EURAMET-K6.2015 Key Comparison

Spectral Regular Transmittance

Technical Protocol

1. Introduction

1.1. At its annual meeting in April 2014, the EURAMET TC-PR decided that a key comparison of spectral regular transmittance would be carried out and appointed LNE-CNAM (France) to act as pilot laboratory.

1.2. This technical protocol is written according to the guideline CCPR-G6 [1] and the CCPR comparison protocol “CCPR-K6.2010 Key Comparison Spectral Regular Transmittance” [2]. It defines the measurands and measurement procedure to be followed in this comparison.

1.3. The protocol covers the technical procedure to be followed during measurement of the transfer standard filters. The procedure is based on current best practice in the use of standard filters and takes account of the experience gained from the previous comparisons organised in this field [3][4][5][6][7].

1.4. This technical protocol has been drawn up by a small working group comprising LNE-CNAM (France), CMI (Czech Republic), INM-Md (Republic of Moldova), DMDM (Serbia), IPQ (Portugal), VSL (Netherlands) and VTT (Finland).

2. Organisation

2.1. Link laboratories

It was agreed at the EURAMET TC-PR meeting in January 2015 that LNE-CNAM and PTB serve as link laboratories to the CCPR-K6.2010 Key Comparison Spectral Regular Transmittance (see section 2.4 for details).

2.2. Participants

2.2.1. The list of participants was agreed upon at the EURAMET TC-PR meeting in January 2015. 16 participants are accepted for this comparison (see section 2.3 for details).

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

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

2.3. Participants’ details

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2.4. Link laboratories

Laboratoire Commun de Métrologie (LNE-CNAM)	Gael Obein 61 Rue du Landy 93210 La Plaine St Denis France	Phone : +33 1 58 80 87 88 gael.obein@cnam.fr
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2.5. Form of comparison

2.5.1. The comparison will be carried out through the calibration of sets of transfer standard filters. Each participant will use a separate set of filters to minimise the time needed for the completion of the comparison.

2.5.2. A full description of the transfer standard filters is given in section 3 of this protocol.

2.5.3. The comparison will take the form of a star comparison comprising 5 steps:

Step 1. The artefacts (filters) will initially be calibrated by the pilot laboratory.
Step 2. The artefacts (filters) will then be distributed to participants who will perform a calibration.
Step 3. The artefacts (filters) will be returned to the pilot laboratory to carry out a repeat calibration.
Step 4. The artefacts (filters) will then be redistributed to participants to make a second calibration.
Step 5. The artefacts (filters) will then be returned to the pilot laboratory.

2.5.4. Each laboratory has 3 months for calibration and transportation. With its confirmed application to participate, each laboratory has confirmed that it will undertake to complete the measurements in the time allocated to it. In steps 2 and 4, the deadline for returning the artefacts will be notified when the filters are shipped to participants.

2.5.5. Final results must be submitted directly to the pilot laboratory within six weeks of completion of each round of measurements by each participating laboratory. The deadline for submitting results will also be notified when the filters are shipped to participants.

2.5.6. If, for some reason, the measurement facility is not ready or customs clearance takes too much time in a country, the participant laboratory must contact the pilot laboratory immediately. For such a situation, it may be possible for the participant to continue to take part by returning the calibrated filters back to the pilot laboratory at an agreed later date. However, in view of the large amount of work for the pilot laboratory, this may not be possible. If this is the case or if results are not reported to the pilot in accordance with the deadlines, then the participant may be disqualified and their results will be excluded from the final report.

