Title: Improvement of emissivity measurements on reflective insulation materials

Abstract

High performing insulation products for buildings rely on reflective insulation which in turn relies on the emissivity of the materials used. CEN/TC 89/WG 12 has requested an improvement of emissivity measurements due to high discrepancies (0.06 for emissivity <0.1) found in a comparison. Proposals addressing this SRT should carry out a metrological study to i) improve existing primary techniques within NMIs and reduce uncertainties to 0.02 for the calibration of emissivity reference samples, ii) establish procedures to improve measurements performed in industry and iii) contribute to the standards development work of technical committees e.g. CEN/TC 89/WG 12 to establish a standardised approach.

Keywords

Reflective insulation, low emissivity, total hemispherical emissivity, thermal resistance.

Background to the Metrological Challenges

The principle of reflective insulation relies on the high sensitivity to emissivity of the radiant heat power exchange between two surfaces. The knowledge of the “total hemispherical emissivity” of surfaces is a crucial parameter for modelling the heat transfer coefficient between surfaces.

Producers of reflective insulation products for buildings have to declare values of emissivity for their products [1]. In agreement with EN 16012 and ISO 6946, declared values are used to calculate the thermal resistance of the insulation system in the condition of use. CEN/TC 89/WG 12 is currently working on the standardisation of test procedures to be used on reflective insulation products to determine their declared emissivity (standard EN 16012).

A comparison of measurement techniques on some products with uniform emissivity has shown high, unexplained discrepancies (emissivity from 0.02 to 0.08 for the same product). The comparison involved integrating spheres and commercially available portable instruments. Likely explanations are the configurations of instruments and the type of reference samples (specular calibrated mirrors or diffusing high reflective calibrated samples). The comparison has brought into question the reproducibility of the measurement technique.

The technique specified in EN12898 for determining the emissivity of low emissivity glass is the measurement of specular reflectance in the spectral range 5 to 50 µm and subsequent calculation of the total hemispherical emissivity. The traceability is provided through a mirror calibrated in specular spectral reflectance. For reflective foils, this technique is not applicable because frequently the sample is not flat and the reflection is more diffuse. Integrating spheres which are most often associated with an infrared spectrometer, calorimetric techniques, directional radiometric techniques or hemispherical near-normal reflectometers can be used as the measurement technique.

Reflectometric techniques are sensitive to the specularity and temperature of the sample, however the sensitivity is not well known and depends on the instrument used. Usually, integrating sphere techniques are calibrated with reference samples far more diffuse than the materials used in reflective insulation. The uncertainties of the emissivity of diffuse reference samples are generally ~0.03 resulting in a high uncertainty on the measured emissivity. Integrating sphere techniques are also quite often limited in their covered spectral range with an upper limit between 16 to 25 µm. The influence of that limitation depends on the spectral emissivity at higher wavelengths which is not yet well known for reflective foils and should be investigated.

Two types of calorimetric techniques can be used for reflective foils. The first measures directly, under vacuum, the heat flux density exchange between the sample bonded to a calorimetric block at a known temperature and a “background” surface at a known temperature. The second uses a guarded hot plate and requires that the emissivity of the heater plates is known. High performing “under vacuum” calorimetric techniques give an uncertainty of about 0.03 for low emissivity.

A radiometric technique consisting in the measurement of the angular resolved spectral directional emissivity with a subsequent integration to provide the total hemispherical emissivity with uncertainties below 0.01 for these measurements has also been developed. However, for the case of (crumpled) foils the thermal contact to the specimen under test is critical. To determine the temperature of the foil and to avoid heating if irradiated, a good thermal contact has to be realised, which has not yet been investigated.

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 emissivity measurements of reflective insulation materials.

The specific objectives are

1. To explain the discrepancies found in recent interlaboratory comparisons by analysing and testing the different techniques and instruments used by end-users (insulation producers, research institutes and instrument manufacturers). This study should involve the effect of specularity, transparency, spectral radiative properties and thermal inertia of the materials and samples to be tested.
2. To improve and validate primary techniques of measurement in at least two participating NMIs. The primary, ideally independent, techniques must be able to measure total hemispherical emissivity below 0.1 with an uncertainty below 0.02. The primary techniques should also be applicable to materials with different ratios of specular reflectance/diffuse reflectance.
3. To establish procedures of calibration and measurement for end-users e.g. insulation producers, research institutes and instrument manufacturers to perform emissivity measurements on reflective insulations and to validate the procedures by comparison of the techniques. The uncertainty for measurements carried out outside the NMIs should be below 0.03 for emissivities below 0.1.
4. To develop capabilities in at least one NMI in the EU to produce appropriate calibrated reference samples for instruments used by end-users e.g. insulation producers, research institutes and instrument manufacturers.
5. To collaborate with technical committees e.g. CEN/TC 89 WG 12 and CEN/TC 254 WG 14, and the users of the standards they develop to ensure that the outputs of the project are aligned with their needs and will be incorporated into standards e.g. EN 16012 and EN 15976 at the earliest opportunity. The outputs should be in a form that can be incorporated into the standards at the earliest opportunity (e.g. procedures, guidelines and recommendations for traceable measurement of emissivity of reflective films).

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.

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, in particular CEN/TC 89
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the industrial sector e.g. building and automotive.

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

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings

CEN/CENELEC identified this topic as one of their priorities. Details are available at http://msu.euramet.org/current_calls/pre_norm_2016/documents/SRT_related_CEN_priorities/cen_priority_12_2015.doc