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IAEA/WHO Network of Secondary Standards Dosimetry Laboratories

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IAEA
International Atomic Energy Agency

Participants positioning ionization chambers during the Technical Meeting on Dosimetry and Comparisons in Diagnostic Radiology held at the IAEA Dosimetry Laboratory.

From the editor

This issue of the SSDL Newsletter contains six contributions. The first contribution is a report of the Technical Meeting on Dosimetry and Comparisons in Diagnostic Radiology held at the IAEA in November 2012. The second contribution is a summary from a consultants'meeting on evaluating the Need for an International Code of Practice for Brachytherapy Dosimetry held at the IAEA Headquarters in May 2013. The third contribution is a report of the Regional Training Course on Activity Measurements using Quantitative Image Techniques held at IAEA Laboratories in Seibersdorf in May 2013. The next two contributions describing protection level comparisons organized by the Regional Metrology Organizations in the Africa region (AFRIMETS) and in the Euro-Asian region (COOMET). The main purpose of these comparisons is to harmonize practices in dosimetry measurements and provide supporting evidence to the SSDLs aspiring to publish their Calibration and Measurement Capabilities in the Key Comparison Database of the CIPM MRA. The sixth contribution describes events occurred during the exchange of a Co-60 source in the therapy level irradiator at the SSDL of Greece.
Finally, we would like to thank to those of you who have participated in our customer satisfaction survey and we appreciate your continued support. Your feedbacks enable us to improve the services we provide to Member States.

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SERVICES PROVIDED BY THE IAEA IN DOSIMETRY AND MEDICAL RADIATION PHYSICS

The IAEA's Dosimetry and Medical Radiation Physics Section focuses on services provided to Member States through the IAEA/WHO SSDL Network and on a system of dose quality audits. The measurement standards of Member States are calibrated, free of charge, at the IAEA's Dosimetry Laboratory. The audits are performed through the IAEA/WHO TLD postal dose assurance service for SSDLs and radiotherapy centres.

The Dosimetry Laboratory's Quality Management System has been reviewed and accepted by the Joint Committee of the Regional Metrology Organizations and the BIPM (JCRB). The IAEA Calibration and Measurement Capabilities (CMCs) have been reviewed and published in Appendix C of Comité International des Poids et Mesures (CIPM), Mutual Recognition Arrangement (MRA).

The IAEA CMCs can be found at the following web site: http://kcdb.bipm.org/AppendixC/search.asp?met=RI

The range of services is listed below.

Services	*Radiation quality*
Calibration of ionization chambers (radiotherapy, diagnostic radiology including mammography, and radiation protection including environmental dose level)	X rays (10–300kV) and gamma rays from ^{137}Cs and ^{60}Co
Calibration of well type ionization chambers for low dose rate (LDR) brachytherapy	γ rays from ^{137}Cs
Comparison of therapy level ionization chamber calibrations coefficients for SSDLs	γ rays from ^{60}Co
TLD dose quality audits for external radiotherapy beams for SSDLs and hospitals	γ rays from ^{60}Co and high energy X ray beams
TLD dose quality audits for radiation protection for SSDLs	γ rays from ^{137}Cs
Reference irradiations to dosimeters for radiation protection	X rays (40–300 kV) and γ rays from ^{137}Cs and ^{60}Co beams

Member States who are interested in these services should contact the IAEA/WHO SSDL Network Secretariat for further details, at the address provided below. Additional information is also available at the web site: *http://www-naweb.iaea.org/nahu/dmrp/SSDL/default.asp*

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Note to SSDLs using IAEA calibration and audit services:

1. To ensure continuous improvement in IAEA calibration and audit services, SSDLs are encouraged to submit suggestions for improvements to the Dosimetry Contact Point.

2. Complaints on IAEA services can be addressed to the Dosimetry Contact Point.

Technical Meeting on Dosimetry and Comparisons in Diagnostic Radiology at the SSDL Level

Report of the Technical Meeting

IAEA, Vienna
05–09 November 2012

Participants: Ammar Herrati (SSDL of Algeria), Siarhei Saroka (Belarusian State Institute of Metrology), Gonzalo Walwyn Salas (Center for Hygiene and Radiation Protection of Cuba), Costas J. Hourdakis (Greek Atomic Energy Commission), Muhammad Jamal Bin Md Isa (Malaysian Nuclear Agency), Mahmood Khalid (Pakistan Institute of Nuclear Science and Technology) and Siri Srimanoroth (Thailand Ministry of Public Health)

IAEA staff: Istvan Csete, Ladislav Czap, Harry Delis and Igor Gomola, DMRP, IAEA

1. Background

To ensure harmonization and consistency in radiation measurements, the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) created a Network of SSDLs in 1976. Although the first SSDLs were established to provide calibrations of dosimeters used in radiation therapy, their activities have been expanded to calibration of equipment used in radiation protection and recently also in diagnostic radiology. Exposures resulting from radiological procedures constitute the largest part of the population exposure from artificial ionizing radiation. Based on the current review of the SSDL Annual Reports, 35 laboratories already have or are planning to establish diagnostic calibration facility in response to the increased demand for dosimetry measurements in diagnostic and interventional radiology. The IAEA publication Technical Report Series no.457 “The Code of Practice for Dosimetry in Diagnostic Radiology” [1] addresses issues of diagnostic dosimetry involving calibrations and measurements from the perspective of both the SSDLs and the clinical users. Although the implementation of this CoP has also been published by the IAEA [2], the QA program of the diagnostic radiology has not been properly established. The SSDLs have a crucial role of providing the necessary link in the traceability chain of DR measurements to the International Measurement System through calibration of end user’s radiation measuring instruments. Unfortunately there are only few publications about international comparison of the measument standards used in the diagnostic radiology [3]. The traceability chain of air-kerma measurement is established only for few mammographic X ray beam qualities by the BIPM.