2.5.7. Draft Timetable

Activity	**Date**
Invitation to participate	November 2014
Receipt of request to participate	January 2015
First measurement by Pilot Laboratory (Step 1)	June 2016
Filters sent to participants (Step 2)	November 2016
First measurement by participants	
Filters returned to Pilot Laboratory (Step 3)	February 2017
Results of first measurement submitted to Pilot	6 weeks from above
Second measurement by Pilot laboratory	
Filters sent to participants (Step 4)	June 2017
Second measurement by participants	
Filters returned to Pilot laboratory (Step5)	September 2017
Final results and other data submitted to Pilot Laboratory	6 weeks from above
Third measurement by Pilot laboratory	
Pre-Draft A process starts	February 2018
Draft A comparison report circulated	May 2018
Draft B comparison report submitted to CCPR	

2.6. Handling the artefacts

2.6.1. During steps 2, 3, 4 and 5 of section 2.5.3, the standard filters should be examined immediately upon receipt at final destination. The condition of the filters and associated packaging should be noted and communicated to the pilot laboratory. The form in *appendix B.1* should be filled in and sent to the pilot laboratory for each of these steps using preferably a *pdf* file.

2.6.2. The standard filters should only be handled by authorised persons wearing powder-free gloves and stored in such a way as to prevent damage.

2.6.3. Filters have to be treated as filters received from a regular client and must follow the measurement protocol of the participant. This is the choice of the lab to clean or not the filters. If cleaning is decided :

- make a measurement before cleaning
- use your own standard cleaning method, which must be described in their calibration report.
- make a measurement after cleaning

2.6.4. Cleaning must be indicated in the measurement report and documented using the form in *appendix B.2.* If a filter appears damaged, a replacement may be available from the pilot laboratory.

2.6.5. After the measurements of each step of section 2.5.3, the form in *appendix B.2* must be filled in and sent to the pilot laboratory before the filters are packaged in their original transit cases for transportation (steps 1, 2, 3 and 4). Ensure that the content of the package is complete.

2.7. Transport of artefacts

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

2.7.2. Artefacts should be marked as “fragile”.

2.7.3. If required, participants may request that the pilot laboratory arrange for a customs carnet to accompany the artefacts on the first round of measurements. If a carnet is not used, the artefacts should be accompanied by documentation identifying the items uniquely.

2.7.4. The pilot laboratory covers the costs for transportation to the participant laboratory. Transportation back to the pilot laboratory is each participant laboratory’s responsibility and cost. Each participating laboratory covers the costs for its own measurements, transportation and any customs charges as well as for any damage that may have occurred within its country. The pilot laboratory has limited insurance for any loss of or damage to the standards during transportation. If damage occurs in France or in transit from the pilot laboratory to the participant then the pilot laboratory will replace the set of artefacts at its own cost.

3. Description of the standards

3.1. The filter set to check the photometric scale consists of 5 neutral grey glass filter plates 50 mm × 50 mm with nominal transmittance, at the wavelength of 546 nm, of 0.92, 0.50, 0.10, 0.01 and 0.001.

3.2. Each filter is identified by a reference engraved in the top left corner outside the area used for measurement. This reference has two parts. One is a number indicating the set to which the filter belongs, the other is a letter indicating the filter type (see table below).

3.3. The main characteristics of the filters are summarised in the following table:

Nominal transmittance, T_n	Type of glass	Nominal thickness, t_n / mm	Filter Type Identifier
0.92	BK 7	4.0	A
0.50	NG 11	2.0	B
0.10	NG 5	3.9	C
0.01	NG 4	3.9	D
0.001	NG 3	3.1	E

4. Measurement instructions

4.1. Traceability

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

4.2. Measurand

4.2.1. The measurand is the average spectral transmittance of each filter

- over a circular area of 17 mm diameter centred on the middle of the filter
- over a bandwidth of 1 nm centred on the wavelengths: 380 nm, 400 nm, 500 nm, 600 nm, 700 nm, 800 nm, 900 nm and 1000 nm
- for a parallel beam with normal angle of incidence
- at a temperature of 23 °C
- and at a relative humidity not exceeding 60 %.

