Technical Protocol of CCPR-K2.b.2016

Key Comparison on

Spectral Responsivity 300 nm to 1000 nm

Approved by CCPR WG-KC on 16 February 2016

Contents

1. INTRODUCTION 2

2. ORGANIZATION 2

2.1. CONDITION OF PARTICIPATION 2

2.2. LIST OF PARTICIPANTS 3

2.3. FORM OF COMPARISON 4

2.4. TIMETABLE 4

2.5. TRANSPORT AND HANDLING OF TRANSFER DETECTORS 6

3. DESCRIPTION OF TRANSFER DETECTORS 7

4. MEASUREMENT INSTRUCTIONS 9

4.1. TRACEABILITY 9

4.2. MEASURAND 9

4.3. MEASUREMENT INSTRUCTIONS 10

5. REPORTING OF RESULTS AND UNCERTAINTIES 12

6. PREPARATION OF COMPARISON REPORT 13

APPENDIX 1: INSPECTION REPORT ON RECEIPT OF TRANSFER DETECTORS 14

APPENDIX 2: RESULT REPORT 15

1. Introduction

1.1. Under the Mutual Recognition Arrangement (MRA), the metrological equivalence of national measurement standards will be determined by a set of key comparisons chosen and organized by the consultative committees of CIPM working closely with regional metrology organizations (RMOs).

1.2. At its meeting in June 2007, the Consultative Committee for Photometry and Radiometry, CCPR, instigated a new series of key comparisons in the field of optical radiation metrology. In particular, it decided that a key comparison of spectral responsivity from 300 nm to 1000 nm would be carried out, and subsequently appointed KRISS of Rep. Korea to act as pilot laboratory.

1.3. In November 2011, the call for participants is circulated to the member institutes of CCPR, and the 12 participants are selected according to the CCPR guidelines[1]. Among the participants, a task group (TG) is formed to draw up this technical protocol. The members of the TG are: KRISS (Korea), MSL (New Zealand), NMIJ (Japan), NIST (USA), LNE-CNAM (France), NPL (UK), and PTB (Germany). The technical protocol is to be agreed by all the participants.

1.4. The procedures outlined in this document cover the technical procedure to be followed during measurement of the transfer detectors. The procedure, which follows the guidelines of the BIPM[2], is based on current best practice in the use of standard detectors and takes account of the experience reported from the previous BIPM spectral responsivity comparisons[3,4].

2. Organization

2.1. Condition of participation

2.1.1. The list of participants was agreed upon in October 2012 by CCPR WG-KC and RMO TCPRs.

2.1.2. In accordance with the guidelines CCPR-G4, all the participants must

- be members of CCPR,
- have made an independent realisation of their spectral responsivity scale, and
- have CMC coverage of spectral responsivity at all wavelengths in the range covered by the comparison (300 nm to 1000 nm)

2.1.3. By their declared intention to participate in this comparison, the laboratories accept the general instructions and the technical procedures written down in this document and commit themselves to follow the procedures strictly.

---

[1] CCPR-G4: Guidelines for preparing CCPR key comparisons (2013); http:/ / www.bipm.org/ utils/ common/ pdf/ CC/ CCPR/ CCPR-G4.pdf

[2] CIPM-MRA-D-05, Measurement comparisons in the CIPM MRA; http:/ / www.bipm.org/ utils/ common/ documents/ CIPM-MRA/ CIPM-MRA-D-05.pdf

[3] R. Kohler *et al*, Results of an international comparison of spectral responsivity of silicon photodetectors, Metrologia 32(6), 463 (1995); http:/ / iopscience.iop.org/ 0026-1394/ 32/ 6/ 12/

[4] R. Goebel et al, Report on the comparison CCPR-K2.b of spectral responsivity measurements in the range 300 nm to 1000 nm, Metrologia Technical Supplement 41, 02004 (2004); http:/ / iopscience.iop.org/ 0026-1394/ 41/ 1A/ 02004

2.1.4. Once the protocol has been agreed, no change to the protocol may be made without prior agreement of all the participants.

