Technical protocol of APMP key comparison for measurement of air kerma for ^{60}Co (APMP.RI(I)-K1.1)

1. Introduction

A regional APMP.RI(I)-K1 comparison of the standards for air kerma for ^{60}Co occurred in 2004-2005. Some countries in the region did not participate. The current APMP.RI(I)-K4 ^{60}Co absorbed dose comparison provides an opportunity to include Indonesia, New Zealand, and Thailand in the APMP ^{60}Co air kerma comparison with an additional multilateral APMP.RI(I)-K1.1 comparison between Australia, Indonesia, New Zealand, Taiwan and Thailand. The objective of this key comparison is to establish the degrees of equivalence of national standards and to support the CMC's of ionization chamber calibration used in radiotherapy for the participants. It is noted that neither BATAN (Indonesia) nor NRL (New Zealand) have yet to be designated a signatory to the CIPM MRA, but are expected to achieve this status in the next year. An indirect comparison of the standards of air kerma will be undertaken using three ionization chambers as transfer instruments. The results of the comparison will be given in terms of the calibration coefficients of the transfer chambers determined at the participating laboratories. One of the laboratories, the ARPANSA, maintains primary standards for air kerma and their participation in the comparison allows the results to be linked to the key comparison (KCDB) of the CIPM MRA.

2. Participants

Participant	Institute	Country	Contact person (E-mail)
1	ARPANSA	Australia	Jessica Lye (Jessica.lye@arpansa.gov.au)
2	BATAN	Indonesia	Caecilia Tuti Budiantari (tuticb@hotmail.com)
3	NRL	New Zealand	Johnny Laban (John_Laban@nrl.moh.govt.nz)
4	INER	Taiwan	Jeng-Hung Lee (jhlee@iner.gov.tw)
5	DMSC	Thailand	Siri Srimanoroth (sirissdl@gmail.com)

3. Procedure

3.1 Comparison methodology

In this comparison, there will be a ring-shaped circulation of the transfer chambers among the participants. The chambers will be continuously tested in INER for at least 3 months before they are delivered to the participants to ensure stable performance of the chambers. Every participant should provide the calibration coefficients of transfer chambers in terms of air kerma and absorbed dose to water for ^{60}Co. The air kerma calibration coefficient will be based on the evaluation of participants' measurement results. A three-step process to secure the stability of the chambers during the circulation period is required by:

- checking the ratio of responses of the three chambers in terms of air kerma;
- checking the ratio of responses of the three chambers in terms of absorbed dose (to water);

- checking the calibration coefficients ratio of the absorbed dose to air kerma for each chamber.

These ratios of transfer chambers calibration coefficients should be reported to INER after each participant completes the calibration. A "Stability check" MS-Excel worksheet will be provided by INER to let the participants fill in the calibration coefficients of transfer chambers in terms of the absorbed dose to water and air kerma for ^{60}Co. If they are within a suitable range, the chambers can be sent directly to the next laboratory. If the ratios are beyond the range, the chambers will have to be sent back to INER to be measured again.

3.2 Reference conditions

The air kerma and absorbed dose to water for ^{60}Co is determined at the BIPM under reference conditions [1] defined by Section I of the Consultative Committee for Ionizing Radiation (CCRI(I)) as:

- the distance from the source to the reference plane (the centre of the detector) is 1 m;
- the field size at the reference plane is 10 cm × 10 cm;
- reference depth for absorbed dose measurements is 5 g cm^{-2}.

The above BIPM reference distance and field size are not necessarily required at the participant's site. However, the actual conditions must be specified if they are different from those of the BIPM. The calibration coefficients of the transfer chambers for air kerma will be expressed in units of Gy/C and referred to standard conditions of 20 °C and 101.325 kPa.