2. Purpose of the meeting

The technical meeting, combined with a small scale pilot comparison of diagnostic standards of the selected 6 participant SSDLs, aimed to survey the actual diagnostic calibration capabilities of the different regions for the extension of the IAEA quality audit program to the diagnostic radiology calibration activities of the SSDLs.

3. Course of the program

The technical meeting comprised one day of lectures followed by three days practical sessions at the Dosimetry Laboratory at Seibersdorf. The last day was dedicated to the common evaluation of the results obtained by the two working groups established for the practical sessions, visiting the Austrian primary standard dosimetry laboratory (BEV) located within the AIT Seibersdorf, and to the evaluation of the technical meeting. The lectures were delivered by Harry Delis, Istvan Csete, Igor Gomola and Costas Hourdakis from the SSDL of Greece, who was also assisting in the practical sessions. The 10 lectures covered the quantity and units in diagnostic radiology including mammography, the International Measurement System CIPM MRA, the primary standards of air-kerma, the instrumentation for diagniostic radiology dosimetry at SSDLs, the clinical dosimetry in diagnostic radiology, the calibration methods at SSDLs (including chambers for measurement of dose area product kerma length, and kVp meters), the quality control and assurance procedures in SSDLs complying with the ISO 17025 standard, and the uncertainty calculation for diagnostic calibrations based on the references [4], [5].

Particular importance was given to the three days practical sessions. Each of the 6 participants established the same diagnostic X ray beam quality (IEC 61267 RQR-5), determined its first and second half value layer thicknesses and the saturation correction factor for his own transfer chamber. These transfer chambers were used to calibrate the IAEA diagnostic back up ionization chamber, type Exradin A3. Finally, a summary report on all measurements, including assessment of the uncertainty components of the calibration of the IAEA ionization chamber was prepared by each participant.

4. Results and Conclusion

The participants performed all the measurements scheduled although some uncertainty estimations have not been completed during the meeting. Due to the shortage of the available high quality diagnostic chambers at the participants` laboratories, there were significant differences in the sensitivity and beam size used by the 5 different types of transfer chambers in this comparison exercise. The comparison results can be seen in the Figure 1. The results were consistent except for the participant No. 2.

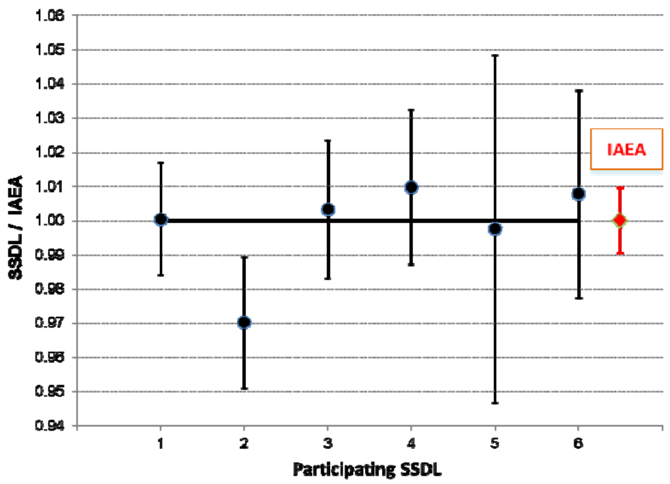

Figure 1: Results of comparison of diagnostic chamber air kerma calibration coefficients for RQR 5 X ray beam quality corrected for the source of traceability. The uncertainty bars represent the expanded uncertainty (k=2) reported by each participant

The general feedback from the participants about the technical meeting, based on the evaluation of the filled-in questionnaires, was very positive. The level of scientific content of the presentations as well as the technical facilities and assistance of the laboratory staff at the IAEA laboratory were highly appreciated. For the future organization of similar meetings was proposed to harmoznize different level of practical experiences and theoretical background of the participants together with a heavy workload of the working groups. The extension of existing IAEA comparison programmes for the field of diagnostic radiology dosimetry at the SSDL level was proposed.

5. References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Dosimetry in Diagnostic Radiology: An International Code of Practice, Technical Reports Series No. 457, IAEA, Vienna (2007).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Implementation of the International Code of Practice on Dosimetry in Diagnostic Radiology (TRS 457): Review of Test Results, IAEA Human Health Report No. 4, IAEA, Vienna (2011).

[3] Radiat. Prot. Dosimetry (2004) 108 (1): 33-45. Calibration of dosemeters used in mammography with different X-ray qualities: Euromet Project No. 526 http://rpd.oxfordjournals.org/content/108/1/33.abstract

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Measurement Uncertainty A Practical Guide for SSDLs, IAEA TECDOC-1585, (2008) http://www-pub.iaea.org/MTCD/publications/PDF/te_1585_web.pdf

[5] ISO, IEC, Evaluation of measurement data — Guide to the expression of uncertainty in measurement, JCGM_100_2008 http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf

Status of Brachytherapy Dosimetry and the Need for the Development of an International Protocol

Report of a consultants meeting

IAEA, Vienna
27–31 May 2013

Consultants: Alex Rijnders (BEL), Carlos Eduardo de Almeida (BRA), Ernesto Mainegra-Hing (CAN), Konstantinos Hourdakis (GRE), Larry DeWerd (USA)

IAEA staff: Ahmed Meghzifene, Godfrey Azangwe, Igor Gomola and Debbie van der Merwe, DMRP, IAEA

In 1996, the IAEA established a calibration service for low dose rate (LDR) Cs-137 brachytherapy sources, which was the most widely used source for treatment of gynaecological cancer. To further enhance harmonization in brachytherapy dosimetry, the IAEA published the IAEA-TECDOC- 1079 entitled "*Calibration of Brachytherapy Sources"* in 1999. In this TEC-DOC methods for calibrating brachytherapy sources with photon energies at or above those of Ir-192 were described. The report was well received and was distributed in a large number of copies to the members of the IAEA/WHO network of SSDLs and to medical physicists working with brachytherapy. In 2002, the IAEA published IAEA TEC-DOC-1274 "*Calibration of photon and beta ray sources used in brachytherapy*". This TEC-DOC described standardization of calibration of the most commonly used brachytherapy sources, including both photon and beta emitting sources.