2.2. List of participants

(No.)* NMI	country	contact person	email address	post address	remarks
(1) KRISS	Rep. Korea	Lee, Dong-Hoon Hong, Kee Suk	dh.lee@kriss.re.kr hongi2011@kriss.re.kr	Korea Research Institute of Standards and Science 267 Gajeong-Ro, Yuseong-Gu, Daejeon 304-340, Rep. Korea	pilot, APMP
(2) IO-CSIC	Spain	Campos, Joaquin Pons, Alicia	joaquin.campos@csic.es alicia.pons@csic.es	Instituto de Óptica "Daza de Valdés" (IO-CSIC) C/. Serrano, 144, 28006 Madrid, Spain	EURAMET
(3) LNE-CNAM	France	Rougie, Bernard Coutin, Jeanne-Marie	bernard.rougie@cnam.fr jeanne-marie.coutin@cnam.fr	LNE-CNAM Case courrier 2LAB10, 61 rue du Landy, FR-93210 La Plaine - Saint-Denis, France	EURAMET
(4) MSL	New Zealand	Shindo, Francois Hamlin, John Swift, Neil	francois.shindo@callaghaninnovation.govt.nz john.hamlin@callaghaninnovation.govt.nz neil.swift@callaghaninnovatoin.govt.nz	Measurement Standards Laboratory of New Zealand, Callaghan Innovation 69 Gracefield Rd, Seaview, Lower Hutt 5040, New Zealand	APMP
(5) NIST	USA	Houston, Jeanne Shirley, Eric Lucatorto, Thormas	jeanne.houston@nist.gov eric.shirley@nist.gov thormas.lucatorto@nist.gov	National Institute of Standards and Technology 100 Bureau Drive, MS 8441, Gaithersburg, MD 20899-8441, UNITED STATES	SIM
(6) NMC-ASTAR	Singapore	Huang, Xuebo Zhang, Jing	huang_xuebo@nmc.a-star.edu.sg zhang_jing@nmc.a-star.edu.sg	National Metrology Centre, A*STAR 1, Science Park Drive, Singapore 118221	APMP
(7) NMIJ	Japan	Kinoshita, Kenichi Ichino, Yoshiro	kenichi.kinoshita@aist.go.jp y.ichiro@aist.go.jp	Photometry and Radiometry Research Group, Research Institute for Physical Measurement, National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST) Tsukuba Central 3-1, 1-1-1 Umezono, Tsukuba, Ibaraki, 3058563 Japan	APMP
(8) NRC	Canada	Gamouras, Angela Baribeau, Réjean Rowell, Nelson	angela.gamouras@nrc-cnrc.gc.ca rejean.baribeau@nrc-cnrc.gc.ca	National Research Council Canada M-36 1200 Montreal Rd., Ottawa, Ontario, Canada K1A 0R6	SIM

			rowell.nelson@nrc-cnrc.gc.ca		
(9) NPL	UK	Goodman, Teresa	teresa.goodman@npl.co.uk	National Physical Laboratory Hampton Rd, Teddington, Middx, TW11 0LW, UK	EURAMET
(10) PTB	Germany	Werner, Lutz Meindl, Peter	lutz.werner@ptb.de peter.meindl@ptb.de	Physikalisch-Technische Bundesanstalt Abbestr. 2 – 12, 10587 Berlin, Germany	EURAMET
(11) UME	Turkey	Bazkir, Ö zcan	ozcan.bazkir@tubitak.gov.tr	TUBITAK UME Dr. Zeki Acar Cad. No:1, TUBITAK Gebze Yerleskesi, 41470, Gebze, Kocaeli, Turkey	EURAMET
(12) VNIIOFI	Russia	Khlevnoy, Boris	khlevnoy-m4@vniiofi.ru	VNIIOFI Ozernaya 46, Moscow 119361, Russia	COOMET

* Numbering in the alphabetical order except the pilot.

2.3. Form of comparison

2.3.1. The comparison will be carried out by distributing multiple sets of the transfer detectors prepared and provided by the pilot. **Each set of the transfer detectors will contain 2 pieces of reflection-type three-element trap detector and 3 pieces of single-element silicon photodiode.** The same type of detectors has been used in the previous CCPR-K2.b comparison. The specifications, preparation, and characteristics of the transfer detectors are described in Chapter 3.

