# Comparison of the air kerma standards for $^{137}$Cs and $^{60}$Co gamma-ray beams for radiation protection measurements (EURAMET Project #1326)

BIPM KCDB: EURAMET.RI(I)-S17

Technical Protocol

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## 1. Introduction

In October 1999, National Metrology Institutes (NMI) worldwide signed the Mutual Recognition Arrangement (MRA: 'Arrangement on the mutual recognition of the equivalence of national standards and of calibration certificates issued by national metrology institutes'). The aim of this arrangement is the establishment of a basis for the mutual recognition of calibration and measurement capabilities (CMCs). The BIPM has been publishing lists of these CMCs provided by the NMIs that have signed the MRA. Calibration services can, however, only be included in this database if a quality management system according to the ISO standard 17025 has been established and the updated evidence of quality assurance and confidence in the calibration and measurement capabilities have been provided. This supporting evidence is usually obtained by the successful participation in comparisons in which the degrees of equivalences (DoE) with the key comparison reference value or with other National Metrology Institutes or Designated Institutes included in the key comparison database have been determined.

Key comparisons for air kerma in $^{137}$Cs and $^{60}$Co beams are conducted bilaterally between the primary standards of the BIPM and the NMIs within the ongoing comparisons labeled BIPM.RI(I)-K5 and BIPM.RI(I)-K1, respectively. Many NMIs maintain radiation qualities with $^{137}$Cs and $^{60}$Co sources of lower activities in order to calibrate dosimeters at protection level air kerma rates of the order of µGy/h and mGy/h. Secondary standards are used to carry out the calibrations in such fields, as in the case of the Metrology Laboratory for Ionizing Radiation (LMRI) of the CIEMAT (Spain).

The aim of this proposed supplementary comparison is to confirm the calibration and measurement capabilities of the LMRI for air kerma calibrations at protection level, in $^{137}$Cs and $^{60}$Co radiation beams. The LMRI secondary standard ionization chambers are traceable to the NPL in terms of air kerma. The comparison partner IST-LPSR-LMRI has a primary standard for air kerma with DoE values in the key comparison database (KCDB) of the CIPM MRA based on the BIPM.RI(I)-K5 (2008) [1] and BIPM.RI(I)-K1 (2005) [2] comparisons and will pilot the comparison. As a supplementary comparison, no link to the respective key comparisons will be established for the LMRI but the results of the IST-LPSR-LMRI will be regarded as the comparison reference values (CRVs) to evaluate the results.

For the comparison, two reference-class transfer chambers of about 1000 cm$^3$ have been selected. The calibration coefficients at air kerma rates between 0,5 mGy/h and about 10 mGy/h and the corresponding uncertainties of the ionization chambers will be compared.

## 2. Participants

*Table 1: Participants and contact persons*

| Institute | Country | Contact | e-mail |
|---|---|---|---|
| IST-LPSR | Portugal | João Cardoso | jcardoso@ctn.tecnico.ulisboa.pt |
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*Note: Complete addresses are given in Appendix B*

## 3. Procedure

### 3.1. Object of the comparison

Calibration of two ionization chambers in term of air kerma in $^{137}Cs$ and $^{60}Co$ reference radiation beams, at protection level. One chamber will be provided by the CIEMAT and the other one by the IST-LPSR.

### 3.2. Transfer chambers

The main data of the transfer chambers are summarized in Table 2, below. Pictures of the transfer chambers and the connectors are shown in Appendix A.

Table 2: Technical data of the transfer chambers

| No. | Type | Serial No. | Nominal Volume ($cm^3$) | Outer Diameter (mm) | Reference point | Polarizing Voltage[(a)] (V) | Cable connection |
|---|---|---|---|---|---|---|---|
| 1 | PTW 32002 | 00345 | 1000 | 140 | Chamber centre | + 400 | Triaxial TNC (Male) |
| 2 | OFZ LS-01 | 113 | 1000 | 140 | Chamber centre | +400 | BNC coaxial + Lemo (HV) |

a) The polarity of the chamber wall shall be positive with respect to that of the collecting electrode.

### 3.3. Reference conditions, measurement procedure and report of results

The air kerma rates should not be less than 0,5 mGy/h. The useful beam diameter (less than 5 % fall) should be at least 1.5 times the chambers diameter. The transfer chambers shall be positioned with the stem perpendicular to the beam axis and the mark on the stem oriented to the source. The reference point for positioning the chambers in the beams will be the geometrical center of the chambers cavity.

The transfer chambers shall be placed in the laboratory at least 12 hours before the measurements start in order to let them adjust to the climatic conditions. The electrometer and high voltage supply shall be warmed up for at least 2 hours. After the polarizing voltage is applied to the transfer chamber and the signal cable is connected to the electrometer, it is advisable to wait at least 1 hour to stabilize the whole ionizing current measurement system.

The chambers background currents, at the point of measurements, should be measured before and after the chambers are exposed to the radiation beams. The averages of background currents shall be subtracted from the measured ionization currents produced in the chambers when exposed to the sources of radiation. The signal to background ratio of the currents should not be less than 1000. A complete measurement should consist of at least 10 repeated single measurements and the mean value should be taken as the result.

The calibration coefficients of the transfer chambers shall be measured at the polarities indicated in table 2 and given in terms of air kerma per unit charge, in units of Gy/C, referred to standard conditions of air

temperature, pressure and relative humidity of $T$ = 293,15 K, $P$ = 101,325 kPa and $h$ = 50 %. No corrections for $h$ = 50 % will be required if during calibrations the relative air humidity is between 20 % and 80 %. No corrections will be applied for the incomplete charge collection.

