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Contents

From the Editor

In this issue of the SSDL Newsletter (No. 77) we focus on the IAEA calibration service for high energy photon beams and how the SSDLs using this service can further disseminate traceability. A short article on types of connectors and adapters used for dosimetry measurements, report on a training hosted by Dosimetry Laboratory (DOL) and the IAEA recent publications are included.

The Dosimetry and Medical Radiation Physics (DMRP) section welcomed its new section head at the start of January 2023. Before joining the IAEA, Mauro Carrara was working as a clinically qualified medical physicist at the National Cancer Institute in Milan, Italy. He was involved in the clinical duties that pertain to a medical physicist whilst also being involved in research, collaborating with several international institutions, participating as principal and co-investigator to several funded projects, and authoring or co-authoring more than 75 peer-reviewed publications in the field of dosimetry and quality assurance. He was appointed as Professor for graduate and post-graduate academic courses, mentoring students approaching the field of medical physics and in training residents beginning their careers as clinical medical physicists. Over the last three years, he joined the IAEA and was working as radiotherapy medical physicist for the Dosimetry and Medical Radiation Physics Section.

“I grew up with the IAEA TRS-398 publication on my hospital desk, thinking about the professionals that were behind this publication with great admiration. This is how I first learned about the existence of the IAEA and over the years I frequently benefitted from the exceptional quality of their publications and activities. I consider it a great honour to serve the IAEA as Head of the Dosimetry and Medical Radiation Physics Section, having particularly in mind the exceptional physicists and persons who came before me. I would like to take the chance to thank them on behalf of the worldwide community of Medical Physicists” says Mauro.

Mr Mauro Carrara, Section Head of Dosimetry and Medical Radiation Physics Section, Division of Human Health.

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Services provided by the IAEA in DMRP Section

The IAEA's Dosimetry and Medical Radiation Physics Section focuses on services provided to Member States through the IAEA/WHO SSDL Network and on dosimetry 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 postal dose audit service for SSDLs and radiotherapy centres by using radiophotoluminescence and optically stimulated luminescence dosimeters (RPLDs and OSLDs).

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). Some of the IAEA Calibration and Measurement Capabilities (CMCs) are published in Appendix C of the BIPM key comparison database (KCDB).

The IAEA CMCs can be found at the following web site: https://www.bipm.org/kcdb/

The range of services offered by the IAEA's DMRP section are listed below.

Services	*Radiation quality*
**Calibration of ionization chambers (radiation therapy, brachytherapy*, radiation protection, and diagnostic radiology including mammography)	X rays and γ rays from ^{137}Cs and ^{60}Co beams ^{137}Cs, ^{60}Co, @linac photon beams* and ^{192}Ir brachytherapy sources
**Comparison of ionization chamber calibrations coefficients (radiation therapy, radiation protection, and diagnostic radiology including mammography) for SSDLs	X rays and γ rays from ^{137}Cs and ^{60}Co beams
Dosimetry audits (RPLD) for external radiation therapy beams for SSDLs and hospitals	γ rays from ^{60}Co and high energy X ray beams
Dosimetry audits (OSLD) for radiation protection for SSDLs	γ rays from ^{137}Cs
Reference irradiations and blind dose checks for dosimetry audit networks (radiotherapy)	^{60}Co and high energy X ray and electron beams
Reference irradiations to dosimeters for radiation protection	X rays and γ rays from ^{137}Cs and ^{60}Co beams

* Calibration services are not included in the IAEA CMCs published in the BIPM KCDB.
** Technical procedures and protocols for calibrations and comparisons are available on our website https://ssdl.iaea.org/
@ Service available only for SSDL's that have activities in this area.

Member States 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: *https://ssdl.iaea.org*

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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.

3. Feedback can be provided using the form on our website: https://ssdl.iaea.org/

https://iris.iaea.org/public/survey?cdoc=DOL00100

Methodology for the dissemination of megavoltage photon-beam calibrations from the IAEA Dosimetry Laboratory to SSDLs and end users

C.E. Andersen, D. Burns and R.P. Kapsch

1 BACKGROUND

The IAEA Dosimetry Laboratory maintains a linear accelerator with a selection of five photon beam qualities in the range from 6 MV ($\mathrm{TPR}_{20,10}$ = 0.665) to 18 MV ($\mathrm{TPR}_{20,10}$ = 0.780). To obtain traceability for these beams reference-class ionization chambers belonging to the IAEA are calibrated at the BIPM in terms of absorbed dose to water for three photon-beam qualities spanning a marginally tighter range, from 6 MV ($\mathrm{TPR}_{20,10}$ = 0.686) to 18 MV ($\mathrm{TPR}_{20,10}$ = 0.774). Evidently, the BIPM qualities are not matched to those at the IAEA, nor will the latter in general match those of SSDLs to whom the IAEA might provide calibrated instruments for the purpose of providing traceability or for use in dosimetry audits.

