Publishable Summary for 16NRM06 EMIRIM
Improvement of emissivity measurements on reflective insulation materials

Overview

This project will address the needs of the standardisation group CEN/TC 89/WG 12 for improvement of the standard EN 16012. The overall objective is to enable end-users to perform SI traceable measurements of total hemispherical emissivity on low emissivity foils used in “reflective insulation” products with an uncertainty below 0.03. The targeted industry focuses on the production of thermal insulation materials

Need

The principle of reflective insulation relies on the high sensitivity of the radiant heat power exchange between two surfaces not in contact to emissivity; the lower the emissivities of the surfaces, the lower the exchanged radiant power will be. In order to conform with the Directive 2010/31/EU on the energy performance of buildings, producers of reflective insulation products for buildings must declare values of emissivity for the products external surfaces. Declared emissivity values are used, in accordance with standards EN 16012 and ISO 6946, to calculate the thermal resistance of the insulation system under the condition of use. A recent comparison of measurement techniques organised by the standardisation CEN/TC 89/WG 12, responsible for defining test methods and declaration rules for the thermal performance of reflective insulation products, has shown high discrepancies with total hemispherical emissivity results from 0.02 to 0.08 on the same reflective foil. The comparison has included “integrating sphere” instruments and commercially available portable instruments (reflectometers). The sources of discrepancies are not yet explained, likely explanations are the geometrical, thermal and optical configurations of instruments and the type of reference sample used for calibration. Being unable to show that the techniques of measurement are reliable when the emissivity is believed to be less than 0.05, CEN/TC 89/WG 12 has set a limitation in the standard EN 16012 that any 'measured' value of emissivity less than 0.05 has to be rounded upwards to 0.05. This limitation is a clear limitation to product development and market innovation since manufacturers cannot achieve the financial return from their investments in products with superior emissivity below 0.05. This status situation is not satisfactory and CEN/TC 89/WG 12 has expressed an urgent need for improvement of the accuracy of emissivity measurements of reflective foils.

Objectives

The specific objectives of the project are:

1. To analyse and test the different techniques and instruments used by end-users to characterise reflective insulation products. The sensitivity of these techniques in relation to the specificities of the reflective foils (specularity, angular diffusion, transparency, spectral properties, thermal inertia and non-flatness of surfaces) will be investigated to enable the definition of the most appropriate types of reference samples for ensuring traceability.
2. To improve and validate reference techniques based on different principles of measurement from at least two NMIs in Europe. The reference techniques will be able to measure total hemispherical emissivity below 0.1 with an uncertainty below 0.02. They will be applicable to materials with different ratios of specular reflectance/hemispherical reflectance.
3. To build new competencies in NMIs/DIs in order to produce appropriate calibrated reference samples for characterising end-users instruments and for ensuring traceability of measurements, via calibration and measurement procedures developed in the project. Calibrated reference samples will also be produced for partners involved in the measurement techniques characterisation.
4. To establish calibration and measurement procedures enabling the end-users to perform emissivity measurements on reflective foils with an uncertainty below 0.03 for emissivities below 0.1.

5. To participate to the revision of EN 16012 and EN 15976, via the provision to CEN/TC 89WG12 and CEN/TC254/WG14 of amendments based on the technical results of the project. To communicate technical reports and guidelines on the calibration and use of end-users techniques to CEN/TC89WG12 and CEN/TC254/WG14. To disseminate the technical results of the project to the wider scientific and industrial community.

Progress beyond the state of the art

No reference technique has been validated up to now for measurement of the total hemispherical emissivity of low emissivity surfaces with an uncertainty below 0.02; the best achieved uncertainties are currently around 0.03. The aim is to adapt and improve existing reference techniques based on two different principles: calorimety and measurement of directional spectral emissivity. The targeted uncertainty at the reference level is below 0.02 for the measurement of emissivity on very low emitting samples. The sensitivities of the techniques mostly used by end-users (integrating sphere systems, commercial reflectometers) to the specificities of reflective foils are not yet well known and a reliable assessment of uncertainties is difficult though necessary. This project will allow the detailed characterisation of several instruments used industrially for the quantification of their sensitivities to the specificities of reflective foils, particularly the angular diffusion. Such a result would produce new important data for reliable assessment of uncertainties. The angular diffusion of reflective foils is currently unknown and will be analysed experimentally for several types of foils. Data will be used for assessment of uncertainties. The project will build new competencies to produce solid samples with non-flat surfaces with angular diffusions similar to the ones of reflective foils. The use of these reference samples will reduce by a factor of at least 2 the dispersions resulting from the type of reference samples currently used (mirrors or diffusers). New guidelines for improved measurement of low emissivity foils with industrially used instruments will also be drafted. The availability of specific calibrated reference samples, as well as the application of improved measurement procedures, will allow end-users to perform measurements on reflective foils with uncertainty below 0.03 (current state of the art is 0.06). This project will therefore improve the quality for emissivity measurements on reflective foils.