4.3. Measurement instructions

4.3.1. Before measurement, each filter should be inspected for damage or contamination. Any initial or subsequent damage or cleaning should be documented using the appropriate form in *appendix B.1* or *B.2.*

4.3.2. The measurement should be performed in suitable laboratory accommodation maintained at a temperature as close as possible to 23 °C and at a relative humidity not exceeding 60 %. The temperature and relative humidity of the laboratory during the time of the measurements should be reported. It is the responsibility of the individual laboratory to correct the measurement for the deviation of the temperature from 23 °C. The pilot laboratory will provide the participants with temperature coefficients and their uncertainties for the filters.

4.3.3. The filter transmittance must be measured independently several times. The number of measurements should be that normally used by the participating laboratory to obtain the appropriate accuracy of their specific measurement facility. The number of measurements used should be stated in the measurement report but only the mean or final declared value of each filter of the set is required to be included.

4.3.4. The transmittance measurement of the filters should be made at wavelengths of 380 nm, 400 nm, 500 nm, 600 nm, 700 nm, 800 nm, 900 nm and 1000 nm.

4.3.5. The measurement of interest in this comparison is the average transmittance of each filter over a circular area of 17 mm diameter centred on the middle of the filter as determined from the edges of the filter. The ideal beam is therefore a circular beam of 17 mm diameter. Should the measurement beam be different to this, then the participant laboratory should incorporate an uncertainty to account for this when estimating the average transmittance over the area of interest for this comparison.

4.3.6. The beam geometry shall be as close as possible to a parallel beam with normal angle of incidence. Any deviation from these conditions should be reported. Any influence on transmittance as defined by 4.2.1 caused by such deviations should be handled as either a correction with associated uncertainty or solely as an uncertainty, whichever is the participant laboratory's regular practice.

4.3.7. The preferred bandwidth for the measurements is 1 nm; the bandwidth used should be stated in the report. Should the participant laboratory make measurements using some different bandwidth, then any bandwidth effects should be accounted for by the participant in their uncertainty budget.

4.3.8. No information relating to the comparison, such as measurement results, obtained by a participant during the course of the comparison shall be communicated to any party other than the pilot laboratory. The pilot laboratory will be responsible for disseminating information to other participants and any other release of information. In the latter case the pilot laboratory will seek permission of all the participants before releasing information.

5. Measurement uncertainty

5.1. Measurement uncertainty shall be estimated according to the ISO Guide to the Expression of Uncertainty in Measurement [8]. In order to achieve optimum comparability, a list containing the principal influence parameters for calibration of spectral transmittance is given below. The participating laboratories are encouraged to follow this breakdown as closely as possible and adapt it to their instruments and procedures if necessary. Other additional parameters can be added to the list as deemed appropriate; these include dependence on specific measurement facilities and should be added with an appropriate explanation and/or reference. All values should be given as absolute uncertainties for a coverage factor of $k = 1$.

5.2. The reproducibility of measurements can be determined by calculating the standard deviation of a set of measurements with realignment and repositioning of the filter between each individual measurement. It characterizes the whole process of the measurement. It is this value which has to be taken into account for the uncertainty evaluated according the type A method.

5.3. Type B uncertainty components may include the following:

- Temperature of the filter during measurement[*],
- Non-linearity of the detector over the dynamic range of the detector used for the measurements,
- Component due to the uncertainty in the wavelength setting of the monochromator,

- Stray light*,
- Beam size and position,
- Inter-reflection between the filter and the various optical and mechanical components of the experimental set-up,
- Obliquity effects (changes to path length and Fresnel reflection) due to a non-parallel beam or the imperfect alignment of the filter*,
- Polarisation of the light,
- Drift of the sources during the measurements*,
- Bandwidth,
- Any other uncertainty components specific to the apparatus used for the measurements as explained in §5.1*.

5.4. Some components of type B uncertainty will be partially or wholly correlated between the measurements of steps 2 and 4. The degree of correlation and the total correlated and uncorrelated type B components must be reported at the completion of step 4 using the table A-3ii in appendix A.3.