In parallel to the establishment of its accelerator services, the IAEA has revised the international Code of Practice TRS-398 [1] for reference dosimetry in external beam radiotherapy based on calibrations in terms of absorbed dose to water. This update, that will be published during 2023, provides values for the factors k_{Q,Q_0} that permit the calibration coefficient for a beam of quality Q to be obtained from the calibration coefficient determined at a reference quality Q_0. When the modality of interest is megavoltage photons and the reference quality is ^{60}Co radiation, equation 1 is used:

$$N_{D,\mathrm{w},Q}(\mathrm{TPR}_{20,10}) = N_{D,\mathrm{w,Co60}}\, k_Q(\mathrm{TPR}_{20,10})\,. \qquad (1)$$

Based on the work of Andreo *et al.* (2020) [2], generic values for k_Q are provided as a function of $\mathrm{TPR}_{20,10}$ for a series of ionization chamber types. These values for a given chamber type are derived from a combination of experimental measurements and Monte Carlo calculations. These data are provided in tabular form for fixed values of the $\mathrm{TPR}_{20,10}$ and also as a fitted equation of the form:

$$k_Q(\mathrm{TPR}_{20,10}) = \frac{1+\exp\left(\frac{a-0.57}{b}\right)}{1+\exp\left(\frac{a-\mathrm{TPR}_{20,10}}{b}\right)}\,. \qquad (2)$$

Values for the fit parameters a and b are given for each ionization chamber type.

The purpose of the present report is to provide a methodology for the transfer of calibration coefficients $N_{D,\mathrm{w},Q}$ that is robust, despite the different beam qualities available at the BIPM, the IAEA, the SSDLs and the end users, and that is consistent with the data treatment and recommendations provided in TRS-398 Rev 1 [1].

It is important to note that although TRS-398 Rev 1 provides generic values for a given chamber type, the principal recommendation made in the Code of Practice is to use calibration coefficients $N_{D,\mathrm{w},Q}$ measured by a standard dosimetry laboratory for a particular chamber. This not only results in a lower uncertainty but it removes the risk of using generic values for an individual chamber that has not been shown to conform to type. It also simplifies subsequent measurements because any polarity effect in the reference chamber is taken into account in the calibration coefficients and no additional polarity measurements are required.

2 METHODOLOGY

The method proposed in the present report can be divided into three distinct phases.

2.1 Calibration of IAEA reference chambers at the BIPM

The recommended method is illustrated in FIG. 1, which shows the results of an IAEA reference chamber calibrated at the three megavoltage photon beam qualities maintained by the BIPM. The result for ^{60}Co radiation is also shown and these four points are fitted with a relation which combines equations (1) and (2):

$$N_{D,\mathrm{w},Q}^{\mathrm{IAEA}}\left(\mathrm{TPR}_{20,10}\right) c_{\mathrm{IAEA}} \frac{1+\mathrm{e}^{\left(\frac{a_{\mathrm{IAEA}}-0.57}{b_{\mathrm{IAEA}}}\right)}}{1+\exp\left(\frac{a_{\mathrm{IAEA}}-\mathrm{TPR}_{20,10}}{b_{\mathrm{IAEA}}}\right)} \qquad (3)$$

where the additional free parameter c_{IAEA} replaces the ^{60}Co calibration coefficient (in other words, the ^{60}Co calibration coefficient is used to provide an additional data point for the fit, but it is not used to fully constrain the fit as it does in the evaluation of k_Q factors in TRS-398 Rev 1[1]). The five vertical dashed lines indicate the $\mathrm{TPR}_{20,10}$ values for the IAEA beams and the corresponding points the values $N_{D,\mathrm{w},Q}^{\mathrm{IAEA}}(\mathrm{TPR}_{20,10})$ for the IAEA reference beams derived from the fit.