Implementation of new brachytherapy sources and treatment techniques into clinical practice has continued over the last decade. A recent survey performed within the IAEA/WHO network of SSDLs have shown that (i) a very few national SSDLs offer brachytherapy calibration services traceable to the International Measurement System for all the brachytherapy sources used by their clinical end-users (ii) most SSDLs and clinical physicists that performed the verification or calibration measurements were applying the IAEA dosimetry guidelines (TECDOC-1079 and TEC-DOC-1274) and the AAPM TG-43 formalism (published in 1995).

National guidelines for brachytherapy differ widely across the world and there is no international code of practice for brachytherapy dosimetry available. In addition, there is a lack of internationally harmonized QA/QC guidelines for all sources used in brachytherapy.

From 27 to 31 May 2013 a consultants' meeting was held at the IAEA Headquarters with the purpose of evaluating the need for an international Code of Practice for Brachytherapy Dosimetry. The current status of brachytherapy dosimetry from a metrological and clinical medical physics perspective was discussed in depth. It was agreed that the need for a Code of Practice should be discussed with the wider international community and a draft white paper (announcement document) was developed accordingly. In addition, a draft table of contents for the proposed code of practice was developed in bullet form. The proposed contents includes the following chapters (i) Introduction (ii) Description of existing brachytherapy sources (iii) Dose calculation formalism (iv) Instrumentation (v) Framework (vi) Calibrations at SSDLs (vii) Calibrations and QA at the Hospital Level, and (viii) Summary.

The draft of the announcement document (white paper) "*Determining the need for an International Code of Practice for Brachytherapy Dosimetry*" was reviewed by the meeting participants and will be circulated to International Professional Organizations in due course for comment. The comments received will be consolidated into a final position paper, which will be submitted to an appropriate international journal. Anyone particularly interested in contributing to this process should contact dosimetry@iaea.org.

Regional (AFRA) Training Course on Activity Measurement using Quantitative Imaging Techniques

IAEA Laboratories, Seibersdorf, Austria
27–31 May 2013

Participants: Mohamed Ahmed (EGY), Lamri Ahmed Nacer (ALG), Belkacem Hattali (ALG), Yolande Huguette Ebele Yigbedeck (CMR), Ejigu Kebede Abdissa (ETH), Edem Kwabla Sosu (GHA), Hind Saikouk (MOR), Obinna Chizoba Asogwa (NIR), John Enyi Ejeh (NIR), Keamogetswe Boom (SAF), Janetta Brand (SAF), Latifatou Basse Gueye (SEN), Mohamed-Jemai Ghezaiel (TUN), Shaid Yusuph (URT)

Lecturers: József Varga (HUN, LCR), Mats Vilhelm Stenstrom (SWE, LCR)

IAEA staff: Gian Luca Poli, Harry Delis, DMRP, IAEA

1. Introduction

RAF/6/038 Promoting Regional and National Quality Assurance Programmes for Medical Physics in Nuclear Medicine is a Technical Cooperation project for the African Region. The purpose of the project is to improve the effectiveness and safety of nuclear medicine procedures by providing support for the design and implementation of quality assurance (QA) programmes and by establishing training and education programmes in medical physics as applied to nuclear medicine, focusing on aspects related to the application of nuclear techniques. For many of the countries participating in RAF/6/038, there is a shortage of Medical Physicists properly trained in Nuclear Medicine imaging and quantitation.

2. Purpose of the Course

The International Atomic Energy Agency organizes regional training courses under project RAF/6/038 with the aim at reducing this shortage and at serving to disseminate the acquired knowledge to the Member States. Some of these courses are organized at the IAEA Gamma Camera laboratory in Seibersdorf. The main role of this laboratory is to develop practical courses for training purposes of students of Member States, on topics considered essential for practical training of medical physicists specializing in Nuclear Medicine.

The regional training course RAF6038/009 on Activity Measurement using Quantitative Imaging Techniques was mainly addressed to Medical Physicists working in nuclear medicine departments. It was held from 27 to 31 May 2013 in Seibersdorf with 14 participants from 11 African Member States.

Image quantification is necessary for the implementation of different procedures, such as evaluation of organ function, comparison with normal databases, internal dosimetry and others. There is a lack in many Member States of trained Medical Physicists in image quantification, capable of identifying image degrading factors and to correct for them.

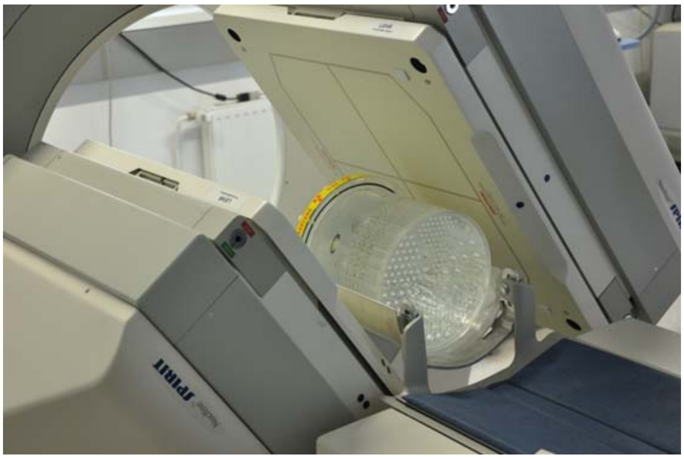

Figure 1: SPECT acquisition of a Jaszczak phantom.