2.3.2. The comparison will take the form of a star comparison, carried out in two phases. The detectors calibrated initially by the pilot will be distributed to the first group of participants without the pilot's calibration results. The participants will then calibrate all of the transfer detectors at the wavelengths requested. They will then return the detector set to the pilot, which will carry out a new calibration for drift monitoring. After the completion of this first phase, the sets of transfer detectors will be sent to the second group of participants, and the same procedure will be followed for the second phase.

2.3.3. **Each participant has three months for measurement after the receipt of the artefact set.** With its confirmation to participate, each participant has confirmed that it is capable of performing the measurements in the time allocated to it. If anything happens so that it cannot meet the timetable, the participant must contact the pilot immediately.

2.3.4. All results are to be communicated directly to the pilot as soon as possible and at the latest within six weeks of the completion of the measurement by a participant.

2.3.5. The timetable given below gives an overview of how the comparison is planned.

2.4. Timetable

Time	Activity of pilot	Activity of participants
~ Sept. 2015	- Preparation of technical protocol draft	- Review of technical protocol draft
~ Feb. 2016	- Finalization and approval of technical protocol by CCPR WG-KC	

Sept. 2015 ~ Jan. 2016	- Preparation of transfer detectors including the initial characterization measurement	
February 2016	- Delivery of transfer detectors to the first-round group (NMC-ASTAR, IO-CSIC)	
March 2016 ~ May 2016		- Receipt and measurement of transfer detectors by the first-round group
June 2016		- Return of transfer detectors to KRISS
June 2016 ~ August 2016	- Control measurement of transfer detectors	
Sept. 2016	- Delivery of transfer detectors to the second-round group (NMIJ, LNE-CNAM, NRC, UME, MSL)	
Oct. 2016 ~ Jan. 2017		- Receipt and measurement of transfer detectors by the second-round group
February 2017		- Return of transfer detectors to KRISS
Feb. 2017 ~ March 2017	- Control measurement of transfer detectors	
April 2017	- Delivery of transfer detectors to the third-round group (NIST, VNIIOFI, NPL, PTB)	
May 2017 ~ August 2017		- Receipt and measurement of transfer detectors by the second-round group
Sept. 2017		- Return of transfer detectors to KRISS
Oct. 2017 ~ Nov. 2017	- Control measurement of transfer detectors	
Dec. 2017	- Pre-Draft A process: preparation and distribution (uncertainty budget & relative data)	
Jan. 2018 ~	- Pre-Draft A process: review and comments by the participants, revision and final review	

Feb. 2018	
March 2018 ~ April 2018	- Draft A report: preparation and distribution
May 2018 ~ June 2018	- Draft A report: review and approval by the participants
July 2018	- Draft B report: preparation and submission to CCPR WG-KC (Or Draft A-2 report process, if required)

2.5. Transport and handling of transfer detectors

2.5.1. It is of utmost importance that the transfer detectors be transported in a manner in which they will not be lost, damaged, or handled by unauthorised persons.

2.5.2. The transfer detectors are sufficiently robust to be sent by courier. Packaging for the transfer detectors should be suitably robust to protect the detectors from being deformed or damaged during transit. The packages should be marked as "Fragile."

2.5.3. The transfer detectors will be accompanied by a suitable customs carnet (where appropriate) or documentation identifying the items uniquely. The packaging will be lockable, but is easy to open with minimum delay to allow customs inspections to take place.

2.5.4. The package of the transfer detectors will be provided by the pilot for the first delivery. The participant should re-use the package when returning the transfer detectors to the pilot.

2.5.5. Transportation is at the cost of the sending laboratory. Each participant covers the costs for its own measurements and any customs charges as well as for any damages that may have occurred within its country. The overall costs for the organization of the comparison are covered by the pilot laboratory, and the transfer detectors (including the package) are the property of the pilot laboratory or of the BIPM[5]. The pilot has no insurance for any loss or damage of the transfer detectors during transportation.

2.5.6. The transfer detectors should be visually inspected immediately upon receipt. However, care should be taken to ensure that the detectors have sufficient time to acclimatise to the laboratory environment thus preventing any condensation, etc. The condition of the detectors and associated packaging should be noted and communicated via email and fax to the pilot by using the form in APPENDIX 1: INSPECTION REPORT ON RECEIPT OF TRANSFER DETECTORS.

2.5.7. The transfer detectors should be handled only by the authorized persons and stored in such a way as to prevent damage.

