COOMET Project 641

Comparison of the national standards of air kerma for x-radiation qualities used for radiation protection and diagnostic radiology

Identifier in Appendix B of the key comparison database (KCDB):

COOMET.RI(I) – S3

Technical Protocol

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Introduction

Up to now only the national air kerma standards for gamma radiation qualities Cs-137 (protection level) and Co-60 (COOMET.RI(I)-S1 and –S2), have been compared among the countries organized in COOMET. Due to the fact that the majority of the member countries do not have realized the so-called CCRI-low- and medium-energy x-ray qualities used for the key comparisons BIPM.RI(I)-K2 and –K3 it was decided at the COOMET TC1.9 meeting in 2014 to change the scope of the corresponding key comparisons within COOMET (projects 446/DE/08, 447/DE/08) to the status of ongoing comparisons. However, for the time being it is more useful to compare the air kerma standards for x-radiation qualities used for radiation protection purpose (ISO 4037 narrow spectrum series) and used in diagnostic radiology (IEC 61267 RQR series). These qualities are already established and used by several members of COOMET and need support for the CMC entries of those countries. Therefore, the main objective of the current project is traceability confirmation of measurements and calibrations for these X-ray qualities according to the *Mutual Recognition Arrangement of national measurement standards and of calibration and measurement certificates issued by national metrology institutes* (CIPM-MRA, Paris, 14 October 1999).

1. Description of the project

The objective of this project is to carry out a supplementary COOMET comparison of the national standards of air kerma for x-radiation qualities used in radiation protection and diagnostic radiology (COOMET.RI(I)-S3) according to the *Mutual Recognition Arrangement of national measurement standards and of calibration and measurement certificates issued by national metrology institutes* (CIPM-MRA, Paris, 14 October 1999).

2. Participants

Table 1: Participants and contact persons

Participant	Institute	Country	Contact person	E-mail of contact person
Confirmed				
1	*VNIIM	Russia	Alexandr V. Oborin	oav@vniim.ru
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* Primary laboratories

3. Procedure

3.1 Object of comparison

Calibration of three ionization chambers of different types in terms of air kerma in the participants X-ray reference radiation fields under reference conditions as defined in 3.3 and 3.4.

3.2 Transfer chambers

Three Standard Imaging spherical ionization chambers with different volumes and wall thicknessesare provided by the BelGIM. Their specifications are in Table 1. The reference point of each chamber is in the centre of the spherical volume. The chambers need to be aligned in the beam with the mark on the stem facing the radiation source. The chambers have a Triax TNC Plug (M/F) with adapter to PTW-M type connector· Pictures of the chambers and the connectors are shown in Appendix A.

Table 1: Main technical data of the transfer chambers

Chamber Model	Exradin A3	Exradin A4	Exradin A5
Serial Number	XR143435	XP151681	XY150091
Collecting volume, cm^3	3.6	30	100
Applied Polarising Voltage,V	+300	+400	+400
Shell Wall Thickness, mm	0.25	0.5	3.0
Outside diameter, mm	19.6	39.1	63.1
Nominal Cal. Coeff, Gy/C	9.0E+6	1.1E+6	3.3E+5
Collector Diameter, mm	2.1	4.1	6.5

3.3 Radiation qualities

The comparison will be carried out by means of the calibration of three transfer ionization chambers in terms of air kerma under reference conditions at the following radiation qualities:
- N-40, N-60, N-80, N-100, N-120, N-150, N-200, N-250, N-300 for transfer chambers A4 and A5
- RQR2, RQR3, RQR5, RQR7, RQR9, RQR10 for transfer chambers A3 and A4.

Preferentially, participants shall calibrate the transfer chambers for all these qualities. If this is not possible, it is mandatory to calibrate the chambers at least for five selected qualities of the suggested set from the N-series and for three selected qualities of the suggested set from the RQR series. If possible, it is preferable to choose for calibration qualities N-40, N-60, N-120, N-300, RQR2, RQR5, RQR10. If participants do not have RQR series realized in there laboratory they are allowed to participate only with the N-series.[1,2]

3.4 Reference conditions, measurement procedure and report of results

The source-to-chamber distance (reference point of the chamber from the focus point of the x-ray tubefocus) shall be 100 cm. If this distance is not possible at any site the distance may vary between 100 and 200 cm. The air kerma rate of the x-ray radiation beam shall be chosen to stay almost constant within a series for the ISO-Narrow or RQR qualities and should be about the range from 10 mGy/h to 100 mGy/h for the ISO-Narrow series and should be in the range from 10 mGy/min to 100 mGy/min for the RQR-series. The useful part of the beam cross section at the reference plane shall fully cover the spherical volume of the chambers. If it is not feasible the nonuniformity correction needs to be estimated.

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. After connection of the high voltage it is advisable to wait at least 1 hour until the measurements begin. The currents of the transfer chambers at the place of measurement should be measured with and without the x-ray radiation beam. The signal to background ratio of the currents should not be less than 1000. The background current shall be subtracted from the signal current. A complete measurement should consist of at least 10 repeated single measurements and the mean value should be taken as the result. The relative percentage Type A standard uncertainty of the repeated measurements shall not exceed 0.1 %. The calibration coefficients of the transfer chambers shall be given in terms of air kerma per unit charge in units of Gy/C referring to standard conditions of air temperature, pressure and relative humidity of T = 293,15 K, P = 101,325 kPa and h = 50 %. The relative air humidity shall be between 20 % and 80 % during the calibrations otherwise a correction to h = 50 % should be applied. Participants do not need to apply any correction for the incomplete charge collection.