3. Course Programme

This course introduced the theories and techniques of image activity quantification, from simple planar representations up to 3D reconstructed images, through a set of graded practical learning activities. It showed the learner the physical effects that degrade image quality and quantitation (attenuation, scatter, collimator-detector response, count losses, partial volume effect) and methods to compensate for them. Based on practical laboratory work with Nuclear Medicine instrumentation, phantoms and sources, it provided the learner with knowledge and skills to implement quantitative imaging techniques in typical Nuclear Medicine environments. It was a “hands on” course, aimed to acquire practical experience working with quantitative images in Nuclear Medicine.

Figure 2: Preparation of the triple line insert for tomographic spatial resolution measurements.

By the end of this course, the students were able to:

- Describe the most significant factors that degrade image quality.
- Identify instruments and methods to compensate these degrading factors.
- Use transmission images obtained by the use of external radiation sources to calculate attenuation correction factors of emission images.
- Compute scatter images using energy-windows method.
- Apply count-losses correction to high activity images.
- Identify partial volume effect and distinguish volume ranges for which it is significant.
- Use corrective restoration filters and evaluate their effect on activity quantitation.
- Reconstruct 3D images from projections, incorporating attenuation, scatter and restorative correction factors.
- Compare the relative influence on quantitation of the different physical effects involved in radiation detection.
- Perform phantom and software simulations for validation of quantitation techniques.
- Design protocols for image acquisition, processing and quantitation to support internal dosimetry planning and/or kinetic analysis.

Figure 3: Participants to the Regional Training Course on Activity Measurement using Quantitative Imaging Techniques IAEA Laboratories, Seibersdorf, 27—31 May 2013.

Progress Report from AFRIMETS.RI (I)-S1 Protection Level Comparison

Zakithi Msimang, SSDL, NMISA, South Africa

Participating Laboratories: Algeria (COMENA, CRNA), Egypt (NIS), Ethiopia (QSAE), Germany (PTB), Ghana (GAEC), Hungary (MKEH), IAEA, Kenya (KEBS), Nigeria (NNRA), South Africa (NMISA), Sudan (SAEC) and United Republic of Tanzania (TAEC).

Pilot Laboratory: SSDL South Africa

1. Introduction

The ^{137}Cs-γ, ^{60}Co-γ and X radiation qualities are typically used for calibration of radiation protection instruments. During the AFRIMETS General Assembly held in South Africa in July 2009 it was resolved that a comparison for air kerma measurements such radiation qualities shall be organized. The main purpose of the comparison is to harmonize practices in dosimetry measurements in the region and also assist those member countries aspiring to publish their Calibration and Measurement Capabilities (CMCs) in the Key Comparison Database (KCDB) of the CIPM MRA. The X ray comparisons is carried out using the ISO narrow beam qualities [1, 2]. The NMISA is the pilot laboratory. The results from two primary standard laboratories, PTB and MKEH, will be used as comparison reference values to calculate the degrees of equivalence.

2. Description of transfer instruments

Three ionization chambers were sent out to the participating laboratories. The technical data regarding the chambers is summarized in Table 1.

Type	Reference point	Nominal volume	*Collecting Voltage / V	Wall Thickness / mm	Outer Diameter/ mm	Diameter of inner electrode / mm	Saturation loss
PTW 32002	Chamber centre	1 litre (1000 cc)	400	3	140	50	<0.5% up to 0.3 Gy/h
A5 Exradin	Chamber centre	100 cc	400	3	62.8	6	<0.4% up to 1 Gy/h
A4 Exradin	Chamber centre	30 cc	400	0.50	39.2	4	<0.2% up to 1 Gy/h

Table 1: Technical data of the transfer chambers.

3. Reporting of the results

The laboratories were asked to submit results, using the excel spreadsheet provided, with a detailed uncertainty budget, measurement set-up, details of national standards including their source of traceability not later than three weeks after shipment of transfer chambers. The air kerma calibration coefficients at reference conditions will be the comparison parameters.

a. Procedure for handling the results of the pilot and linking laboratories

The pilot laboratory will participate in the comparison and make stability measurements on the instruments. The linking laboratories are MKEH and PTB. The MKEH will determine the transfer chambers' calibration coefficients at the beginning and the PTB at the end of the cycle. The NMISA will report its results to the linking laboratories, not later than three weeks after shipment of transfer chambers to the next participant. The MKEH and the PTB will then submit their results to the pilot laboratory. For all the other laboratories, the report on these measurements will be sent to the AFRIMETS TC-IR Chair not later than three weeks after shipment of transfer chambers. Both linking laboratories have their degrees of equivalence for air-kerma published in the BIPM key comparison database (KCDB). These values will be used to calculate the degrees of equivalence for all the participating laboratories.
Although, the transfer instruments have high stability performance in laboratory circumstances, for purpose of constancy checks, the pilot laboratory will measure the leakage and air-kerma calibration coefficient of each chamber after receiving it from each participant.

b. Evaluation of the results

The pilot laboratory will evaluate the comparison on the basis of the results given by the participants. The indirect comparison of the national standards will be based on the average of the calibration coefficients in terms of air-kerma. The reference values for the transfer chambers will be determined as the average of the linking laboratories` results corrected with their degrees of equivalence published for air-kerma quantities in the KCDB. For calculation of the participants` degrees of equivalences the weighted mean results for the three trasfer chambers will be used.
The radiation protection X ray results in the KCDB are based on the EUROMET. RI(I)-S3 supplementary comparison of air-kerma standards in ISO 4037 radiation qualities [6]. The evaluation procedures for this comparison will be similar to those used by the BIPM for the determination of the degrees of equivalence. More details of the evaluation will be given in the draft A report on the results.