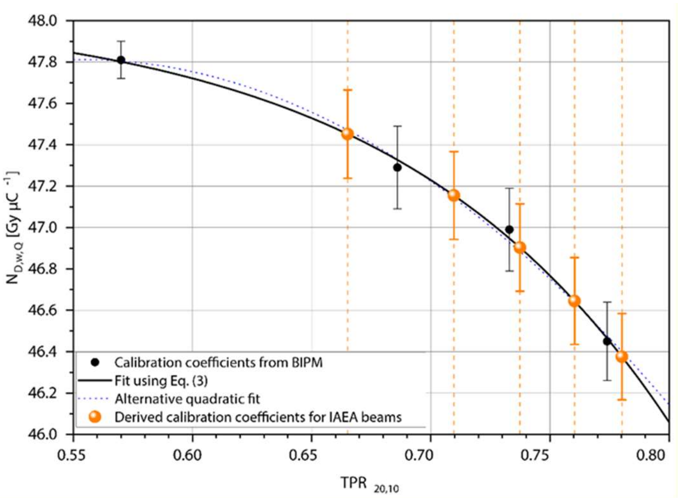

FIG. 1. The IAEA reference chamber is calibrated at the BIPM for three photon beams and for ^{60}Co (black points). These data are fitted using Eq. (3) (solid black line); an alternative, quadratic fit is shown (dotted blue line) for information only. Fitted calibration coefficients (orange points) are evaluated from the fit for the $TPR_{20,10}$ values available at the IAEA.

Note that the fitted value $N_{D,\mathrm{w},Q}^{\mathrm{IAEA}}(0.57)$, which reduces to just c_{IAEA}, should be close to the value for $N_{D,\mathrm{w},\mathrm{Co60}}$ given in the ^{60}Co calibration certificate issued by the BIPM. But it should *not* be used to replace the directly calibrated value. To verify the correct implementation of the fit equation, values of $N_{D,\mathrm{w},Q}^{\mathrm{IAEA}}(\mathrm{TPR}_{20,10})$ should be calculated for the $\mathrm{TPR}_{20,10}$ values corresponding to the BIPM calibration qualities and compared with the certificated values. The differences should be less than 0.1 %.

Also shown in the figure is a quadratic fit to the four points. This is used only to demonstrate that the fitting procedure is relatively insensitive to the details of the chosen model. The uncertainty bars on the BIPM calibration coefficients represent those stated by the BIPM, typically 0.40 %. The procedure giving rise to the fitted values $N_{D,\mathrm{w},Q}^{\mathrm{IAEA}}(\mathrm{TPR}_{20,10})$ for the IAEA qualities necessarily introduces additional uncertainty, but this is relatively small because of the goodness of the fit (in this case showing a root-mean square (rms) deviation of 0.06 %). Prior knowledge that the fitting model is representative (Andreo et al. 2020) [2] and the fact that no significant extrapolation is made contribute to the goodness of the fit. It is recommended that the IAEA includes a component of 0.10 % for this process in their uncertainty budget; this increase is already included in the uncertainty bars associated with the fitted values in FIG. 1.

Note that an SSDL that obtains a direct calibration in the BIPM beams may choose to use a method of interpolation similar to that described above.

2.2 Calibration of SSDL reference chambers at the IAEA

This process is similar to that described in the preceding section. A suitable SSDL reference chamber is calibrated at the IAEA in the five megavoltage beams and in ^{60}Co. These six points are fitted with an equation similar to (3), now expressed as

$$N_{D,\mathrm{w},Q}^{\mathrm{SSDL}}\left(\mathrm{TPR}_{20,10}\right) = c_{\mathrm{SSDL}} \frac{1 + \exp\left(\frac{a_{\mathrm{SSDL}} - 0.57}{b_{\mathrm{SSDL}}}\right)}{1 + \exp\left(\frac{a_{\mathrm{SSDL}} - \mathrm{TPR}_{20,10}}{b_{\mathrm{SSDL}}}\right)} \qquad (4)$$

By this means the IAEA provides to the SSDL not only the directly measured values for $N_{D,\mathrm{w},Q}^{\mathrm{SSDL}}$ at the five calibration qualities but also the fit parameters (a_{SSDL}, b_{SSDL}, c_{SSDL}). However, care must be taken because of the risk that an SSDL uses the calibrated chamber (either in their own laboratory or elsewhere) for beams with $\mathrm{TPR}_{20,10}$ values that fall outside of the range of the five IAEA qualities. In order to maintain traceability, the IAEA should state clearly that the calibration data they provide to an SSDL be used

[1] As stated in the calibration certificates issued by the BIPM, the data should not be used to evaluate k_{Q} factors because the ^{60}Co results are not based on the same primary standard as the megavoltage results, and also because by convention the BIPM ^{60}Co results are not corrected for ion recombination or beam non-uniformity.

without additional uncertainty only for beams falling within a restricted range of $\mathrm{TPR}_{20,10}$ values, here recommended to be between 0.65 and 0.79.

