EMPIR Call 2019 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-n05**
Version: 1.0

Title: Reference electrical conditions for measurement of AC-operated light-emitting diode products

Abstract

As tungsten filament lamps phase out, new energy efficient Light-emitting diode (LED) lighting products take over the market. To assess the luminous efficacy and energy classification of LED products, accurate electrical measurements are important. However, measurements of the root-mean-square (RMS) current, power factor and electrical power of some product types are affected by the AC voltage source, wiring, bandwidth of the power meter and the type of AC/DC-converter used in the LED product. In several comparisons, errors up to several percent have been found between laboratories. Proposals addressing this SRT should develop and deploy the uptake of revised reference electrical conditions for measurement of AC-operated LED products, and update standards for testing of LED products, to support the global surge of LED lighting products, as well as the work of NMIs, test laboratories and standardisation bodies.

Keywords

Light-emitting diode (LED), luminous efficacy, electrical power, Root-mean-square (RMS) current, power factor, proficiency testing

Background to the Metrological Challenges

LED lamps and luminaires have become popular among consumers looking for new energy-efficient lighting products. The European Ecodesign Directive 1194/2012 defines the minimum requirements for the luminous efficacy, i.e. the energy efficiency, and other requirements on LED lighting products. Test laboratories measure luminous efficacy of LED products coming to market and the measurement data is used for determining the energy classification of the products, and the specifications printed on the packaging.

While for tungsten filament lamps the measurement of electrical power was straightforward, due to the AC/DC-converters used in LED products and the underlying systematic errors of AC electrical sourcing and power metering, the uncertainty associated with the measurement of electrical power is often significant and should not be overlooked in the measurement of the luminous efficacy.

In 2013, the International Energy Agency (IEA) arranged an Interlaboratory Comparison (IC 2013) with over 100 laboratories to measure the luminous efficacy of AC-operated LED products. In the case of luminous flux, the results showed agreement within ±5 % between most of the participants. For LED lamps with low power factor, the active power consumption showed an agreement within ±6 %, with results from some individual laboratories deviating by up to 35 %. Similar issues were found in measurements of RMS current and power factor of the products. The report concluded that impedance could be the cause for such large deviations and further work was necessary.

Due to these issues, there is a risk that some products are wrongly labelled or incorrectly placed on the market. EMRP project ENG62 MESaIL and the ongoing EMPIR project 15SIB07 PhotoLED have developed new measurement technologies that solve many of the issues of luminous flux measurements. However, the metrological infrastructure for accurate and reliable electrical power measurement of LED products is still missing.

The International Commission on Illumination, CIE, has identified the need for developing improved electrical measurements methods to be included in future revisions of standards CIE S025:2015 and EN 13032-4:2015 that are currently used by most test laboratories as the reference documents for testing of LED lamps, luminaires and modules.

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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 characterisation of AC-operated LED products.

The specific objectives are:

1. To define revised reference electrical conditions for harmonised measurement of electrical power consumption and luminous efficacy of AC-operated LED products at NMIs and at test laboratories, including information of relevant sources of uncertainties and their sensitivities.
2. To characterise the impedance features of typical 230 V AC electrical sources, power measurement equipment, transducers and wiring used by laboratories. Additionally, to develop an optimised impedance stabilisation network that enables stable and repeatable measurement of active power, RMS current and power factor of LED products with different types of AC electrical sources, with target system impedance close to the real electrical network.
3. To select the most stable commercial LED products with different types of AC/DC converters and power consumption, and use those as test artefacts in the validation of the revised reference electrical conditions. Additionally, to develop stable electrical load standards with properties similar to LED products, to be used for proficiency testing of electrical power measurement equipment.
4. To validate the improved measurement uncertainties of electrical power and luminous efficacy in an intercomparison, and to determine the new level of agreement that can be achieved in measurement of LED products of different types. The target uncertainty of electrical power measurements for test artefacts is 0.1 % (k = 2) at NMIs and 0.2 % (k = 2) at test laboratories, thus enabling luminous efficacy measurements with uncertainties less than 1.0 % (k = 2) at test laboratories.
5. To facilitate the uptake of the reference standards technology and measurement methods validated in the project by engaging the measurement supply chain (e.g. test laboratories), standards developing organisations (e.g. CIE Division 2, CEN TC169, IEC TC34, IEC TC77, IEA and ILAC) and end users (e.g. instrument and lighting product manufacturers).

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or 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. In particular, proposers should outline the achievements of the EMRP projects ENG05 Lighting, ENG 62 MESail and EMPIR project 15SIB07 PhotoLED and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.8 M€, and has defined an upper limit of 1.0 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

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 the lighting sector.

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

CIE identified this topic as one of their priorities. Details are available at:

https://msu.euramet.org/current_calls/pre_norm_2019/documents/cie_priority_001.pdf