4. Progress of the comparison

As of November 2013, nine out of the twelve laboratories have performed their measurements and submitted their results. There have been significant delays due to breakages at some of the laboratories. Challenges with custom clearances has also caused delays and these were mainly caused by laboratories not filling in the forms for shipment properly and not submitting pro-forma invoices needed for clearance of equipment when the transfer chambers arrive at port of entry. However, the expected date of completion is in 2014.

NMISA set up of LS01 during calibration.

5. 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 Atomic Energy Agency, Safety Report Series No. 16, 1999.
[3] International Atomic Energy Agency, SSDL Newsletter, No. 52, L. Czap, A. Meghzifene, C. Pychlau, Understanding the high voltage polarity of electrometers, July 2006.
[4] International Organization for Standardization, Guide to the Expression of Uncertainty in Measurement, ISO, Geneva (1995).
[5] International Atomic Energy Agency, Measurement Uncertainty A Practical Guide for Secondary Standards Dosimetry Laboratories, TECDOC-1585, IAEA, Vienna (2008).[6] Büermann 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
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http://www.bipm.org/utils/common/CIPM_MRA/CIPM_MRA-D-05.pdf

COOMET Project 445: Comparison of national measurement standards of air kerma for Cs-137 gamma radiation at protection level

Ludwig Büermann, Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

A COOMET supplementary comparison of the national measurement standards of air kerma for Cs-137 gamma radiation at protection level (~10 mGy/h) was carried out between May 2011 and February 2013. Participants were VNIIM (Russia), BelGIM (Belarus), CPHR (Cuba), GEOSTM (Georgia), INSM (Moldova), NSC-"IM" (Ukraine), SMU (Slovakia), PTB (Germany), BIM (Bulgaria), VMT/FTMC (Lithuania) and the International Atomic Energy Agency (IAEA). The PTB acted as the pilot laboratory. The comparison reference value (CRV) was obtained as the mean of the results obtained by PTB and VNIIM, both of which had previously taken part in the key comparison BIPM-RI (I)-K5. Results will be published in Appendix B of the BIPM key comparison database (KCDB) using the identifier COOMET.RI(I)-S1 as soon as the Draft B report is accepted.

The comparison was organized within an extended COOMET project (identified as Project 445/DE/08), the aim of which was not only to compare national standards but also for educational purposes. Some of the participants had taken part in such a comparison for the first time and, therefore, an introductory seminar was held at PTB in May 2011. The seminar was open for participation also to those countries of the COOMET region which did not participate in the comparison and to non-MRA signatories and countries without an approved quality management system in order to acquire measurement routine and theoretical as well as organizational knowledge for future comparisons. The main goal of this seminar was to prepare the participants for the procedure of having entries accepted for the CMC list in the metrological area of Ionising Radiation, Section I, x and gamma rays.

Figure 1: Participants of the COOMET meeting at the PTB

The seminar was very successful and the 21 participants from 15 different countries (among them were delegates from Armenia, Azerbaijan, Kyrgyzstan, Tajikistan and Uzbekistan) found it to be extremely helpful.

The goal of the supplementary comparison was to confirm the calibration and measurement capabilities of the participating NMIs for air kerma calibrations at protection level Cs-137 gamma radiation. For this purpose the calibration coefficients and the corresponding uncertainties of three circulating ionization chambers with sensitive volumes of about 1000 cm^3 were compared at air kerma rates of about 10 mGy/h. This type of comparison differs significantly from the established key comparison BIPM.RI (I)-K5 due to the lower dose rates and larger ionization chambers and the expected larger uncertainties. Therefore, it was decided by COOMET-TC1.9 and confirmed by the key comparison working group (KCWG) to regard this comparison as a supplementary one with the identifier COOMET.RI (I)-S1. PTB and VNIIM had previously participated in the key comparison BIPM.RI (I)-K5. Therefore, it was decided that their mean result shall be regarded as the comparison reference value (CRV). The comparison was conducted by at least three different transfer ionization chambers. Each participant determined the calibration coefficients of the three transfer ionization chambers under reference conditions. The degrees of equivalence with the CRV were evaluated based on these results. The three transfer chambers were circulated star-shaped between PTB and the participants. After each participant's calibration, PTB performed chamber constancy checks. The comparison started in May 2011 with PTB's measurements and was completed in February 2013 with the last stability measurements at PTB.

The Draft A report of results was discussed and agreed upon by the participants during a concluding seminar within Project 445, held at PTB in September 2013. The concluding seminar was again open to non-comparison participants of those countries which had already participated in the introductory seminar described above. In addition, Igor Gomola from IAEA was invited and reported on the status of cooperation between the IAEA and SSDLs in COOMET member countries. The seminar offered the opportunity to discuss and coordinate the work of the PTB Technical Cooperation and the IAEA, together with concerned delegates from countries within the COOMET region. This second seminar within Project 445 was a great success because it resulted not only in the preparation of the Draft B report of the current comparison but also in several future comparison projects piloted by other COOMET NMIs who will assume this responsibility for the first time. These new pilots are taking advantage of the knowledge they have gained during the two seminars at PTB.