2.5.8. The detectors are mechanically robust but sensitive to dust and pollution. When not used, they must always be stored, with the protection cap closed, in the anti-static bags they have been sent in. No cleaning of any detector surface or window should be attempted. If any apparent contamination is visible, the pilot laboratory should be contacted immediately.

[5] The trap detectors used in this comparison are provided by the BIPM.

2.5.9. If a transfer detector appears damaged, a replacement will be available from the pilot laboratory. However, appropriate insurance should be taken out by the participant to cover the cost of such a replacement if the damage occurred in transit.

2.5.10. During operation of the detectors, if there is any unusual occurrence, e.g. change of the noise characteristics, etc., the pilot laboratory should be notified immediately before proceeding.

2.5.11. Please inform the pilot laboratory via e-mail and fax when the measurement on the detectors are completed to arrange a suitable date for dispatch.

2.5.12. After the measurements, the transfer detectors should be repackaged as received. Ensure that the content of the package is complete before shipment.

3. Description of transfer detectors

3.1. A set of transfer detectors consists of three single-element silicon photodiodes of type Hamamatsu S1337-1010BQ (with quartz window) and two three-element reflection-type trap detectors containing Hamamatsu S1337-11 (windowless).

3.2. The housing[6] for the single-element photodiodes is shown in Fig. 1. Each detector is fitted with a BNC connector for reading of photocurrent and a 4-pin LEMO connector for a 4-wire reading of a PT100 temperature sensor attached to the detector housing. The connection diagram of the detector is shown in Fig. 2.

[6] Housing designed by MSL, New Zealand.

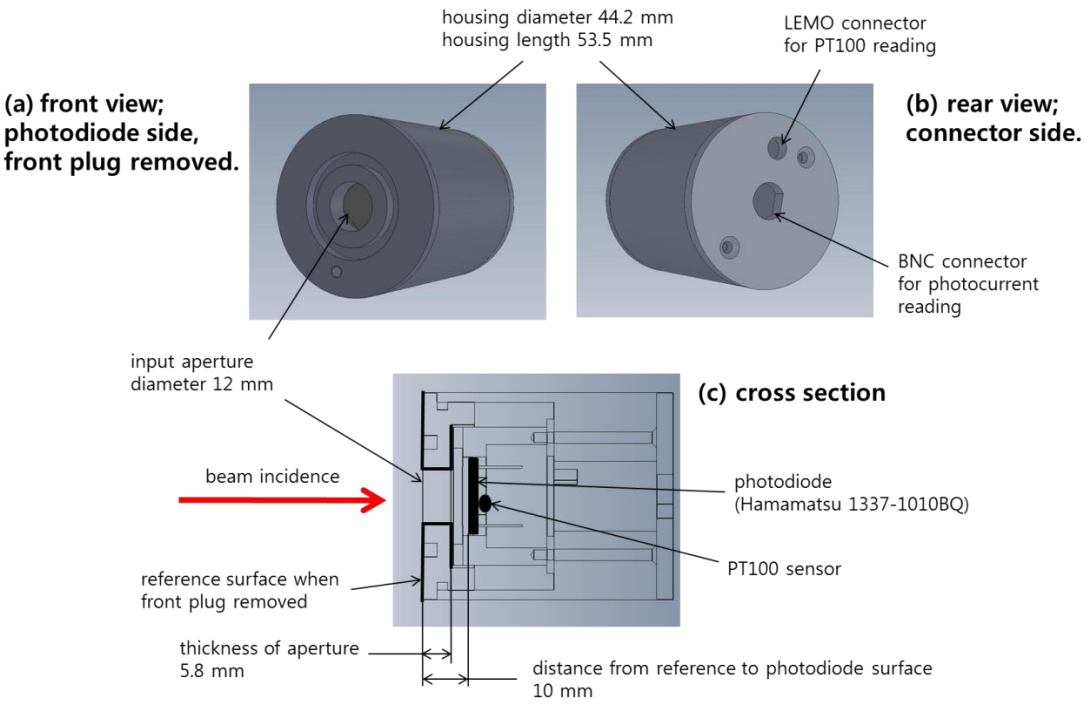


Fig. 1 Schematic drawing of the single-element photodiodes.