6. Reporting of results

6.1. The final results should be submitted to the pilot laboratory at the latest within six weeks from completion of measurements in steps 2 and 4. The tables in *appendices A.1* and *A.2* should be completed after step 2 and the tables in *appendices A.1* and *A.3* should be completed after step 4.

6.2. The measurement report tables (*appendices A.1*, *A.2* and *A.3*) of this document will be sent by e-mail (as a Microsoft word document) to all participants to be filled in. It would be appreciated if the completed form could be sent back electronically to the coordinator. **In any case, the signed report including the results must also be sent in paper form by mail, or in PDF or JPG.** In case of any differences, these signed versions of the reports are considered to be the definitive versions.

6.3. In completing the description of the participant's measurement facility, *Appendix A.1*, a schematic diagram of the facility should be included.

6.4. Following receipt of all measurement reports from the participating laboratories, the pilot laboratory will follow the procedure outlined in the Guidelines for CCPR Comparison Report Preparation [1].

* These components have to be systematic and the participant must check to not double count components that have been accounted for in 'reproducibility'.

7. Analysis of Comparison Results

7.1. Introduction

In the Technical Supplement to the Mutual Recognition Arrangement (MRA) [10], key comparisons are identified as the technical basis for the arrangement. The technical deliverables of a key comparison are outlined as:

(a) Reference values, known as key comparison reference values (KCRV).

(b) Unilateral degree of equivalence (DoE) of each national measurement standard, both its deviation from the KCRV and the uncertainty of that deviation at the 95 % level of confidence.

The bilateral degrees of equivalence between pairs of national measurement standards are also defined in the Technical Supplement; however, it has been decided by CCPR that these are no longer required to be reported in CCPR key comparison reports [11].

As the key comparisons are the technical basis for the MRA, the results reported should be the basis upon which CMCs are validated and subsequently evaluated. The CCPR Guidelines state that all participants should be able to "check the consistency of their CMCs with the KC results" ([9], §7.4). This means that the comparison should determine the value of each participant's bias (DoE) and the uncertainty associated with that value in order to give some indication as to whether a participant has adequately estimated the likely magnitude of that bias.

7.2. Data Analysis Model

The results of the EURAMET-PR comparison are analysed according to the appendix A of the Guidelines for RMO PR Key Comparison §A.2.3 [1].

In the following, we will call the pilot link laboratory *p*, the non pilot link laboratory *j* and the participant α.
Each of the 40 measurements (5 filters × 8 wavelengths) is considered an independent comparison of standards, with its own DOEs.
For a single measurement of a single artefact, the DoE of the participant α, through the pilot *p* and the other link *j*, is given by:

$$D_{\alpha(p)} = D_p + (y_\alpha - y_{p\alpha}) \quad (1)$$

$$D_{\alpha(j)} = D_j + (y_{pj} - y_j) + (y_\alpha - y_{p\alpha}) \quad (2)$$

Where

- $D_{\alpha(p)}$ is the unilateral DoE for the laboratory α, calculated via pilot *p*, and $D_{\alpha(j)}$ is the unilateral DoE for the laboratory α, calculated via link *j* and pilot *p*.
- D_p and D_j are the unilateral DoEs for the link laboratoties *p* and *j* respectively, calculated during CCPR-K6.
- $y_\alpha - y_{p\alpha}$ is the average value over the 2 rounds of the difference between participant α's measurement result and the pilot *p*'s measurement result.
- $y_{pj} - y_j$ is the average value over the 2 rounds of the difference between pilot *p*'s measurement result and the link *j*'s measurement result.