Acknowledgement:

COOMET Project 445 was strongly supported by the PTB Technical Cooperation within a project entitled "Support of regional cooperation of member states in regional metrology organizations (COOMET)" funded by the Federal Ministry for Economic Cooperation and Development, Germany. The organizational work of Annette Kögler, Katrin Hoffmann and Olga Krasota is highly acknowleged.

Reload of therapy ^{60}Co source: the IRCL/GAEC-EIM/GAEC-EIM experience

C.J. Hourdakis, M. Nikolaki, S. Vogiatzi, Boozier A. and V. Kamenopoulou,
SSDL of Greece, Greek Atomic Energy Commission

1. Introduction

In the Ionizing Radiation Calibration Laboratory (IRCL) of the Greek Atomic Energy Commission (GAEC) a ^{60}Co irradiator (C-9 model) is installed, used mainly for the calibration of radiotherapy dosimeters. The head of the irradiator is in a fixed position, in order to produce a horizontal irradiation beam. At the time of installation, April 1999, the activity of ^{60}Co was 148 TBq (4000 Ci). Ten years later, the activity decayed to about 38 TBq (1000 Ci) making the unit inappropriate for therapy level calibrations.

This report presents the difficulties and the events occurred during the reload of the ^{60}Co source; it aims to provide SSDLs and other laboratories using high activity sources "lessons learnt" from the implementation of source reloading projects and procedures.

2. Event history

In the first semester of 2010, GAEC published two international tenders for the installation of a new ^{60}Co source (148 TBq) to the existing irradiation head and the disposal of the old (used) source. Both tenders became fruitless, since no company worldwide submitted the legal documents and offers. Following this and upon direct contacts, GAEC requested and received offers from two companies: (i) a German company, which, however, requested for the transport the irradiator head to its premises for the reload of the source; (ii) the manufacturer of the irradiator from the US (hereafter referred to as the "Company"), that could perform the source reload on site. The *"Company"* undertook the project, since it was the manufacturer and had proven its technical capabilities. The respective contract was approved in July 2010.

In February 2011, the source was manufactured in a Russian facility; however, the reload was conducted in the period 19-25 April 2012, since many technical and administrative problems had to be resolved by the "Company". The main problems were the availability of the transport container, which was Russian made (Russian certificate of approval) and the approval for the final destination of the old source for recycling to a Hungarian company. Consequently, the delivered activity of the ^{60}Co became 135.6 TBq – April 2012 (15% less than the ordered activity).

As appears, several companies and authorities from several countries were involved. The coordination of the organizations involved was a responsibility of the *"Company"*.

The technical part of the source replacement was fully undertaken by the manufacturer of the irradiator (the *"Company"*), who also provided the technical personnel – two technicians (named as technicians A and B hereafter). A third person – subcontractor of the *"Company"* and representative for the source and container provider - was also joined the mission", taking care of the source and container transport and other administrative issues.

During the source reload, staff members of GAEC were present and supervised the operations. Although technicians A and B hold their own individual dosemeters, GAEC additionally provided them TLD badges and active personal dosimeters (APD), in order to record and assess the delivered doses independently.

On April 19th 2012 the technicians initiated the replacement procedure which consisted of three steps:

- 1st step: Alignment of the source container to the irradiator head, in a manner that the source could be driven through a sleeve from the container to the irradiation head and vise versa (fig 1). The source container was suspended from a rigid steel frame (crane), in order to level the container and the irradiator head. This step was completed successfully on April 19th 2012, although the crane was not included to the accessories tools of the Company, but it was supplied by a local Greek company (subcontractor of the Company).

Figure 1: Left side photo: The alignment of the source container (grey) to the irradiator head (green). Right side photo: The source container aligned in contact with the irradiator head.

- 2nd step: The removal of the old source from the irradiator head and its transfer to the safe position inside the container, through the sleeve (fig 2). During this step the technicians had to overcome a few technical difficulties arising from the fact that (i) the length of the sleeve for the removal of the old source was not appropriate and an extra sleeve (extension) had to be used and (ii) an appropriate lead plug had to be used since shielding at the sleeve end was not available. The extra sleeve and lead plug had been manufactured by the *"Company"* (its subcontractor company). Overcoming these problems, this step was completed successfully on April 19th 2012.

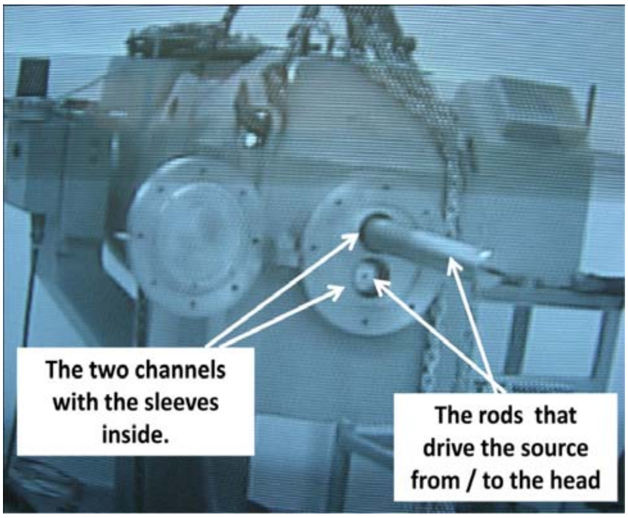

Figure 2: The source exchange procedure. The"old" source is screwed at the end of the inserted rod and is pulled from the irradiator head back to the source container through the sleeve (upper channel). Then, the container is leveled so the lower channel is aligned with the head window and the "new" source is pushed by the rod into the head by the rod through the sleeve.