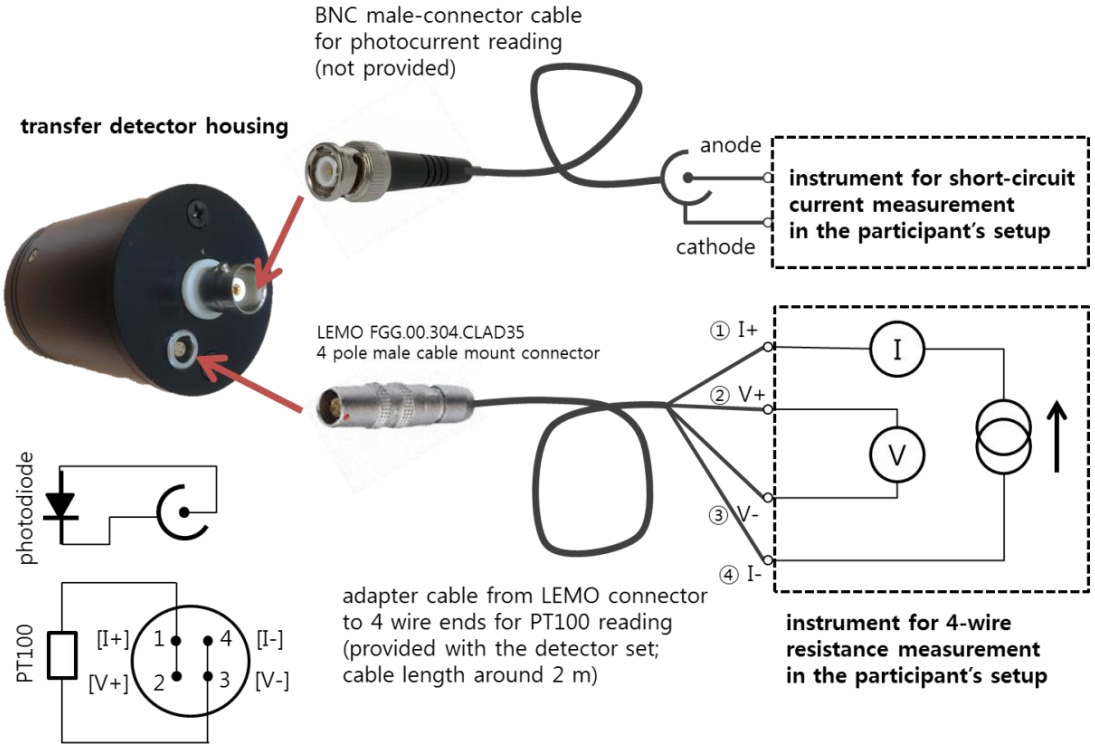


Fig. 2 Introduction for connection of the transfer detectors.

3.3. The housing for the three-element reflection-type trap detectors is shown in Fig. 3. These trap detectors are provided by the BIPM and modified by the pilot laboratory to enable the temperature monitoring. Similar to the single-element photodiodes, each trap detector is fitted with a BNC

connector for reading of photocurrent and a 4-pin LEMO connector for a 4-wire reading of a PT100 temperature sensor attached to the detector housing.

3.4. Each set of transfer detectors is accompanied with an adapter cable to the LEMO connector with a length of longer than 2 m and 4 bare-wire ends indicated as V+, V-, I+, and I-.