FIG. 2 shows the results of a test calibration made at the IAEA for a nominal SSDL chamber. The fit to these data is shown as a solid line over the $\mathrm{TPR}_{20,10}$ range from 0.65 to 0.79, also indicated by the green band. The vertical dashed lines indicate nominal $\mathrm{TPR}_{20,10}$ values within this range for which the SSDL might derive fitted values for $N_{D,\mathrm{w},Q}^{\mathrm{SSDL}}(\mathrm{TPR}_{20,10})$ for subsequent use either for the calibration of end user instruments or for auditing purposes.

Considering the uncertainty introduced by the fitting procedure as well as the possibility that the chamber be used for 'non-standard' beams (still falling within the $\mathrm{TPR}_{20,10}$ range from 0.65 to 0.79), it is recommended that the SSDL includes an uncertainty component of not less than 0.2 %. A higher value might be appropriate if the rms deviation of the SSDL reference chamber relative to the fit (as shown in the example of FIG. 2) is greater than 0.2 %. Indeed, it is reasonable to choose the additional uncertainty to be equal to this rms deviation, with a minimum value of 0.2 %. For the example shown in FIG. 2, the rms deviation is 0.08 %.

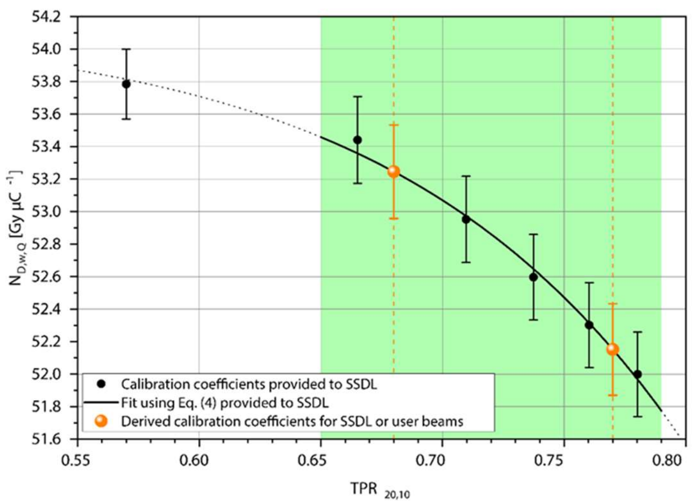

FIG. 2. The SSDL reference chamber is calibrated at the IAEA for five photon beams and for ^{60}Co (black points). These data are fitted by the IAEA using Eq. (4) (black line). Fitted calibration coefficients (orange points) are evaluated from the fit for nominal $\mathrm{TPR}_{20,10}$ values as required by the SSDL. The green region indicates the $\mathrm{TPR}_{20,10}$ range from 0.65 to 0.79 within which calibration coefficients can be derived without additional uncertainty.

2.3 Subsequent use of SSDL reference chambers for end users

Equipped with a calibrated chamber and the fit parameters (a_{SSDL}, b_{SSDL}, c_{SSDL}), an SSDL can serve end users in several ways. From the point of view of simple data handling, the most straightforward is for the SSDL to use the chamber directly in a user beam, for example to cross calibrate a local reference chamber or to audit the local dosimetry.

For this purpose, the fitted calibration coefficient $N_{D,\mathrm{w},Q}^{\mathrm{SSDL}}(\mathrm{TPR}_{20,10})$ for the SSDL reference chamber is evaluated for the $\mathrm{TPR}_{20,10}$ of each user beam of interest. As noted in Section **Error! Reference source not found.**, to verify the correct implementation of the fit equation, values of $N_{D,\mathrm{w}}^{\mathrm{SSDL}}(\mathrm{TPR}_{20,10})$ should also be calculated for the $\mathrm{TPR}_{20,10}$ values corresponding to the IAEA calibration qualities and compared with the certificated values. The differences should generally be less than 0.2 %. Note also that the fitted value $N_{D,\mathrm{w}}^{\mathrm{SSDL}}(0.57)$, which is just c_{SSDL}, should be close to the value given in the ^{60}Co calibration certificate issued by the IAEA but it should *not* be used to replace the directly calibrated value.

