EURAMET.PR-K4.3
Protocol

for the Bilateral Comparison on

Luminous Flux

December 2016

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Bilateral Comparison

Luminous Flux

Technical Protocol

Contents

1. Introduction

In 1997, the Comite International des Poids et Mesures (CIPM) had initialized two key comparisons CCPR-K3a of luminous intensity and CCPR-K4 of luminous flux with the Physikalisch-Technische Bundesanstalt, Germany, acting as pilot laboratory. The maintained units of 16 national metrological laboratories and of the Bureau International des Poids et Mesures (BIPM) were compared in a 'star-type' structure, using more than 200 lamps as transfer standards. The results of these comparisons are key comparison reference values (KCRV) for the two quantities. All results were published[1] in 1999 and the DOEs are listed in the data base[2] of the Bureau Internationale des Poids et Mesures (BIPM).

In 2010, under the auspices of the European Association of National Metrology Institutes (EURAMET) as the Regional Metrology Organisation (RMO) two international key comparisons of the values of luminous intensity (EURAMET.PR-K3.a) and luminous flux (EURAMET.PR-K4) were carried out[3]. The units are transferred by batches of incandescent lamps from the participants to the pilot laboratory, the Physikalisch-Technische Bundesanstalt (PTB). When it was decided to carry out the EURAMET Key Comparison, the Institute National de Métrologie (BNM-INM / CNAM, France) and the Instituto Nazionale di Ricerca Metrologica (INRIM, Italy) agreed to act as link laboratories for both units. Key comparisons are intended to determine the Degrees of Equivalence (DOE) for each non-link participant and the associated expanded uncertainty. The DOE for a quantity states for a participant the relative difference of his value with the related Key Comparison Reference Value (KCRV).

According to paragraphs T.8 and T.9 of the MRA, a bilateral key comparison is to be carried out between two institutes as outlined in CIPM Guideline for key comparisons[4]. The scheme for performing comparisons within the framework of EURAMET is presented in Euramet Guidelines on Conducting Comparisons[5]. RMO key comparisons in the field of photometry and radiometry are performed in accordance with the *Guidelines for CCPR and RMO Bilateral Key Comparisons* (*CCPR-G5*)[6] and *Guidelines for RMO PR Key Comparisons* (*CCPR-G5*)[7].

On the bases of the referenced documents, it is intended to propose an intercomparison on luminous flux between TUBİTAK-UME and CSIC as a EURAMET Bilateral comparison. This comparison will link TUBİTAK-UME result of the measurements to KCRV defined by the CCPR-K4 comparison, and thus will allow to record of measurement capabilities in the BIPM database as required by the MRA.

This technical protocol has been drawn up by the pilot and participating laboratories.

The procedures outlined in this document cover the technical procedure to be followed during measurement of the transfer standards. This procedure has been prepared following the main procedure applied in the CCPR-K4 International comparison on Luminous Flux of 1997-1998.

[1] CCPR Key Comparison K3a of Luminous Intensity and K4 of Luminous Flux with Lamps as Transfer Standards; PTB-Opt-62; ISBN 3-89701-471-8
[2] BIPM database: http://kcdb.bipm.org/appendixB/default.asp
[3] BIPM database: http://kcdb.bipm.org/appendixB/appbresults/EURAMET.PR-K3.a/EURAMET.PR-K3.a_Technical_Protocol.pdf
[4] Guidelines for CIPM key comparisons, 1 March 1999
[5] Euramet Guide No.3, Euramet Guidelines on Conducting Comparisons Ver 02.7 (2002)
[6] CCPR-G5, 10 October 2014
[7] CCPR-G6, 10 October 2014

2. Organization

2.1. Participants

The participants for this bilateral comparison are CSIC / Spain and UME / Turkey. CSIC will be a link laboratory (CSIC participated in CCPR-K4). UME is to be linked to the CCPR-K4 KCRV. CSIC has been recognised as the pilot laboratory for this comparison following the recommendation depicted in paragraph 10 (a) of CIPM guideline[4]. UME will demonstrate its traceability to an independent realisation of the quantity, or make clear the route of traceability to the quantity via another named laboratory. By their declared intention to participate in this bilateral key comparison, the laboratories accept the general instructions and the technical protocols written down in this document and commit themselves to follow the procedures strictly.
A third party (WG-KC Secretary) is designated for the comparison, and all the measurement results, both from the non-link laboratory and the link laboratory are submitted to the third party upon completion of each measurement, to ensure blindness of the comparison. At completion of all measurements, the third party sends all the data received to the link laboratory, so that the link laboratory can start Pre-Draft A process.