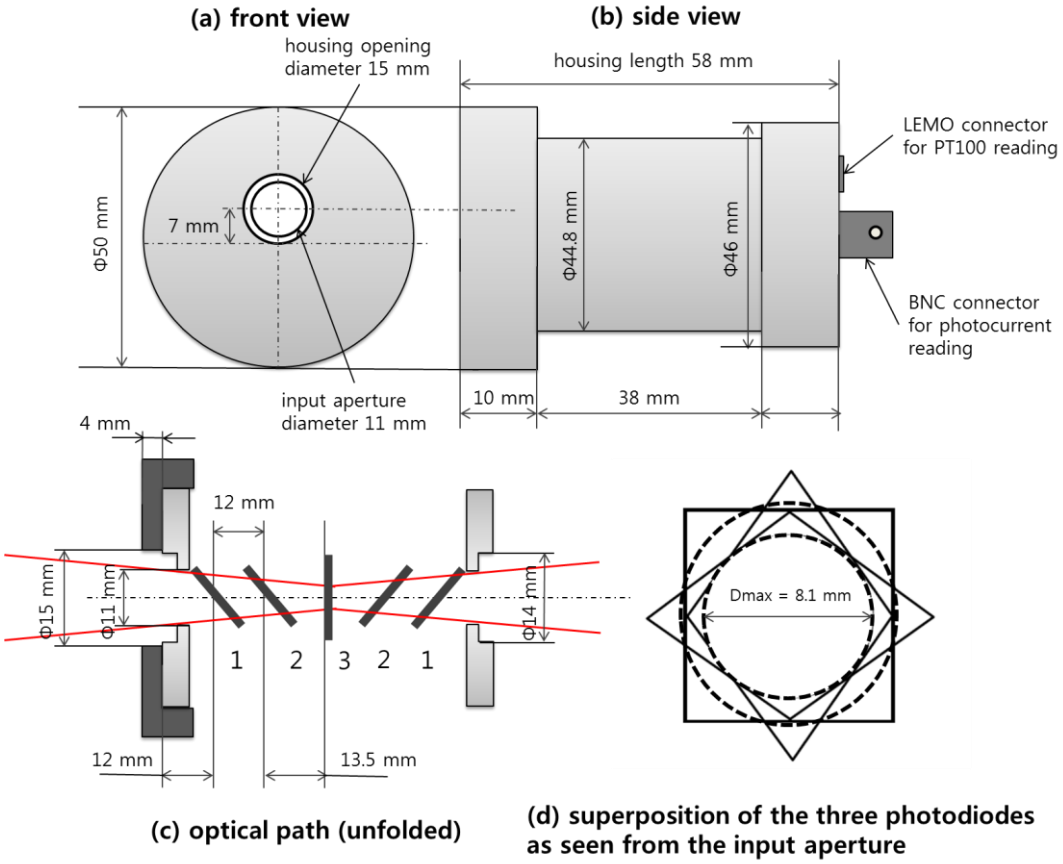


Fig. 3 Schematic drawing of the trap detectors.

3.5. The pilot will characterise a subset of the transfer detectors for uniformity, linearity, and temperature dependence of the spectral responsivity, if these data are not already available.

4. Measurement instructions

4.1. Traceability

4.1.1. Temperature measurements should be made using the International Temperature Scale of 1990 (ITS-90).

4.1.2. Electrical measurements should be traceable to the latest realisation of the Ampere and Volt.

4.2. Measurand

4.2.1. The measurand is the **spectral power responsivity** of a detector, i.e., the responsivity against the radiant power as a function of the wavelength in the unit of A/W, which are measured under

the following nominal conditions: normal incidence[7] of monochromatic and non-polarised radiation to the centre of the effective sensitive area[8] of the detector at a temperature of 23 ℃.

4.2.2. Since a perfect realization of the nominal measurement conditions is not possible in practice, the acceptance limits of the measurement conditions, in which the deviations can be regarded as the uncertainty components, are specified in 4.3.

4.2.3. Each individual measurement shall consist of the detector being realigned in the measurement facility. It should be noted that each individual measurement may consist of more than one set of measurements, and the actual 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 actual number of individual 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.

4.2.4. In order to perform a temperature correction of spectral responsivity, the **reading of the temperature sensor** attached to each transfer detector should be recorded before and after each measurement at a given wavelength. The mean value of the temperature sensor readings (in Ohm) during the time of the measurement at each wavelength should be reported together with the final results of spectral responsivity for each detector (see Appendix 2). The target value of the PT100 reading for temperature correction is 109.0 Ohm.[9]

4.3. Measurement instructions

4.3.1. The participants should perform the measurement using the facilities and procedures which are used for their calibration services, while meeting the conditions of measurement specified by this technical protocol.

4.3.2. Before using the detectors, they should be inspected for damage or contamination. Any damage should be documented and communicated to the pilot using the form in APPENDIX 1: INSPECTION REPORT ON RECEIPT OF TRANSFER DETECTORS.

4.3.3. Each detector should be mounted and aligned so that the optical beam is **centred to the effective sensitive area at normal incidence**. The recommended method for identifying the centre of the effective sensitive area is to scan the detector while monitoring the photocurrent signal. The recommended method for checking the normal incidence is to monitor the reflected beam from the detector, which should be collinear with the incident beam.[10]

4.3.4. The measurements should be performed in suitable laboratory accommodation which maintains the temperature of the detector under test **at a temperature as close as possible to 23 ℃.** The actual ambient temperature and relative humidity of the laboratory during the time of the measurements must be reported.[11]

[7] The normal incidence is defined with respect to the surface of the photodiode or of the third photodiode in case of the trap detectors.