The situation is more complex when the reference chamber is used at the SSDL to calibrate a user chamber. This is because interpolation, or perhaps even extrapolation, is required between the $\mathrm{TPR}_{20,10}$ values used for calibration at the SSDL and those for which the user chamber will subsequently be used. If the SSDL is able to calibrate the user chamber at three or more $\mathrm{TPR}_{20,10}$ values (which may or may not include ^{60}Co), a fitting procedure similar to that described in the preceding sections might be adopted. In the event that the SSDL has only one or two beams available for calibration the fitting procedures become unreliable or impossible. Reference must be made to the procedures given in the Code of Practice TRS-398 (Rev 1) [1], specifically the use of ratios of k_Q factors to convert from one beam quality to another.

In the event that an SSDL or user quality of interest has a $\mathrm{TPR}_{20,10}$ value nominally the same as one of the five IAEA beams for which a value for $N_{D,\mathrm{w},Q}^{\mathrm{SSDL}}$ is given in the calibration certificate, this latter calibration coefficient can be used instead of the corresponding fitted value. This has the advantage of a lower uncertainty.

We recall the limitation on the use of the SSDL reference chamber stated in Section **Error! Reference source not**

found., namely that its use be restricted to beams with $TPR_{20,10}$ values in the range from 0.65 to 0.79. In the event that its use outside of this range cannot be avoided, the additional uncertainty must be assessed.

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry Based on Standards of Absorbed Dose to Water, Technical Reports Series No. 398 (Rev.1), Vienna (2023)

[2] ANDREO, P., et al., Determination of consensus k (Q) values for megavoltage photon beams for the update of IAEA TRS-398, Phys. Med. Biol. **65** (2020) 095011.

HDR brachytherapy course hosted at IAEA DOL

The IAEA dosimetry laboratory hosted medical physicists and radiation metrologists from Latin America, participating in a regional training course on dosimetry for high dose rate (HDR) brachytherapy, under a technical cooperation project RLA9091. There were 21 participants from 14 Member States. Two of the five days for training were dedicated to practical sessions at the IAEA Seibersdorf dosimetry laboratory. The course was conducted in the Spanish language.

The training covered dosimetry for HDR brachytherapy machines with ^{192}Ir and ^{60}Co sources and dissemination of traceability to the user at a hospital. Participants gained hands on knowledge in how to calibrate well type reference chambers including how to use and transfer that traceability to their treatment process and the quality control that needs to be performed when receiving sources.

Participants had the opportunity to perform the measurements in their teams, estimate measurement uncertainty and report to the rest of the participants on all the activities that were assigned to them.

FIG. 3 Participants of the Brachytherapy training course at the IAEA Seibersdorf laboratories.

Connectors and adapters used for dosimetry measurements

J. Cardoso, L. Czap, Z. Msimang

1 Introduction

The scope of calibration services that the SSDL's are providing is increasing. In recent years more SSDL's have established the calibration capabilities for diagnostic radiology. With this increase in scope, also came calibration and verification of equipment with different connectors than those the SSDL's have been using for calibration in radiation therapy and radiation protection.

2 Connectors and adapters

The recently published IAEA Human Health Report 44 [1] on the establishment of an SSDL gave the most used connectors for ionisation chambers as coaxial, triaxial and special, see FIG. 4, extract from IAEA HHS 44. Another connector type that is available in the markets for mostly the diagnostic radiology chambers is the Lemo connector shown in FIG. 5.

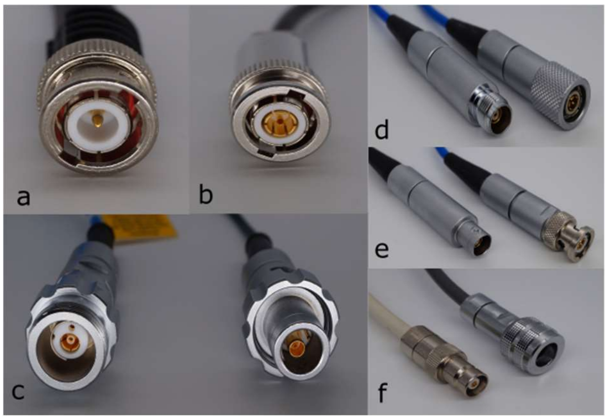

FIG. 4 Connector types: (a) coaxial, (b) triaxial, (c) PTW M type, (d) TNC, (e) BNC and (f) miniQuick [1]

It is not always possible for SSDL's to have electrometers that may be used with all the connector types for various ionization chambers in the market. The laboratories may however standardize on the connector they use for their equipment and procure adapters to be used with the equipment they are to calibrate.