The DoE of the laboratory α to the CCPR-K6 key comparison reference value, is then calculated as

$$D_\alpha = W_p D_{\alpha(p)} + W_j D_{\alpha(j)} \; ; \; W_j + W_p = 1 \quad (3)$$

$$D_\alpha = W_p\left[D_p + \left(y_\alpha - y_{p\alpha}\right)\right] + W_j\left[D_j + \left(y_{pj} - y_j\right) + \left(y_\alpha - y_{p\alpha}\right)\right] = \\ W_pD_p + y_\alpha - y_{p\alpha} + W_j\left(D_j + y_{pj} - y_j\right) \quad (4)$$

The weights are:

$$W_p = \frac{\bar{W}}{\bar{\sigma}_p^2 - u_{p,r,\mathrm{RMO}}^2 - s_{\mathrm{RMO}}^2}\ ;\ W_j = \frac{\bar{W}}{\bar{\sigma}_j^2 + u_{p,r,\mathrm{RMO}}^2}\ ; \bar{W} = \frac{\left(\bar{\sigma}_j^2 + u_{p,r,\mathrm{RMO}}^2\right)\left(\bar{\sigma}_p^2 - u_{p,r,\mathrm{RMO}}^2 - s_{\mathrm{RMO}}^2\right)}{\bar{\sigma}_p^2 + \bar{\sigma}_j^2 - s_{\mathrm{RMO}}^2} \quad (5)$$

$$\bar{\sigma}_p^2 = s_{\mathrm{KC}}^2 + s_{\mathrm{RMO}}^2 + u_{p,\mathrm{st}}^2 + u_{p,r,\mathrm{KC}}^2 + u_{p,r,\mathrm{RMO}}^2 \quad (6)$$
$$\bar{\sigma}_j^2 = s_{\mathrm{KC}}^2 + s_{\mathrm{RMO}}^2 + u_{j,\mathrm{st}}^2 + u_{j,r,\mathrm{KC}}^2 + u_{j,r,\mathrm{RMO}}^2 \quad (7)$$

where

- s_{KC} is the transfer uncertainty for CCPR.K6. It quantifies the artefact instability factor and it is the term added, during the Mande-Paule approach, to obtain consistency in the key comparison.
- $u_{p,\mathrm{st}}$ and $u_{j,\mathrm{st}}$ are standard uncertainties associated with the instability of the scale for respectively the pilot and the link laboratory between CCPR.K6 and EURAMET.K6.
- $u_{p,r,\mathrm{KC}}$ and $u_{j,r,\mathrm{KC}}$ are the standard uncertainties associated with random effects for respectively the pilot and the link laboratory during CCPR.K6.
- $u_{p,r,\mathrm{RMO}}$ and $u_{j,r,\mathrm{RMO}}$ are the standard uncertainties associated with random effects for respectively the pilot and the link laboratory during EURAMET.K6.
- s_{RMO} is the standard transfer uncertainty of EURAMET.K6 key comparison that may come from the instability of the filters.

The standard uncertainty is calculated using

$$u^2(D_\alpha) = {W_p}^2\, u^2\left(D_p\right) + u^2(y_\alpha) + u^2\left(y_{p\alpha}\right) + {W_j}^2\left(u^2\left(D_j\right) + u^2\left(y_{pj}\right) + u^2\left(y_j\right)\right) \\ +2W_pu\left(D_p, y_{p\alpha}\right) - 2W_pW_ju\left(D_p, y_{pj}\right) - 2W_pW_ju\left(D_p, D_j\right) \\ +2W_ju\left(y_{p\alpha}, y_{pj}\right) + 2W_ju\left(y_{p\alpha}, D_j\right) - 2{W_j}^2u\left(D_j, y_{pj}\right) + 2{W_j}^2u\left(D_j, y_j\right) \quad (8)$$

All of the correlation coefficients required for this analysis are given in the appendices L and M of the CCPR K6 final report [12] except for

$$u\left(y_{p\alpha}, y_{pj}\right) = {u_{p,\mathrm{sy}}}^2 \quad (9)$$

where $u_{p,\mathrm{sy}}$ is the systematic component of the pilot and link uncertainty budget.†

The uncertainty component of the unilateral DoE of the participant α is given as an expanded uncertainty

$$U(D_\alpha) = 2u(D_\alpha) \quad (9)$$

References

† Equation (8) and (9) estimating the uncertainty of D_α assume that the systematic component of uncertainty reported by the two link labs is the same in the CCPR comparison as the RMO comparison, and any changes in systematic components are considered part of $u_{i,\mathrm{st}}$.