[8] The boundary of the effective sensitive area is defined both by the input aperture and by the sensitive area of the photodiode.

[9] The actual temperature of the detector housing for this target value of PT100 can differ for each detector due to difference in thermal contact.

[10] In order to make the reflected beam visible, especially for the trap detectors, an additional alignment laser may be required.

[11] If the detector to be measured is placed in a chamber or holder whose temperature and humidity are controlled separately from the laboratory room, the condition of the detector chamber should be reported.

4.3.5. After alignment and before starting the measurements, sufficient time should be allowed to let the detectors reach thermal equilibrium.

4.3.6. The spectral responsivity of the transfer detectors should then be measured over the spectral region from 300 nm to 1000 nm[12]. Measurements should be made at intervals of 20 nm starting from 300 nm up to 400 nm and at steps of 50 nm from there on until 1000 nm.

4.3.7. The **spectral bandwidth** used to measure the spectral responsivity should be less than 10 nm (Full Width at Half Maximum) and ideally less than 5 nm. The actual bandwidth used for each spectral point should be reported, together with the centre wavelength (or the effective wavelength).

4.3.8. The parameters such as **spot size** of the beam on the sensitive surface and **beam divergence** (f-number) of the beam should be selected to fulfil the underfilled condition for radiant power measurement without any vignetting.[13] The participants should specify the estimated or measured values of the spot size at the detector surface and the f-number of the beam used in the technical report (see 5.2).

4.3.9. For the trap detectors, the maximum spot size and beam divergence should be deduced from the following pictures. Fig. 3(c) shows a view of the unfolded optical path inside the trap where the right-hand side of the picture represents the beam reflected from the third photodiode. Fig. 3(d) shows the superposition of the three photodiodes as seen from the entrance hole. The incident beam should be collimated or converging with the focus imaged onto the surface of the third photodiode. The size of the beam should be adjusted to avoid the vignetting[14] by the input aperture with a diameter of 11 mm, and the spot size at all the photodiodes should be significantly smaller than 8 mm in diameter.

4.3.10. 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 participants in the comparison. No other measurements are to be attempted by the participants nor any modification to the operating conditions during the course of this comparison. In particular, **the detectors must never be intentionally exposed to radiation below 280 nm nor above 1100 nm**. They must never be placed under vacuum.

4.3.11. Any information obtained relating to the use or any results obtained by a participant during the course of the comparison shall be sent only to the pilot laboratory as quickly as possible. The pilot will be responsible for co-ordinating how the information should be disseminated to other participants. No communication whatsoever regarding any details of the comparison other than the general conditions described in this protocol shall occur between any of the participants or any party external to the comparison without the written consent of the pilot laboratory. The pilot laboratory will in turn seek permission of all the participants. This is to ensure that no bias from whatever accidental means can occur.

[12] Wavelengths specified in this document are values in air.

[13] When laser radiation is used for measurement, a collimated beam with a diameter larger than 1 mm and a radiant power lower than 1 mW is recommended to avoid the nonlinearity at high irradiance. Moreover, the interference effect at the window of the single-element detectors should be considered for lasers.

[14] Note that vignetting can have spectral effects. See K. D. Stock and R. Heine, Influence of vignetting errors on relative spectral responsivity of trap detectors, Metrologia 35, 447-450 (1998)

5. Reporting of results and uncertainties

5.1. On completion of the measurements by a participant, the measurement results should be reported to the pilot via email or fax by using the form in APPENDIX 2: RESULT REPORT[15] **immediately after the measurement is finished**, at the latest within six weeks. Only the scanned copy of the reports signed by the contact person (or one of the contact persons) of the participating laboratory can be accepted as the official submission of the comparison results.[16]

5.2. In addition to the result report, the participant is requested to provide the pilot a **technical report** containing the information listed in the following. The template, a Microsoft Word file, for the technical report will be provided by the pilot via email before the transfer detectors are delivered. The report should be sent to the pilot via email as an editable file **within six weeks** after the completion of measurement.