FIG. 5 Lemo connector type used by Radcal

Using adapters may be tricky for some combinations and simple for other. Suppliers of the chambers may sell adapters of certain type which may be procured by the SSDL's. When an SSDL decides to build their own adapters, care must be taken as a wrongly configured connector may lead to wrong results and even harm for the personnel performing measurements. It is crucial for the user to understand the electrometer connection scheme when using the adapters. Certain combinations combining coaxial and triaxial connectors may result in the presence of polarizing voltage (bias) on the outer housing of the connector.

In the SSDL Newsletter 52, which was published in 2006, an article on high voltage polarity of electrometers was published. This article is still useful for understanding how polarity is applied to an ionisation chamber during calibration. A variation in "triaxial TNC" connectors has been observed for some ionisation chambers. SSDL's need to take caution and not to force fit the connectors. Even though the connectors are of the same type, the size is slightly different.

3 References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Establishing a Secondary Standards Dosimetry Laboratory, IAEA Human Health Series No. 44, IAEA, Vienna (2023).

[2] Czap, L., Meghzifene, A., & Pychlau, C., Understanding the high voltage polarity of electrometers, SSDL Newsletter No. 52, IAEA, Vienna (2006).

Commissioning of an irradiator at the IAEA DOL

The IAEA Dosimetry Laboratory has recently commissioned a G10-2-360 gamma beam irradiator that was donated by Hopewell Designs, Inc. The irradiator has ^{137}Cs and ^{60}Co sources and is being used for radiation protection level calibrations of different types of dosimeters, reference irradiations of personal dosimeters, irradiation of reference dosimeters for audit services, calibration of survey instruments, and for the training of visiting scientists and trainees. It will also be used to support the BIPM key comparisons of primary standards for radiation protection in ^{137}Cs beams

Figure 6. New gamma irradiator at DOL

QUATRO course hosted at the IAEA DOL

The objective of a comprehensive radiotherapy audit is to review and evaluate the quality of all components of the radiotherapy programme, including safety infrastructure and the implementation of international standards and best practices. Responding to the growing need for more radiotherapy professionals with sound knowledge on the QUATRO (Quality Assurance Team in Radiation Oncology) methodology, to serve as national, regional and international auditors, the DMRP jointly with the ARBR (Applied Radiation Biology and Radiotherapy) section hosted a training course on QUATRO methodology from 02 to 05 May 2023. As a quality improvement tool, QUATRO audits are performed by a multidisciplinary team of experts composed of a radiation oncologist, a medical physicist, and a radiotherapy technologist through a comprehensive review of the entire clinical process in a radiotherapy department.

The training course was held in the Spanish language with a total number of 53 participants from 16 Latin American Member States. The attendees were supported through the Technical Corporation Project INT 6063.

The IAEA dosimetry laboratory hosted practical sessions for 18 Medical Physicists, participating in the training course. The practical sessions covered the following topics:

- Reference dosimetry measurements in linac radiation beam qualities;
- Treatment planning case evaluation and discussions;
- Auditing IMRT - End to End methodology using SHANE phantom;
- How to provide data, complete and review check lists, and questionnaires relevant to QUATRO.

Figure 7. Medical physics participants for the QUATRO training course at the IAEA Seibersdorf laboratories

Quality Assurance Team for Radiation Oncology (QUATRO) – IAEA methodology for comprehensive audits of radiotherapy practices: A tool for Quality Improvement – Second edition published in 2022

J. Swamidas

1 Comprehensive quality audits in radiotherapy

The IAEA has a long history of providing assistance for dosimetry audits to its Member States. Together with the World Health Organization, it has operated postal dose audit programmes to verify the calibration of radiotherapy beams since 1969. The programme currently covers 139 Member States.