2.2 Participants' details

Table 1 - Participants

Contact	Institute	Contact Details	Shortcut	Role
A. Pons J. Campos Acosta	Instituto de Optica CSIC C/. Serrano, 144 28006 Madrid SPAIN	Tel : +34 91 561-8806 Fax: +34 91 411-7651 email: alicia.pons@csic.es joaquin.campos@csic.es	CSIC	Pilot Link lab.
F. Sametoglu	TUBİTAK-UME Optics Laboratories, Baris Mah., Dr.Zeki Acar Cad. No :1, TUBITAK Gebze Yerleskesi, 41470, Gebze, Kocaeli-TURKEY	Tel : +90 262 679 50 00 Ext :3300 Fax : +90 262 679 50 01 email : ferhat.sametoglu@tubitak.gov.tr	UME	Non-link lab.

2.3. Form of comparison

The comparison will mainly be carried out by the calibration of a group of transfer standard lamps (four lamps) supplied by UME. The used type of lamps have to show a reasonable stability and robustness. They will be returned to UME after completion of the comparison.

The bilateral comparison will mainly be carried out in three steps. Initial measurements will be performed by UME before delivering to CSIC. CSIC will then calibrate the lamps. CSIC will then return the lamps to UME to carry out a repeated calibration.

2.4. Timetable

The timetable showing how the comparison is planned is given in the following Table 2

Table 2 - Timetable of the comparison

Activity	**Start Date**
Full protocol agreed by participants	November/December 2016
Protocol and notification of the comparison sent to Euromet Chairman	November/December 2016
Protocol approved by CCPR-WG-KC	June 2017
Registration at KCDB	June 2017
Initial measurements at UME and sending the lamps to CSIC	June/July 2017
Measurements at CSIC	September 2017
Lamps returned to UME	October 2017
Repeat measurements at UME	November 2017
Distribution of Pre-Draft A	December 2017
Distribution of Draft A	January 2018
Draft B submitted to Euramet	February 2018

2.5. Handling of artefacts

Artefacts (luminous flux lamps) should be transported by hand-carriage from UME to the pilot laboratory (CSIC) and back again to UME. The standard lamps should only be handled by authorized persons and stored and packed in such a way as to prevent damage.

The standard lamps should be examined immediately upon receipt at final destination. However, care should be taken to ensure that the lamps and packaging have sufficient time to acclimatise to the actual environment thus preventing any condensation etc. The condition of the lamps and associated packaging should be noted and communicated to the pilot laboratory.

After the very first calibration at UME no cleaning of any lamp envelope should be attempted. No parts other than noted within operating conditions belonging to specific lamps should be removed from or connected to this lamp. If a standard lamp appears damaged a replacement if possible will be only available from UME. However, appropriate insurance should be taken out by participating laboratories to cover the cost of such a replacement if the damage occurred in transit.

During operation of the standard lamps any unusual occurrence, e.g. change of voltage, change in output etc. should be notified immediately to another participant and discussed.

The participants will inform each other via fax or e-mail when the measurement on the standard lamps are completed.

2.6. Transport of artefacts

It is of utmost importance that the artefacts (luminous flux lamps) be transported in a manner in which they will not be lost, damaged or handled by unauthorised persons.

Packaging for the artefacts should be made which is suitably robust to protect the artefacts from being deformed or damaged during transit.

Luminous flux lamps should as a preference be carried by hand by UME. The lamp case should be marked as ‘Fragile’.

The artefacts should be accompanied by a suitable customs carnet (where appropriate) or documentation identifying the items uniquely. UME has to pay attention to the import/export regulations during transport. The packaging should be lockable e.g. by clasp, so that it will be easy to open with minimum delay to allow customs inspections to take place.

2.7. Description of the standards

2.7.1. Transfer standards used within the comparison

The measurement artefacts are specially developed transfer standard lamps (four items) for luminous flux of the Polaron LF200W type. The use of these lamps was decided and determined by the participants on request of UME.

Figure 1: Standard luminous flux lamps of UME (Polaron LF200W) used within this comparison.

2.8. Measurement Conditions

2.8.1. Traceability

Temperature measurements should be made using the International Temperature Scale

of 1990 (ITS-90).

Electrical measurements should be independently traceable to the latest realisations of the amp and volt.

2.8.2. Measurand

The measurand is the luminous flux of a lamp. This photometric quantity should be measured for the defined operating conditions of each lamp, where the operating current acts as the setting parameter. The measurements should be performed in suitable laboratory accommodation maintained at a temperature of 20 °C to 25 °C. The temperature of the laboratory during the time of the measurements should be reported.

The luminous flux should be measured independently at least 2 times. Each independent measurement should consist of the lamp being realigned in the measurement facility and being switched off and on after a break of at least 1 h for each lamp. Each independent measurement set should be reported. It should be noted that each independent measurement may consist of more than one set of measurements, the exact number should be that normally used by the participating laboratory to obtain the appropriate accuracy as limited by the noise characteristics of their specific measurement facility. The exact number of measurements used should be stated in the measurement report but only the mean or final declared value of the set is required to be included. Participants are reminded that the luminous flux of the transfer standard lamps will change as a function of the operational burning time and so it is recommended that this is kept to a minimum.