- Measurement setup and instruments
- Measurement conditions and parameters
- Traceability of measurement
- Detailed uncertainty budget according to the *ISO Guide to the Expression of Uncertainty in Measurements* (including model equation, origin and type of uncertainty, probability distribution, sensitivity, degree of freedom, etc.)

5.3. The uncertainty budgets of the technical report should include, at least, the following principal components:

- Repeatability and/or resolution of readings of photocurrent and resistance
- Accuracy of measurement instruments for readings
- Accuracy of reference standards (or of the scale realization)
- Effect of wavelength accuracy and spectral purity (spectral stray) of radiation source
- Effect of spectral bandwidth of radiation source
- Effect of beam alignment to detector
- Effect of size and divergence of radiation beam
- Effect of radiant power stability
- Effect of polarization of radiation beam
- Effect of ambient stray light
- Effect of detector nonlinearity

5.4. In the uncertainty budgets of the technical report, the participant should state whether and how an uncertainty component is artefact-dependent.

[15] In Appendix 2, "the relative standard uncertainty associated with random effects" should be separately reported, which is the combined standard uncertainty value of all the uncertainty components in the budget evaluated by a statistical analysis (type A evaluation).

[16] The pilot can request additionally a result report in the form of an Excel file for convenience for data analysis. However, the signed report submitted via email and fax will have priority.

5.5. According to the CCPR-G2 guidelines[17], the result will be known only to the pilot until the completion of the Pre-Draft A process.

6. Preparation of comparison report

6.1. After the measurement schedule of every participant is completed, the pilot will prepare the report of the comparison according to the CCPR-G2 guidelines.

6.2. Before starting the Pre-Draft A process, the pilot will re-confirm its reception of the transfer detectors, the measurement results, and the technical reports from every participant. If any result or report is missing by this time, the pilot will announce a deadline for re-submission. After this, the pilot will proceed with the report preparation with only the data submitted by the deadline.

6.3. In order to allow a linkage to the follow-up RMO key comparisons only by using a set of single-element photodiodes, **the data analysis will be separated for each type of transfer detectors**. As a result, two sets of DoEs will be reported: one for the single-element photodiodes, and the other for the trap detectors.

6.4. For data analysis, the analytical method described in the CCPR-G2 guidelines will be used. In addition to this method, an alternative approach, e.g., the generalised least squares (GLS) approach applied to CCPR-K6.2010[18], can be used when its validity and usefulness is verified by CCPR.

[17] CCPR-G2: Guidelines for CCPR key comparison report preparation, Rev. 3 (2013);
http:/ / www.bipm.org/ utils/ common/ pdf/ CC/ CCPR/ CCPR-G2.pdf

[18] CCPR-K6.2010 Key Comparison Spectral Regular Transmittance, Technical Protocol;
http:/ / kcdb.bipm.org/ AppendixB/ AppBResults/ CCPR-K6.2010/ CCPR-K6.2010_Technical_Protocol.pdf

APPENDIX 1: INSPECTION REPORT ON RECEIPT OF TRANSFER DETECTORS

Has the detector set package been opened during transit? (e.g. by Customs) …… Y / N

If Yes, please give details.

Is there any damage to the transportation package? …… Y / N

If Yes, please give details.

Are there any visible signs of damage to the detector or housing? …… Y / N

If Yes, please give details (e.g. scratches, contaminations, etc).

Do you believe the transfer detectors are functioning correctly? …… Y / N

If No, please indicate your concerns.

Laboratory: ……

Date: …… Signature: ……..……

APPENDIX 2: RESULT REPORT

- Transfer detector serial number: _____
- Measurement dates: from _____ to _____
- Laboratory condition: temperature (±) ℃ , relative humidity (±) %

wavelength (nm)	spectral responsivity (A/W)	relative standard uncertainty (combined)* (%)	spectral bandwidth** of radiation source (nm)	number of individual measurements	relative standard uncertainty associated with random effects (%)	PT100 reading (Ohm)
300						
320						
340						
360						
380						
400						
450						
500						
550						
600						
650						
700						
750						
800						
850						
900						
950						
1000						

* with a coverage factor $k = 1$ ** full width at half maximum (FWHM)

Laboratory: ……

Date: …… Signature: ……..……