Quality audits can be of various types, either reviewing specific critical parts of the radiotherapy process (dosimetry audit) or assessing the whole process (comprehensive audit) including staff, equipment and procedures, patient protection and safety and the overall performance of the department. An independent external audit (peer review) is important to ensure adequate quality of practice and treatment delivery and is also a requirement of the IAEA International Basic Safety Standard [1]. The IAEA, through its technical cooperation programme, has received numerous requests from low- and middle-income countries to perform comprehensive audits to assess the entire radiotherapy process. In response to these requests, the IAEA has developed a methodology for the comprehensive audit in radiotherapy called Quality Assurance Team for Radiation Oncology (QUATRO), with an objective to review and evaluate the quality of all components of the radiotherapy programme, including professional competence, with a view to quality improvement.

2 QUATRO methodology

A QUATRO audit is performed by a multidisciplinary team of experts composed of a radiation oncologist, a medical physicist, and a radiotherapy technologist, who are experienced professionals in their discipline and have received additional training in auditing procedures. The auditors are selected by the IAEA and spend 3-5 days onsite at the audited facility. A major part of the audit is patient oriented, and follows the clinical path of the patient, from diagnosis, decision to treat, prescription, treatment planning and delivery, to the end of the follow-up process excluding the treatment outcome. Staffing levels, professional education and training programmes are given special attention. The methodology consists of the application of various checklists, questionnaires, reviews, observation, staff interviews, and onsite dosimetry measurements to evaluate the quality of all elements involved in radiotherapy. It does not represent one radiotherapy standard applicable to all visited departments but provides a general methodology that can be applied in a range of economic settings. A preliminary assessment of the radiotherapy programme is provided to the institution at the conclusion of the visit followed sometime later by a detailed written confidential report with recommendations for quality improvement. Adoption of the auditors' recommendations is purely at the discretion of the audited institution.
The methodology for conducting comprehensive clinical audits was published in 2007 as Comprehensive Audits of Radiotherapy Practices: A Tool for Quality Improvement [2] and has been successfully applied in more than 100 clinical audits worldwide.

3 Second edition (2022)

In the light of developments in techniques and equipment in radiotherapy, and lessons learned from past audits, an updated second edition of the QUATRO guidelines was published in 2022 [3]. It includes guidelines for auditing new technologies, incorporated in the form of 42 checklists. The new features of the second edition include the modified criteria for centre of competence, quality management system, considerations for the introduction of new technology, communication, education, and clinical training program in compliance with IAEA curricula [4-6]. The publication is freely available to download from the IAEA website.

The QUATRO methodology has been endorsed by the European Federation of Organisations for Medical Physics (EFOMP), the European Society for Radiotherapy and Oncology (ESTRO), and the International Organization for Medical Physics (IOMP). The availability of an internationally harmonized guidance document, endorsed by professional societies, would be a significant contribution towards the improvement of radiotherapy practice all over the world.

4 References

1. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. 2014; Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards | IAEA

2. INTERNATIONAL ATOMIC ENERGY AGENCY, Comprehensive audits of radiotherapy practices: A tool for quality improvement, Quality Assurance Team for Radiation Oncology (QUATRO) First Edition 2007; Comprehensive Audits of Radiotherapy Practices: A Tool for Quality Improvement | IAEA

3. INTERNATIONAL ATOMIC ENERGY AGENCY, Comprehensive audits of radiotherapy practices: A tool for quality improvement, Quality Assurance Team for Radiation Oncology (QUATRO) Second Edition 2022; Comprehensive Audits of Radiotherapy Practices: A Tool for Quality Improvement | IAEA

4. INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Syllabus for the Education and Training of Radiation Oncologists, IAEA Training Course Series No. 36, IAEA, Vienna (2009); IAEA Syllabus for the Education and Training of Radiation Oncologists | IAEA

5. INTERNATIONAL ATOMIC ENERGY AGENCY, Postgraduate Medical Physics Academic Programmes, IAEA Training Course Series No. 56 (Rev. 1), IAEA, Vienna (2021); Postgraduate Medical Physics Academic Programmes | IAEA

6. INTERNATIONAL ATOMIC ENERGY AGENCY, A Handbook for the Education of Radiation Therapists (RTTs), IAEA Training Course Series No. 58, IAEA, Vienna (2014) A Handbook for the Education of Radiation Therapists (RTTs) | IAEA.

Publication announcements

IAEA publications have been made available in different areas of dosimetry and medical radiation physics. The relevant links to freely access the material are listed below for material published from 2022 to date.