3.3 Transfer chambers

The main technical data of the three transfer chambers provided by INER for this comparison are listed in Table 1. These chambers are good representatives commonly used in clinical radiotherapy dosimetry. The chambers are circulated without an electrometer. At each laboratory, the transfer chambers are positioned with the stem perpendicular to the beam direction and with appropriate markings on both the chamber and the envelope (engraved lines or serial numbers) facing the source. At each laboratory, a collecting voltage specified by the manufacturer is applied to each chamber at least 30 min before starting the measurement. Each chamber has its own build-up cap for calibration in terms of air kerma. For the absorbed dose to water calibration, the waterproof chamber does not need the sleeve in the water phantom. **Never leave the waterproof PTW 30013 chamber in the water phantom after finishing the calibration.** The pilot laboratory will also provide the commercial waterproof rubber sleeves and the PMMA sleeves made by INER for the non-waterproof Farmer chambers (NE 2571 and PTW 30001) and the adaptors for switching the chamber BNT and TNC connectors as requested by some participants.

Table 1. Main technical data of the transfer chambers

Type	Cavity volume	Cavity length	Cavity Inside diameter	Wall material	Wall thickness	Connector	Waterproof	Applied voltage*
NE 2571	0.69 cm^3	24 mm	6.3 mm	Graphite	65 mg cm^{-2}	TNC	No	+250 V

(S/N 3025)								
PTW 30001 (S/N 2340)	0.60 cm^3	23 mm	6.1 mm	Acrylic/ Graphite	60 mg cm^{-2}	BNT	No	+400 V
PTW 30013 (S/N 0348)	0.60 cm^3	23 mm	6.1 mm	Acrylic/ Graphite	49 mg cm^{-2}	BNT	Yes	+400 V

*** the central electrode is positive**

3.4 Comparison schedule

The draft comparison protocol is sent to every participant for review and comments, then the revised protocol is submitted to the CCRI(I) for approval. If approved, the comparison is scheduled to begin in March 2010 and expected to be completed within one year. The total time period for chambers delivery and calibrations is about one month. Each participant should measure the transfer chambers for **no longer than 15 days**. The proposed schedule is shown in Table 2. The calibration coefficient ratios mentioned in Section 3.1 should be reported to INER to determine if the chambers should be sent directly to the next laboratory.

In order to control the progress and time of the whole comparison, INER agreed to take responsibility for the coordination and costs of transportation. To keep the comparison going as scheduled and to make sure it will be completed in October 2010, any laboratory that is not able to perform the measurements according to the approved itinerary must find another participant to exchange their measurement time.

Table 2: Proposed schedule of APMP.RI(I)-K1 comparison

Participant	Date of chambers arriving at participant	Measurement duration at laboratory	Date of chambers leaving for the next participant
Date chambers leaving INER for DMSC: 10-Feb-2010			
DMSC	28-Feb-2010	01-Mar-2010 to 15-Mar-2010	16-Mar-2010
BATAN	31-May-2010	01-Jun-2010 to 15-Jun-2010	16-Jun-2010
INER	30-Jun-2010 Chambers testing	16-Jul-2010 to 30-Jul-2010	31-Jul-2010
ARPANSA	15-Aug-2010	16-Aug-2010 to 30-Aug-2010	31-Aug-2010
NRL	15-Sep-2010	16-Sep-2010 to 30-Sep-2010	01-Oct-2010
INER	15-Oct-2010		

3.5 Calibration results submission

It is expected that all the participating laboratories submit calibration results within 4 weeks after the calibration to INER. The submission must include at least the calibration coefficients (Gy C^{-1}) of the transfer chambers, the absorbed dose rate of the radiation field (mGy s^{-1}), the

calibration conditions, the standard traceability and the relative standard uncertainties of absorbed dose measurements and chamber calibrations. Furthermore, it is requested that the relative humidity conditions at the time of calibration are to be stated on the results. Ideally, the relative humidity of the participating laboratories at the time of measurement should be within the range from 30% - 70%. To report the results, a “Results” MS-Excel worksheet is provided in which information about the national standards used by the participants and the calibration results can be completed.