Results

Analysis and tests of the techniques used by end-users

The two techniques mostly used by end-users (integrating sphere systems and commercial reflectometers) recommended by EN 12898, will be characterised in detail. Key new knowledge will be gained particularly regarding the sensitivities of the two techniques to the angular distribution of the radiation reflected by the sample and the sensitivities to the type of reference sample (mirror like or diffusing) used to calibrate the instruments. For the hemispherical near-normal reflectometers (e.g. TIR100 from INGLAS), the effect of the spectral sensitivity and the linearity (response in function of reflectance) will be quantified as well. The sensitivities of the two techniques to the experimental parameters are not well known yet and are required to quantify the uncertainties and to explain discrepancies of results.

Improvement and validation of reference techniques

The emissometers of PTB and DTU will be adapted for measurement on foils, they will give the angular distribution of emissivity over the angular range 0° to 70° required to quantify the uncertainty related to the extrapolation of total hemispherical emissivity from near-normal emissivity. The calorimetric technique from LNE will be improved with the objective to reduce the uncertainty below 0.02. The improved reference techniques will be validated by comparison and used to calibrate in total hemispherical emissivity and with uncertainty below 0.02 the reference samples required for the project.

Production of appropriate calibrated reference samples

Specific metal samples with textured (non-flat) surfaces will be produced by additive manufacturing with the aim to have angular diffusions at reflection similar to the ones of the main types of reflective foils industrially produced. The shapes of the surfaces will be calculated with ray-tracing technique and using angular diffusions measured on the main types of reflective foils commercialized. The other samples required for the characterization of end-users techniques (mirrors, high reflective diffusers, high and medium emissivity samples) will be calibrated as well with reference techniques.

Establishment of calibration and measurement procedures for end-users

The experience and new knowledge gained when characterizing the end-users techniques and the availability of new specific reference samples will allow the establishment of improved calibration and measurement procedures for end-users. The objective is that end-users are able to measure total hemispherical emissivity of reflective foils with uncertainty below 0.03 applying improved procedures and using appropriate calibrated reference samples. The new procedures will be applied by end-users and validated by comparisons.

Participation to the revision of EN 16012 and EN 15976

The standards EN 16012 and EN 15976 in their current state will be analysed in detail and criticized taking into account the technical results of the project. Improved draft versions will be written and provided to CEN/TC89WG12 and CEN/TC254/WG14 for improvement of the standards.

Impact

The objective of the project is to support CEN/TC 89/WG12 to improve EN 16012 on the measurement of total hemispherical emissivity of low emissivity foils. The technical results will be summarised in technical reports, publications and good-practice guides that will be communicated to the convenor and members of the working group. New improved versions of the technical sections of the standard related to emissivity measurements will be drafted at the end of the project and proposed to CEN/TC89/WG12 for incorporation into a revision of EN 16012. Similarly, the technical results of the project will be communicated to CEN/TC/254/WG14 for the improvement of standard EN 15976.

The project results will also benefit producers of low emissivity insulation products, producers of flexible sheets for waterproofing buildings and organisations testing and certifying these products. The results will be disseminated in the form of technical presentations/reports, publications and good-practice guides.

The achievement of the objectives (better measurements of low emissivities of non-flat surfaces by NMIs and end-users) will contribute to the reduction of energy consumption by improving the control of thermal performance of insulation products. It will facilitate the development of new high performance thermal insulation systems based on multi-low-emissivity-foils used under vacuum. The improved knowledge of the performance and limitations of measurement techniques used industrially and the availability of appropriate calibrated samples will help end-users from many industries to perform reliable emissivity measurements, with commercially available instruments, at lower costs and with validated uncertainties. Reflective foils are used as heat protection screens in many other applications apart from building insulation, e.g. in aircrafts, land vehicles, boats, space crafts, nuclear power generation, packaging and satellites. Therefore, many industrial sectors will benefit from the progress made in low emissivity measurements on reflective building insulation materials.

Project start date and duration:		01 June 2017, 36 months
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