The information to be included in the **results report,** for each radiation quality, is as follows:

- Method of determination of air kerma rate with the national air kerma standard, including a short description of the measuring devices and a detailed description of the determination of the conventional true value with the corrections used and the corresponding uncertainty budget.
- Description of the calibration measurements, if possible with pictures of the experimental set-up.
- Specifications of the electrometer used for the calibration of transfer chambers, including the traceability of its calibration.
- Climatic conditions prevailing in the calibration laboratory during the calibrations (Temperature, Pressure, Humidity)
- Description of the radiation field during calibrations: type of source, beam cross-section on the reference plane, air kerma rate, source to reference point distance
- Calibration coefficients of the two chambers
- Uncertainty budget of the calibration coefficients

The uncertainties shall be given in accordance with the ISO Guide to the expression of uncertainties in measurements [3].

### 3.4. Course of the comparison

The transfer chambers will be calibrated by both participants in their own respective $^{137}$Cs and $^{60}$Co beams. The CIEMAT will cover the transportation cost of the chambers to the IST-LPSR-LMRI and back to the CIEMAT. For the purpose of constancy check, each laboratory will repeat the calibrations of its respective transfer chamber after its return from the other laboratory. The circulation scheme is showed in Figure 1.

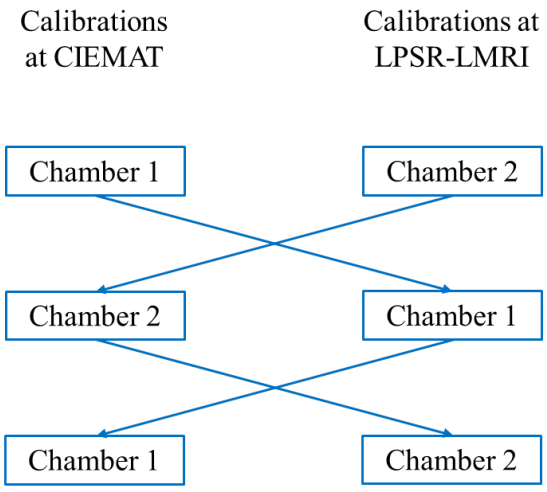



Figure 1: Circulation scheme for the calibrations at CIEMAT and IST-LPSR.

To preserve the confidentiality, the results report indicated in 3.3, shall be sent by each laboratory to the CCRI Executive Secretary and will be disclosed to both participants once both sets of data have been received.,

### 3.5. Prospective time schedule

The comparison is scheduled to commence in September 2014, according to the Table 3.

*Table 3: Proposed schedule of the comparison (September 2014 until November 2014)*

| Month | Calibrations at CIEMAT | Calibrations at IST-LPSR |
|---|---|---|
| September 2016 | Chamber 1 | Chamber 2 |
| October 2016 | Chamber 2 | Chamber 1 |
| November 2016 | Chamber 1 | Chamber 2 |

Transportation time from the chambers from CIEMAT to IST-LPSR and vice versa is about one week.

### 3.6. Evaluation of the results

The CCRI(I) Executive Secretary will provide the pilot laboratory with the other partner results so they can evaluate the comparison and prepare the Draft A report including the calculated DoE values for the CIEMAT standards with respect to the CRVs. The CRVs will be the results obtained by IST-LPSR who previously took part in the pertinent key comparisons. More details of the evaluation will be given in the first draft of the report on the results.

### 3.7. Publication of the results

After an agreement is reached between CIEMAT and IST-LPSR, the revised report Draft B will be produced as the official comparison report. This will be submitted to the EURAMET TC-IR Chairman for revision by that committee. After Draft B approval by the EURAMET TC-IR committee, the report will be sent to the CCRI Executive Secretary for a six-week period of comment and editorial control by the KCWG(I) and CCRI(I). After revision (if necessary), the final report will be sent to the CCRI Executive Secretary for publication in the KCDB and in the Technical Supplement of Metrologia.

## 4. References

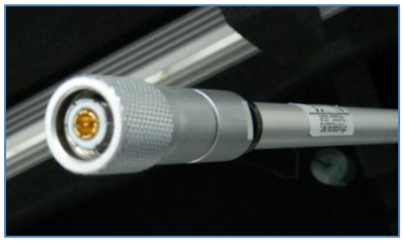

[1] Kessler C., Allisy-Roberts P. J., Burns D. T., Cardoso J., Oliveira C., Comparison of the standards for air kerma of the ITN (Portugal) and the BIPM for $^{137}$Cs γ-rays. Metrologia 46 - 06012, 2009

[2] Allisy-Roberts P. J., Burns D. T., Kessler C., Cardoso J., Comparison of the standards for air kerma of the ITN (Portugal) and the BIPM for $^{60}$Co γ-rays. Metrologia 46 – 06007, 2009

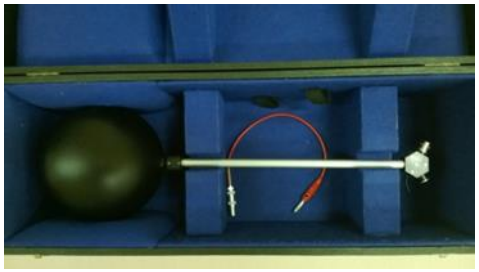
[3] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION: Uncertainty of measurement - Part 3: Guide to the Expression of Uncertainty in Measurement (GUM:1995) (Geneva: ISO), BIPM JCGM 100:2008; Guide to the Expression of Uncertainty in Measurement (GUM) ISO/IEC Guide 98-3, 2008

# Annex A: Pictures of the transfer chambers

Chamber 1: PTW 32002



Connector TNC of the chamber PTW 32002



Chamber 2: OFZ LS-01

Connectors of the chamber LS-01: BNC (female) and Lemo.

# Annex B: Complete addresses of the participants

**IST-LPSR - Portugal**

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