- 3rd step: Reload of the new source into the irradiator head, through the sleeve. While driving the source from the container into the head, the source stuck inside the sleeve within the container, away from the safe position, close to the sleeve end adjacent to the irradiation head entry window. At this point, the technicians were not in the position to affirmatively exclude the possibility of an accidental source drop from the container (sleeve end) on the floor inside the bunker. For this, GAEC immediately reported by phone the incident to the IAEA and investigated the possibility of receiving technical assistance from the IAEA in the case of an accident occurrence.
On April 23rd 2012, after several efforts, checks and tries, the source was returned back to the safe position within the container. During these efforts the dose rate inside the bunker (outside the primary beam) reached 10 mSv/h.
On the following day and after the sleeve removal, the technicians verified that the internal surface of the sleeve was defective, and had to be replaced. A new sleeve was manufactured at the factory of the Greek subcontractor of the Company and checked prior to use with the help of the dummy source. Finally, the reload of the source into the irradiator unit was completed successfully on April 25th 2012.

The transport of the old source to a recycling facility abroad (Hungary) took place from Athens to Budapest airport on 27th April 2012 with a cargo flight. However, 2 days after, the container with the source was returned back to Athens, due to - as GAEC was notified – insuperable administrative and legislative problems for the road transportation of the source from Budapest airport to the Hungarian recycling company. It has to be mentioned that the relevant shipment documents and the consent of the Hungarian regulatory authorities for the import of the source to Hungary had been obtained by GAEC in advance. The container with the source had been remained in the interim storage facility at GAEC for more than 6 months. After extensive communications between GAEC, the *"Company"*, the air carriers, the consignees and the regulatory authorities of the involved countries, the source was finally shipped to Germany for recycling in November 2012.

3. Radiation protection measures

After the problems that came up during the first day (2nd step), the technicians were requested to provide a full report including risk assessment and describing the procedure to be followed in order to complete the source replacement. From that point onwards, all actions performed by the technicians were thoroughly discussed and approved by GAEC at high management level and the radiation protection officer. All actions were monitored and timed to minimize technicians' exposure.
GAEC provided technicians A and B with additional TLD personal dosimeters and APDs; one set (TLD and APD) was worn on the chest (most likely to be exposed to the primary beam) and the other set on the abdomen (recording the total body irradiation from the scattered radiation). According to the dosimeter readings and the dose assessments, technician A received $H_p(10)$ dose

(total body) of 28.3 mSv; at chest region (partial body irradiation) the dose was estimated to 150 mSv, due to exposure to the primary beam. Technician B received *H*p(10) dose (total body) equal to 12.1 mSv; at chest region the dose was estimated to be similar (i.e. no exposure to the primary beam). Taking into account the dosimeter readings it was concluded that the main fraction of the dose was received by the technician A during the first day (TLD reading 23.4 mSv). Based on his experience, technician A made several attempts to load the source into the head, without realizing the full extent of the existing obstacles.

Following this, GAEC asked both technicians to conduct biological dosimetry at the National Center of Science and Research, NCSR "Demokritos". The biological dosimetry based on the analysis of solid stained bicentric chromosomes in cultivated peripheral blood lymphocytes was applied to estimate absorbed doses by reference to a dose response calibration curve. Specifically, based on the analysis of 2000 randomly assessed lymphocyte metaphases it was assessed that:

The results of the biological dosimetry indicated that Technician A received a whole body dose of no more than 197 mSv (95% upper confidence level) and no less than 30 mSv (95% lower confidence level), with a mean dose of 102 mSv.

Technician B received a whole body dose in the range of 0 mSv to 60 mSv (95% confidence level).

GAEC requested from technician A to provide his official dose records, which showed that the recorded accumulated dose for 2011 was 1.22 mSv. A dosimetric report for both technicians was officially sent to the radiation protection officer of the *"Company"*., Finally, an INES report (accidental overexposure of radiation worker of scale 2) has been submitted to the IAEA INES service.

4. Conclusion and lessons learnt

According to the contract for the ^{60}Co source procurement, the full responsibility for all practical arrangements concerning the import, replacement, transport and export of the sources was undertaken by the *"Company"*. For the realization of the project, the *"Company"* cooperated with several subcontractors from several countries. The *"Company"* had the responsibility of the coordination of them, which had been proved to be a difficult task.

Although, the *"Company"* was the manufacturer of the irradiator having the expertise and the experience of such system for many decades, several problems had not been predicted in advance, while the available accessories tools were not sufficient and appropriate. Unforeseen problems, incidents and accidents should always be considered during the planning phase of such projects and available "plan B" should be in place.

Although the irradiator head was manufactured many years ago, it is still being used by some SSDL worldwide. The availability and the manufacture of new ^{60}Co source suitable for this irradiation type is a difficult task, while the availability of appropriate transport container is always a problem.

The design of the irradiation head in a fixed position, in order to produce horizontal beam, is not optimum from the radiation protection point of view; in inadvertent situations (like this described herein, or the source stuck in unsafe position, etc) the personnel may step inside the primary beam to resolve the problem. Appropriate protective portable shielding barriers should be available. Furthermore, the room access from the back side of the irradiators, optimize the radiation protection.

Strict and well established procedures, regarding the work of technicians, personnel and outside workers should be in place and should never be override. In the case described herein, GAEC should have considered preventing the initiation of the replacement procedure (i.e. cancel the whole project mission), once it appeared that appropriate accessory tools (e.g. crane, sleeve, tabs, etc) were not readily available, even if the *"Company"* guaranteed the appropriateness of the measures that had taken.

Finally, the disposal of the used radiation sources is a big issue that must be considered prior any source replacement. The optimum solution is to have a legally binding agreement with the source manufacturer that it accepts back the source after its useful life. The guarantee period of the source use, as provided by some manufacturers (e.g. 10 years), should also be considered, since after this period the manufacturer may not accept the source back.

