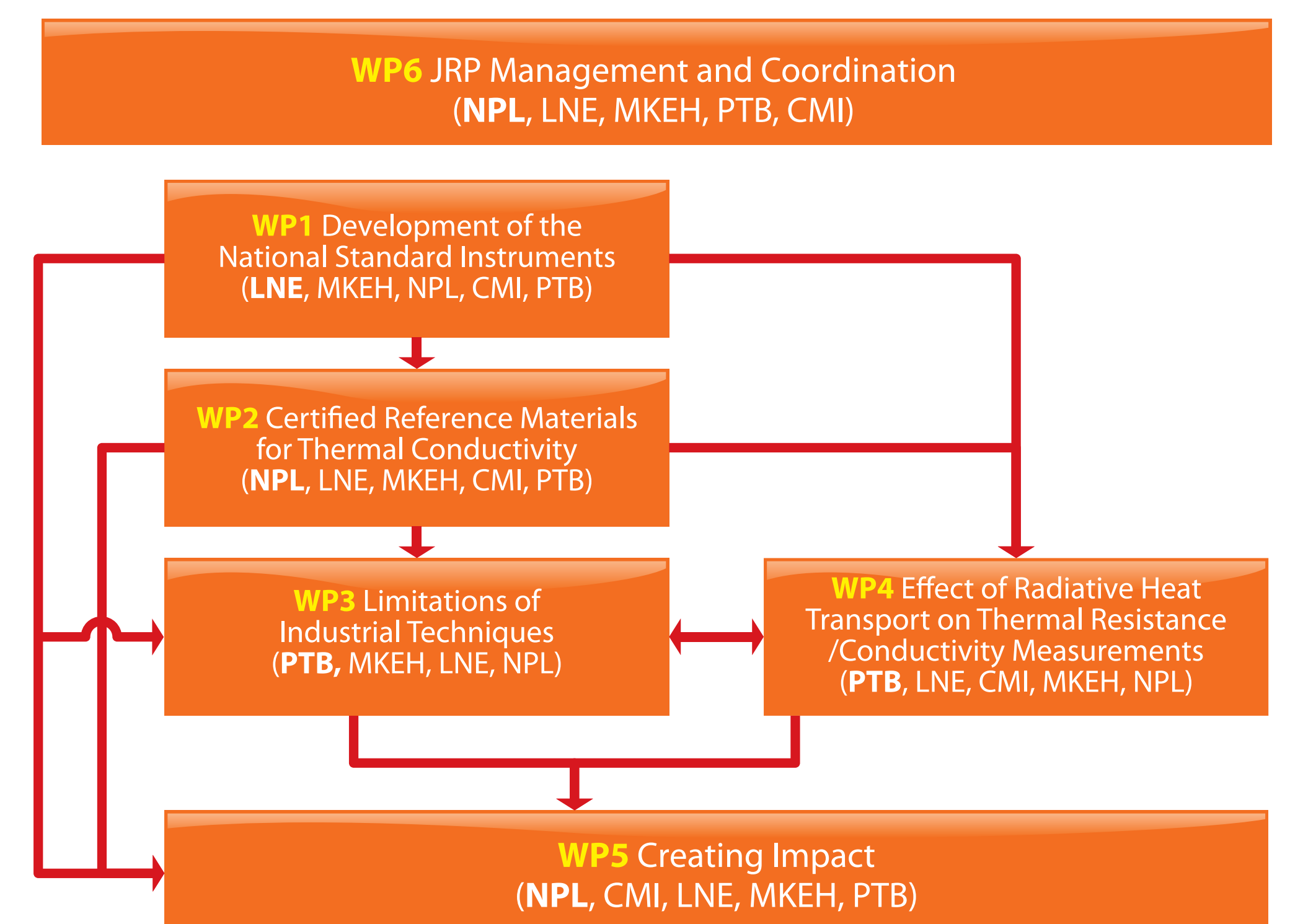
**WP4:** Investigation of radiative heat transport effects on thermal conductivity measurements using a combination of theoretical, numerical and experimental approaches, including determination of appropriate levels of tolerance for thermal conductivity measurement apparatus (SRT-s21 objective No. 1)

### WP5: Creating Impact

- The output of this JRP will be provided to CEN TC 89 for finalising a new European measurement standard EN/TS 15548-1 and also support the work of BIPM CCT WG9 (key-comparison), Euramet TC-TP, CEN TC 127 and ISO TC92.
- JRP website, 2 workshops at key conferences, 10 peer-reviewed papers, and 5 Good Practice Guides.
- Dissemination will be driven by the Stakeholder Committee (also project collaborators).



High-Temperature Guarded Hot-Plate



**NIST**  
National Institute of Standards and Technology  
U.S. Department of Commerce

**Rolls-Royce**

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**FIW**  
Forschungsinstitut für Wärmeschutz e.V. München

**CPA**

**eurima**  
European Insulation Manufacturers Association

**ROCKWOOL**

**ISOVER**

**PAROC**

## Impact - Mandatory EU regulations

### Direct impact

- The output of the project will immediately provide the metrology that is urgently needed to implement new European regulations (EU NO. 305/2011) in the form of mandatory EN product standards (EN 14303 to EN 14309, EN 14313 and EN 14314).
- Allow European manufacturers to meet the mandatory CE marking requirements and market their high-temperature insulation products. The global high-temperature insulation product market was € 2.2B in 2011 and Europe is the largest consumer of products with 39 % market share.
- Help instrument manufacturers to develop and market commercial equipment that is needed to meet growing industrial demand for measurements.
- Increase the capability and the capacity of thermal conductivity metrology within Europe. The funded partners will become the core of a European measurement infrastructure providing traceability for thermal conductivity.



**NPL**  
National Physical Laboratory

**MKEH**

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Sharing a passion for progress

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### Financial impact

Due to the broad range of applications and industries, the full extent of the financial impact is huge and impossible to estimate reliably, but the following examples highlight the stakes:

- High-performance thin light-weight thermal protection composites are an essential technology for reducing aircraft weight and emissions. Fines for aircraft operators not meeting the EU Emission Trading Scheme will be between €4.5 M to € 19 M per aircraft.
- Netherlands Centre for Technical Insulation suggests that European refineries could be €3.5 billion/year more competitive if the current levels of insulation were rectified.

### Social impact

- Enable the designers of fire engineering (Structural Eurocodes EN 1990 to EN 1999) and transportation safety systems to select the best performance thermal protection materials, thereby reducing the rate of industrial disasters/incidents and saving lives.
- Enable the uptake of innovative thermal protection systems, which in turn support implementation of many Key Enabling Technologies.



**Rolls-Royce**

*"In particular the performance of high temperature insulation at elevated temperatures is of critical importance to protect a range of components for the harsh on-engine environment. Such thermal protection applications range from engine instrumentation and controls, where the ability to mount engine accessories closer to the engine core delivers architecture benefits, through to oil and fuel systems and the fire protection of organic matrix composites."*

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*"New materials have the potential to provide thermal performance that is radically superior in comparison to conventional materials, thereby offering cost and weight reduction opportunities to the products from which they are manufactured"*