[1] CCPR-G6 “Guidelines for RMO PR Key Comparisons”, October 10, 2014
[2] “CCPR-K6.2010 Key Comparison Spectral Regular Transmittance.” Technical Protocol”, May 2013.
[3] K.L. Eckerle, J. Bastie, J. Zwinkels, V. Sapritsky and A. Ulyanov, 1993, “Comparison of regular transmittance scales of four national standardizing laboratories,” *Col. Res.Appl.* **18** 35.
[4] J.F. Verrill, 1996, “Intercomparison of spectrophotometric measurements of regular transmittance,” Report contract N°. MAT1-CT940021.
[5] Obein G. and Bastie J., 2008, *Report on the CCPR Key Comparison K6 Spectral regular transmittance*, available at http://kcdb.bipm.org/AppendixB/appbresults/ccpr-k6/ccpr-k6_final_report.pdf
[6] Obein G., Bastie J., 2009, “Report on the CCPR Key Comparison K6: Spectral Regular Transmittance,” *Metrologia* **46**, Tech. Suppl., 02002.
[7] Obein G., Bastie J., 2011, Report on the key comparison EUROMET-PR-K6: Spectral regular transmittance, *Metrologia*, **48**, Tech. Suppl., 02002
[8] BIPM IEC IFCC ILAC ISO IUPAC IUPAP and OIML 2008 *Guide to the Expression of Uncertainty in Measurement* (Geneva: International Organization for Standardization) available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf
[9] CCPR-G2 “Guidelines for CCPR Key Comparison Report Preparation”, July 3, 2013
[10] International Committee for Weights and Measures, 2003, Mutual Recognition of National Measurement Standards and of Calibration and Measurement Certificates Issued by National Measurement Institutes (Paris: Comité International des Poids et Mesures), available at http://www.bipm.org/utils/en/pdf/mra_2003.pdf
[11] CCPR 2009 *20th CCPR Meeting*, Decision D8.
[12] CCPR-K6-2010 final report published on BIPM website on Feb 2017-11-08 https://www.bipm.org/utils/common/pdf/final_reports/PR/K6/CCPR-K6.2010_Final_Report_with_AppendicesILM.pdf

Appendix A.1
Description of measurement facility and measurement method

Laboratory:

Indicate whether this table relates to Step 2 [ ] or Step 4 [ ]

If the measurement setup has not changed from Step 2, check here [ ] and the following table does not need to be completed. Otherwise, please fill out the whole table.

Table A-1 Details of Measurement Setup

Make and Type of Spectrophotometer	
Additional Stray Light Rejection	
Source Drift Monitoring	
Source	
Detector	
Temperature[(a)]	
Humidity	
Beam Size	
Beam Collimation	
Measurement Sequence[(b)]	
Bandwidth	

[(a)] i.e. describe method of temperature monitoring of filters and range of temperatures [(b)] i.e. describe number of measurements and whether filter orientation with respect to beam changes between measurements

Description of measuring technique (please include a diagram)

If any damage, contamination or cleaning of the filters was carried out, please give details

Signature : **Date :**

Appendix A.2
Measurement Results

Please reproduce the following tables for each of the five filters measured **at the completion of step 2 of the comparison**.