Courses, Meetings and Consultancies in 2013 and 2014

Courses and workshops

IAEA/ESTRO Training Course on Advanced Imaging for Physicists (RER/6/023), Vienna, Austria, 8—12 September 2013

RAS 6/062 Regional Training Course on 3D Image Guided Brachytherapy, Thailand, 7—11 October 2013

RAF6045/6044 Regional (AFRA) Training Course on Transitioning from 2D to 3D CRT, South Africa, 21—25 October 2013

RAF6038/010 Regional (AFRA) Training Course on "Internal Dosimetry Procedures for Dose Assessment", Vienna, Austria, 4—8 November 2013

Joint ICTP-IAEA-AAPM International Training Workshop on Accuracy Requirements and Uncertainties in Radiation Therapy, ICTP, Miramare, Trieste, Italy, 9—13 December 2013

RAS6062 Workshop on Transitioning from 2D to 3D Image-Guided Brachytherapy Services, Australia, 28—31 January 2014

Regional (AFRA) Training Course on Quality Management in Radiotherapy; Zimbabwe, 17—21 February 2014

Standing Advisory Group "Scientific Committee of the IAEA/WHO Network of Secondary Standards Dosimetry Laboratories (SSDLs)" (SSC-16), IAEA HQ, Vienna, Austria, 10—14 March 2014

Joint RAF6/045 (RO, MP and RTT) Regional (AFRA) Training Course on Transitioning from 2D to 3D CRT (French); Tunisia, 12—16 March 2014

RAF6048/9001/01 First Project Coordination Meeting, Vienna, Austria, 31 March—4 April 2014

Midterm Joint Coordination Meeting of RAF6044 and RAF6045; Ghana, 7—9 April 2014

7th conference of the AFrican Radiation Oncology Group (AFROG); Ghana, 10—11 April 2014

Regional (AFRA) Training Course in Commissioning of Treatment Planning Systems; Morocco, 21—25 April 2014

RAS6077 Technical Workshop on Radiotherapy Clinical Training Programmes, Vienna, 12—16 May 2014

Regional (AFRA) Training Course on RTT update (English course); Zambia, 19—23 May 2014

RAF6048/001 Regional (AFRA) Training Course on Quality Assurance in Medical Imaging, Tanzania, 26—30 May 2014

IAEA/ICTP Joint Workshop on Determination of Uncertainties of Medical Radiation Dosimetry, 9—13 June 2014

RER6028/9001/01 Workshop on procedures and guidelines for QA/QC of diagnostic equipment, Vienna, Austria, June 2014

Regional (AFRA) Training Course in Imaging in radiotherapy; Egypt, August 2014 (dates to be decided)

Joint RAF6/045 (RO, MP and RTT) Regional (AFRA) Training Course in Accuracy in Radiotherapy; Sudan, 26—30 October 2014

Regional (AFRA) Training Course in Gastrointestinal Cancers; Egypt, 19—23 October 2014

Regional (AFRA) Training Course in Commissioning of Linear Accelerators; Argonne, USA, November 2014 (dates to be decided)

Meetings and consultamcies

Consultants Meeting on "The use of PET/CT for Radiation Treatment Planning" (ARBR and NMDI), 15—17 July 2013

1st RCM on the CRP in treatment related uncertainties in radiotherapy, Vienna, Austria, 26—30 August 2013

1st RCM of Doctoral CRP E2.40.19 on Advances in Medical Imaging Techniques, Vienna, Austria, 28 October—1 November 2013

1st RCM on Standardizing Interpretation Criteria for early response evaluation with 18F-FDG PET/CT in paediatric lymphoma, Vienna, Austria, 28 October—1 November 2013

1st RCM on Nuclear cardiology in congestive heart failure, Vienna, Austria, 4—8 November 2013

3rd RCM on Resource sparing curative treatment of advanced rectal cancer, Vienna, Austria, 13—15 November 2013

Consultants Meeting on "Development and adoption of guidance document on accuracy in internal dosimetry for therapeutic nuclear medicine", Vienna, Austria, 18—21 November 2013

2nd RCM on Enhancing capacity for early detection and diagnosis of breast cancer through imaging, Ljubljana, Slovenia, 25—29 November 2013

3rd RCM on The Use of Sentinel Lymph Node in Breast, Melanoma, Head & Neck and Pelvic Cancers, Vienna, Austria, 25—29 November 2013

Consultants Meeting on Finalizing the Guidance document on Radiation Protection Calibrations at the Secondary Standards Dosimetry Laboratories, Vienna, Austria, 9—13 December 2013

Consultants Meeting on the Preparation of the publication on "Development of advanced dosimetry techniques for diagnostic and interventional radiology (CRP E2.10.08), Vienna, Austria, 10—13 December 2013

1st RCM on Integrated Imaging (SPECT/CT; PET/CT; MRI) in Infection/Inflammation Spine Pathology, Vienna, Austria, 9—13 December 2013

1st RCM on Doctoral CRP on Longitudinal measures of body composition of healthy infants and young children up to 2 years of age using stable isotope techniques, Vienna, Austria, 16—19 December 2013

1st RCM on Development of quality audits for advanced technology in radiotherapy dose delivery, Vienna, Austria, 16—20 December 2013

Technical Meeting on Harmonizing Quality Audit in Radiotherapy and Promoting the Concept of Audits in Member States, Vienna, Austria, 16—20 December 2013

1st RCM on Integrated Imaging (SPECT/CT; PET/CT; MRI) in Infection/Inflammation Spine Pathology, Vienna, Austria, 9—13 December 2013

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