The **report of the results** shall at least contain the following information:

- Full name of the participant laboratory
- Description of the set-up (electrometer type, connector types used, traceability of the electrometer calibration)
- Climatic conditions prevailing in the calibration laboratory during the calibration (Temperature, Pressure, Humidity)
- Description of the radiation field (radiation quality, HVL, distance, field size, air kerma rate)
- Uncertainty of the air kerma rate measured with the national air kerma standard
- Uncertainty of the calibration coefficient
- Calibration coefficients of the three transfer chambers for all choosen qualities.

The detailed uncertainty calculation should be given in accordance with the Guide to the expression of uncertainties in measurements (GUM) [3].

3.5 Course of comparison

There will be a star-shaped circulation of the transfer chambers between BelGIM and the participants. **BelGIM pays for the transport of the chambers to the participants. The participants pay for the transport of the chambers back to BelGIM.** After every participant calibration, BelGIM will perform chamber constancy checks. The chambers should stay at the participant's site for **no longer than 3 weeks**. The results should be reported to the coordinator **within 2 weeks** after the calibration.

3.6 Prospective time schedule

The comparison is scheduled to commence in April 2016 (starting with BelGIM measurements) and expected to be completed within 1.5 years. The proposed schedule is shown in Table 2.

Table 2: Proposed schedule of COOMET 641 comparison
(April 2016 until May 2017)

Participant	Date of Chambers leaving BelGIM for participant	Measurement duration at laboratory	Date of chamber leaving participant for BelGIM
BelGIM		April 2016	
PTB	02-May-2016	16 May– 03 Jun -2016	06-Jun -2016
NMI	07-Jul-2016	18 Jul – 05 Aug -2016	08-Aug-2016
IAEA	05-Sep-2016	19 Sep-07 Oct-2016	10-Oct-2016
CPHR	07-Nov-2016	28 Nov – 16 Dec-2016	19-Dec-2016
"Azstandard" Committee	23-Jan-2017	13 Feb – 03 March-2017	06-March-2017
SMU	10-April-2017	24 April – 12 May-2017	15-May-2017
VNIIM	12-Jun-2017	26 Jun – 14 Jul-2017	17-Jul-2017
GEOSTM	14-Aug-2017	04 Sep – 22 Sep-2017	25-Sep-2017

Notes:
1. Duration of measurement for each laboratory is three weeks.
2. Transportation time for the chambers from the BelGIM to a participant is about one-two weeks, and vice versa.
3. Duration of constancy measurements at BelGIM laboratory is about two weeks.

3.7 Procedure for handling the results of the pilot laboratory

The pilot laboratory will participate in the comparison. The BelGIM results will be the calibration coefficients determined in April 2016. The report on these measurements will be sent to the COOMET TC-IR Chairman and to the Secretary of CCRI before the first participant has submitted his report to the pilot laboratory.

3.8 Evaluation of the results

The pilot laboratory will evaluate the comparison on the basis of the reports of results (see 3.4) given by the participants. The comparison reference value (CRV) will be evaluated as the mean of the results obtained by the PTB and the VNIIM. The degree of equivalence of the participant's results will be evaluated with respect to the CRV. More details of the evaluation will be given in the first draft of the report on the comparison.

3.9 Publication of the results

After finishing the whole program with all the participants, the pilot laboratory will prepare a Draft A version of the report on the comparison. The Draft A will be circulated for comments and discussion of the results among all the participants and once agreement is reached, the revised report Draft B, will be produced as the official final report of the COOMET 641 project. This will be submitted to the COOMET TC-IR Chairman and to the CCRI Executive Secretary for six-week revision within the KCWG(I) and CCRI(I). After the approval of Draft B by the CCRI(I) the results and the report will be sent to the BIPM for publication in the KCDB and in the *Technical Supplement* of *Metrologia.*

4 References

[1] International Organization for Standardization ISO 4037-1: X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy - Part 1: Radiation characteristics and production methods, 1996.

[2] International Electrotechnical Commission IEC 61267:2005: Medical Diagnostic X-ray Equipment – Radiation Conditions for use in the determination of characteristics.

[3] Guide to the Expression of Uncertainty in Measurement JCGM 100:2008

[4] Buermann L, O'Brien M, Butler D, Csete I, Gabris F, Hakanen A, Lee J-H, Palmer M, Saito N, de Vries W, 2008, Comparison of national air kerma standards for ISO 4037 narrow spectrum series in the range 30 kV to 300 kV,*Metrologia* **45** *Tech. Suppl.* 06013

APPENDIX A: Picture of the transfer chamber type

Fig.1.Spherical ionization chamber Exradin A3

Fig.2.Spherical ionization chamber Exradin A4

Fig.3.Spherical ionization chamber Exradin A5 and adaptor to electrometer with M-type connector

Fig.4.View of the connector

APPENDIX B: Complete addresses of the participants

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