3.6 Evaluation of measurement uncertainty

All the participating laboratories are required to evaluate the uncertainty of calibration coefficients as Type A and Type B according to the criteria of the “Guide to the Expression of Uncertainty in Measurement” issued by the International Organization for Standardization (ISO) in 1995 [4]. The type A uncertainty is obtained by the statistical analysis of a series of observations; the Type B uncertainty is obtained by means other than the statistical analysis of a series of observations. In order to analyse the uncertainties and take correlations into account for degrees of equivalence entered in the BIPM key comparison database, the CIPM has recommended that the participating laboratories submit their detailed uncertainty budgets (preferably with the relative standard uncertainties, k=1) to the pilot laboratory. **The two MS-Excel worksheets “Primary standard uncertainty” and “Chamber calibration uncertainty”** will be provided by the pilot laboratory in which the participants can detail the uncertainty. The participant is allowed to flexibly adjust the analysis items in the uncertainty evaluation worksheets. **The sheets should be submitted together with the calibration results to INER.**

3.7 The comparison report

At the conclusion of the comparison measurements, INER will send to ARPANSA the MS-Excel worksheets from each participant containing the calibration coefficients and the uncertainty budgets, as well as the stability measurements. ARPANSA will prepare a draft report to be circulated to all participants for comments and discussion of the results. A revised final report will be the official report of the comparison and submitted to the APMP/TCRI Chairman and the CCRI(I). After the approval of APMP and CCRI(I), it should be published as a Technical Supplement in the Metrologia journal. In addition, for those institutes that are qualified, the comparison results will be sent to the BIPM for inclusion in the key comparison database (KCDB).

4. The linking of regional comparisons to international comparisons

ARPANSA will be the linking laboratory to link the APMP/TCRI comparison (a regional comparison) with the BIPM (an international comparison). Then, through the following equation, the measured calibration coefficients for each laboratory will be converted to ratios relative to the BIPM;

$$R_{\mathrm{NMI,BIPM}} = R_{\mathrm{NMI,Link}} \times R_{\mathrm{Link,BIPM}} \qquad (1)$$

In this equation,

$R_{NMI,Link}$ = the ratio of the air kerma determinations from a participating NMI to that of the linking laboratory

$R_{Link,BIPM}$ = the ratio of the linking laboratory and the BIPM obtained in the BIPM.RI(I)-K1 air kerma comparison [3]

$R_{NMI,BIPM}$ = the derived ratio of the participating NMI and the BIPM

5. References

[1] P. J. Allisy-Roberts, D. T. Burns, C. Kessler, “Measuring conditions used for the calibration of national ionometric standards at the BIPM” ,Rapport BIPM-2009/04 (2009)

[2] “Guide to the Expression of Uncertainty in Measurement”, International Organization of Standards, Switzerland (1995)

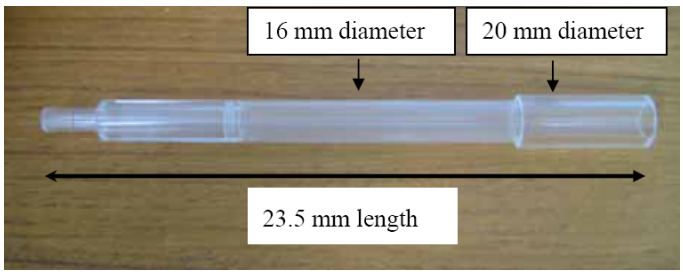
[3] P. J. Allisy-Roberts , M Boutillon, F. Boas and R. B. Huntley, Comparison of the air kerma standards of the ARL and the BIPM for ^{60}Co gamma rays, Rapport BIPM-98/04, BIPM Publications (1998)

APPENDIX A: Pictures of the transfer chambers

NE 2571 chamber
(S/N 3025, non-waterproof)

PTW 30001 chamber
(S/N 2340 non-waterproof)

PTW 30013 chamber
(S/N 0348, waterproof)



PMMA sleeve made by INER

APPENDIX B: complete addresses of the participants

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