Laboratory: Filter Identifier:

Table A-2i Measurement Results

Wavelength, λ / nm	380	400	500	600	700	800	900	1000
Spectral Transmittance[(a)], T								
Number of Measurements, N								
Temperature, t / °C								
Type A Uncertainty[(b)], u_A								
Type B Uncertainty[(c)], u_B								
Total Uncertainty[(d)] , u_{total}								
Degrees of Freedom, ν								

[(a)]**Spectral transmittance.** The value of the spectral transmittance of the central 17 mm diameter of the filter as measured by the participant laboratory. [(b)]**Type A Uncertainty.** The uncertainties associated with the spectral transmittance values attributed to reproducibility of the measurement. [(c)]**Type B Uncertainty.** The uncertainties associated with the spectral transmittance values attributed to all type B sources. [(d)]**Total Uncertainty.** The total uncertainty of the measurement of spectral transmittance for a coverage factor of $k = 1$.

Table A-2ii Type B Uncertainty Budget[(a)(c)]

All uncertainties should be reported as absolute uncertainties.

Wavelength, λ / nm	380	400	500	600	700	800	900	1000
Nonlinearity								
Temperature								
Wavelength								
Stray Light								
Beam Size & Position								
Inter-reflection								
Obliquity								
Polarization								
Source Drift & Fluctuation								
Bandwidth								
Other[(b)]								
Total Type B Uncertainty								
Degrees of Freedom								

[(a)] Please record any uncertainties considered negligible as zero (rather than e.g. < some value) [(b)]Add lines to the table as necessary, itemising other components of uncertainty considered (c)The uncertainty of the measurement of spectral transmittance for a coverage factor of $k = 1$

Signature : **Date :**

Appendix A.3
Measurement Results

Please reproduce the following tables for each of the five filters measured **at the completion of step 4 of the comparison**.

Laboratory: Filter Identifier:

Table A-3i Measurement Results

Wavelength, λ / nm	380	400	500	600	700	800	900	1000
Spectral Transmittance[(a)], T								
Number of Measurements, N								
Temperature, t / °C								
Type A Uncertainty[(b)]), u_A								
Type B Uncertainty[(c)], u_B								
Total Uncertainty[(d], u_{total}								
Degrees of Freedom, ν								

[(a)]**Spectral transmittance.** The value of the spectral transmittance of the central 17 mm diameter of the filter as measured by the participant laboratory. [(b)]**Type A Uncertainty.** The uncertainties associated with the spectral transmittance values attributed to reproducibility of the measurement. [(c)]**Type B Uncertainty.** The uncertainties associated with the spectral transmittance values attributed to all type B sources. [(d)]**Total Uncertainty.** The total uncertainty of the measurement of spectral transmittance for a coverage factor of k = 1.

Table A-3ii Type B Uncertainty Budget[(a)]

All uncertainties should be reported as absolute uncertainties.

Wavelength, λ / nm	380	400	500	600	700	800	900	1000	Correlated component
Nonlinearity									
Temperature									
Wavelength									
Stray Light									
Beam Size & Position									
Inter-reflection									
Obliquity									
Polarization									
Source Drift & Fluctuation									
Bandwidth									
Other[(b)]									
Total Type B Uncertainty									
Degrees of Freedom									

[(a)] Please record any uncertainties considered negligible as zero (rather than e.g. < some value). [(b)] Add lines to the table as necessary, itemising other components of uncertainty considered

Signature : **Date :**

Appendix B.1
Receipt of Standards

To Laboratory:

From Laboratory:

Has the filter transportation package been opened during transit? e.g; Customs…..Y / N
If yes please give details:

Is there any damage to the packaging?…….Y / N
If yes please give details:

Are there any visible signs of damage or contamination on the filters?……Y / N
If yes please give details:

We confirm receipt of the standards of the BIPM Key comparison K6.2010 "Regular Spectral Transmittance".

Signature : **Date :**

Appendix B.2
Condition of the transfer standards on departure

Laboratory:

Were the filters contaminated or damaged in any way while at your laboratory? Y / N
If yes please give details:

Was any cleaning of filters undertaken while at your laboratory? Y / N
If yes please give details:

Signature : **Date :**