EMPIR Call 2017 – Industry, Fundamental, Normative and Research Potential

Selected Research Topic number: **SRT-n07**
Version: 1.0

Title: Thermal conductivity measurement of Super Insulating Materials and measurement uncertainty reduction

Abstract

Europe's policy to reduce CO_2 emissions in the building sector depends on efficient insulating materials with reliable thermal performance values. The thermal performance of a material depends on the efficiency of the insulating material and therefore, super insulating materials (SIMs) could be used to support this reduction in CO_2 emissions. SIMs such as vacuum insulation-panels and advanced porous materials are predominantly used in the household appliances and transport boxes. However, whilst measurement methods and standardised procedures currently exist for conventional insulation materials, e.g. polystyrene and mineral wool boards, the same is not true for SIMs. SIMs are up to a magnitude lower in terms of their thermal conductivity than conventional insulation materials and therefore new methods need to be developed for the accurate measurement of the thermal performance and thermal conductivity of SIMs.

Keywords

Super insulating materials, thermal conductivity measurement, thermal resistance, measurement uncertainty, boundary conditions

Background to the Metrological Challenges

Over the last few years a new group of insulating materials has become available to the market. These SIM materials are mainly vacuum insulation panels and advanced porous materials, with aerogels and nano-porous powders such as fumed silica as a sub-groups of advanced porous materials. SIMs owe their reduced overall thermal transport to the suppressed thermal conductance of the gas in the materials pores, either through the size of these pores (the Knudsen-effect) or by evacuating the material. Hence they are up to a magnitude lower than conventional insulation materials in terms of their thermal conductivity, i.e. 0.002 $Wm^{-1}K^{-1}$ or less for freshly evacuated vacuum insulation panels with fibre glass cores.

The thermal conductivity for conventional insulation materials ranges from 0.020 $Wm^{-1}K^{-1}$ for freshly produced polyurethane foam to 0.070 $Wm^{-1}K^{-1}$ for wood wool or Calcium silicate boards. And the measurement of the thermal conductivity and thermal performance of such materials is covered by CEN standards EN 12667, EN 12664, EN 12939, EN 1946-2 and EN 1946-3, which describe the apparatus and procedures necessary for a measurement uncertainty of less than 2 % for these materials. However, current standards do not cover SIMs and therefore new and standardised methods need to be developed for the accurate measurement of their thermal performance and thermal conductivity.

The accuracy of methods and testing conditions for SIMs is particularly important as uncertainty in sample thermal conductivity measurements has been demonstrated to be due to thickness, temperature measurements, density variation, sample uniformity and heat flux through specimens, as well as sample handling conditions. Therefore, it is important to develop validated and traceable SIMs measuring standards for thermal conductivity including boundary conditions, thickness and temperature measurements, stop criteria for stationary heat transfer and drying procedures. In addition it is important to compare laboratory results from SIM samples in order to improve the consistency of measurement results and to reduce measurement uncertainty.

The long term performance of SIMs also needs investigating and should include the effects of ageing of SIMs due to physical or chemical deterioration. An accurate estimation of the performance of SIMs over time is particularly important in order to be able to distinguish between uncertainty (i.e. repeatability and uncertainty from methods and apparatus) and impact of ageing (deterioration) of the product.

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Finally, reduced measurement uncertainty is needed for SIMs for energy demand calculations (on the building envelop and heating, ventilation and air conditioning systems) and for declarations of performance. This is needed to support the European Construction Products Regulation (EU No. 305/2011) for insulation products used in buildings and to enable manufacturers of insulation products marketed in Europe to accurately declare the thermal conductivity/performance of their products.

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 metrology research necessary to support standardisation in thermal conductivity measurements of super insulating materials (SIMs) and a reduction in measurement uncertainty.

The specific objectives are

1. To develop accurate simulations of and calculations for the thermal performance of structures containing SIMs, in view to reduce the measurement uncertainty for thermal conductivity measurements.
2. To develop validated methods for measuring small changes in the thermal performance over time of SIMs. This should include the effects of ageing of SIMs due to physical or chemical deterioration and lead to a reduction in the measurement uncertainty for thermal conductivity measurements of SIMs.
3. To reduce the measurement uncertainty for energy demand calculations (on the building envelop and heating, ventilation and air conditioning systems) and for declarations of performance. This should include the development of improved apparatus, measurement procedures and boundary conditions for measuring the thermal performance of SIMs.
4. To develop validated and traceable super insulating material measurement standards for thermal conductivity. This should include boundary conditions, thickness measurement, temperature measurement, stop criteria for stationary heat transfer and drying procedures. To propose an inter-laboratory comparison to improve measurement results.
5. To collaborate with the technical committees CEN TC 88 WG11, CEN TC 89 and ISO TC 163 SC3, and SC1 and the users of the standards they develop to ensure that the outputs of the project are aligned with their needs, including the provision of a report on the measurement of the thermal properties of super insulating materials and recommendations for incorporation of this information into future standards at the earliest opportunity.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.6 M€, and has defined an upper limit of 0.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded 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,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to insulation manufacturers and the construction industry.

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 EMPIR 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.

Additional information

[1] CEN/CENELEC identified this topic as one of their priorities. Details are available at: https://msu.euramet.org/current_calls/pre_norm_2017/documents/SRT_related_CEN_priorities/cen_priority_016_2017.pdf