2.8.3. Geometrical Conditions

Participants have to describe their geometrical measurement conditions. The basic conditions used within this comparison are as follows:

- Lamp axis (cap up) is vertical.
- All the light emitted by the lamp will be measured.

2.8.4. Electrical Conditions

All luminous flux lamps have to be operated with DC power where the lamp current is stabilized. The exact values of the operating current and the polarity will be supplied by UME. The lamps voltage will be measured to monitor stability of the lamps electrical conditions. Lamp voltages should be measured using 4-pole technique directly at the lamp cap (figure 2).

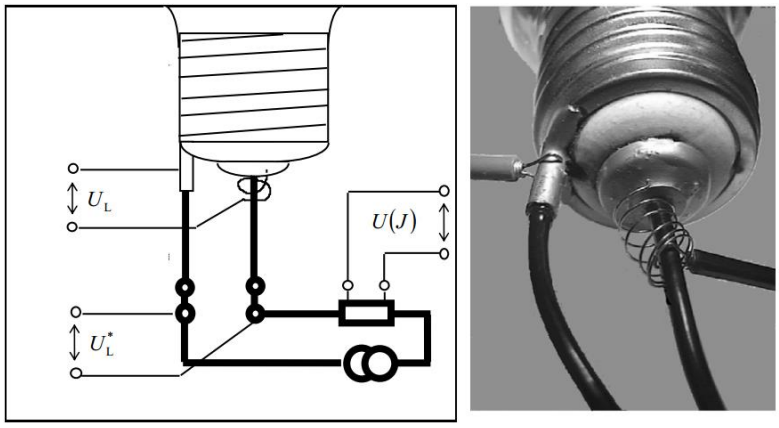

Figure 2: (left) schematic diagram showing the circuitry for using a Polaron luminous flux lamp. Instead of using the Voltage drop U^*_L at the high current clamps, which is influenced by the current flow over the contact resistance, the lamp voltage U_L at the soldered thread should be used. (right) photo of the cap with clamps as additional contacts for voltage measurement

2.8.5 Measurement Instructions

Before connecting to any electrical power supply, the standard lamps should be inspected for damage or contamination of either the window of the lamp, the cap or its supporting mount. Any damage should be documented by photos and the other laboratory should be informed immediately.

Before switching on the current for any lamp, an appropriate time recording device and notebook should be established to allow the operation time for each lamp to be recorded.

After connecting the electrical power to the lamps, the prescribed warm-up procedure for each lamp should be followed. Operational parameters for each lamp (specified in the lamp operating procedure) should be recorded and compared to those supplied with the lamp by UME.

The operational conditions, specially the polarity, and alignment procedure for each lamp should be noted and followed according to the details described in the notes supplied with each lamp. A photograph should be taken from the lamp installed and kept by the participants for documentation and quality insurance.

The luminous flux of each the lamp should be measured together (at the same time if possible) with the electrical values.

The signed results of the measurements together with the operating condition (e.g. lamp number, current, voltage, corr. colour temperature) and the uncertainty budget (k=1) and facility descriptions will be sent to the Third party (WG-KC Secretary) by electronic mail.

A typical value of the correlated colour temperature (CCT) of each lamp is 2715 K.

No other measurements are to be attempted by the participants nor any modification to the operating conditions during the course of this comparison. The transfer standards used in this comparison should not be used for any purpose other than described in this document nor given to any party other than the predetermined participants in the comparison.

2.9. Reporting of the results

On completion of the measurements by the participating laboratory the measurement results including uncertainty for each transfer standard should be sent to the third party as soon as possible and at the latest within six weeks. UME must send the results after each of 1st and 2nd measurement, but the results of the 1st measurement can be treated as preliminary and these can be revised if necessary when the 2nd measurement results are submitted.

The report containing the comparison results must include a description of the participant's measurement facility. It would be useful for a schematic diagram of the facility to be included

The report on the comparison results must contain a comprehensive uncertainty budget, comprising all the contributions to the total uncertainty. The uncertainty of measurements shall be estimated according to the ISO Guide to the Expression of Uncertainty in Measurements.

A short but a descriptive explanation on how the luminous flux is realized should be given by both participating laboratories. Uncertainty contributions from main sources must also be tabulated in the form of an uncertainty budget.

At completion of all measurements, the third party sends all the data received to the link laboratory (CSIC), so that the link laboratory can start Pre-Draft A process. The third party sends to both participants all the raw data received after Draft A is issued.

CSIC (the link and pilot laboratory) will carry out Pre-Draft A procedures and then will prepare Draft A report following the CCPR Guideline G5 "Guidelines for CCPR and RMO Bilateral Key Comparisons".

2.9. Evaluation of Degree of Equivalence of non-link laboratory

The *Degree of Equivalence of the non-link laboratory (*UME*) will be evaluated using the results of present RMO bilatera*l KC and the results of CCPR-K4 *following the* analysis approach recommended by the *CCPR Guideline G5 "*Guidelines for CCPR and RMO Bilateral Key Comparisons*".*