Establishing a Secondary Standards Dosimetry Laboratory, (**IAEA Human Health Series No. 44**), March 2023
[Establishing a Secondary Standards Dosimetry Laboratory | IAEA]

Education of Radiation Metrologists for Secondary Standards Dosimetry Laboratories (**Training Course Series No. 76**), February 2023
[Education of Radiation Metrologists for Secondary Standards Dosimetry Laboratories | IAEA]

Handbook of Basic Quality Control Tests for Diagnostic Radiology, (**IAEA Human Health Series No. 47**), February 2023
[Handbook of Basic Quality Control Tests for Diagnostic Radiology | IAEA]

Comprehensive Audits of Radiotherapy Practices: A Tool for Quality Improvement (Second edition), September 2022
[Comprehensive Audits of Radiotherapy Practices: A Tool for Quality Improvement | IAEA]

Audit Methodology for Medical Physics Clinical Training Programmes (**Training Course Series No. 74**), July 2022
[Audit Methodology for Medical Physics Clinical Training Programmes | IAEA]

Selecting Megavoltage Treatment Technologies in External Beam Radiotherapy (**IAEA Human Health Reports No. 17**), January 2022
[Selecting Megavoltage Treatment Technologies in External Beam Radiotherapy | IAEA]

External publications by IAEA staff in the field of dosimetry and medical radiation physics are presented below.

S M Judge et al, Traceability for nuclear medicine: the status of primary radioactivity standards, Metrologia **60** 012001, 2023. DOI 10.1088/1681-7575/aca67a. [Traceability for nuclear medicine: the status of primary radioactivity standards]

TSALAFOUTAS, I.A, ALKHAZZAM, S., **TSAPAKI, V.**, ALNAEMI, H., KHARITA, M.H., Digital radiography image quality evaluation using various phantoms and software, Journal of Applied Clinical Medical Physics, Vol. 23 (12), pp 1-15, December 2022, e13823, https://doi.org/10.1002/acm2.13823.

TRAUERNICHT, C., HASFORD, F., KHELASSI-TOUTAOI, N., BENTOUHAMI, I., **KNOLL, P., TSAPAKI, V.,** Medical physics services in radiology and nuclear medicine in Africa: challenges and opportunities identified through workforce and infrastructure surveys. Health Technol. (2022). Open Access; published: 31 March 2022; https://doi.org/10.1007/s12553-022-00663-w

Courses, Meetings and Consultancies in 2023

TC Courses and Workshops related to DMRP activities

- RAS6102 Regional Training Course on Quality Assurance and Dosimetry for Junior Medical Physicists, Amman, Jordan, 11 – 15 January 2023
- RAF6058 Workshop on Quality Control Programme in Africa: Analysis of Results and Way Forward, Vienna, Austria, 16 – 20 January 2023
- RAF6058 Training Course on Dosimetry using Monte Carlo Techniques, Accra, Ghana, 16 – 20 January 2023
- RLA 6091 Regional Training Course on Quality Assurance and Dosimetry in Mammography Including Tomosynthesis and Contrast Enhanced Mammography, Curitiba, Brazil, 5 – 10 February 2023
- RLA9091 Regional Training Course on Calibration of Radiation Protection Equipment Using Neutron Sources in Secondary Standard Dosimetry Laboratory (SSDL), Rio de Janeiro, Brazil, 20 – 24 March 2023
- RER 6040 Image Guided Radiotherapy for Cervical Cancer: Focus on Brachytherapy, Belgrade, Serbia, 27 – 31 March 2023
- RAS6101 Regional Training Course on Roles Responsibility, Education &Training of Medical Physicist and Certification for Clinically Qualified Medical Physicist, Krabi, Thailand, 27-31 March 2023
- RLA9091 Regional Workshop on brachytherapy calibrations and measurements for SSDL and medical physicist, Vienna, Austria, 17 – 21 April 2023
- INT6063 Interregional Training Course on Quality Assurance Teams for Radiation Oncology, Vienna, Austria, 2 – 5 May 2023
- RLA9091 Regional Workshop on Calibration of Radiation Protection Equipment Such as Survey Instruments and Reference Irradiation, with Cs-137, Recife, Brazil, 08 – 12 May 2023
- RLA9091 Regional Training Course on Brachytherapy Calibrations and Measurements Including SSDL and Medical Physicist, Lima, Peru, 08 – 12 May 2023
- RAF6058 Regional Training Course on Image Quality and Radiation Dose Management in Radiology for English Speaking Countries, Pretoria, South Africa 15 – 19 May 2023
- RAS6101 Regional Training Course on Quality Management and Quality Assurance in Medical Imaging for Medical Physicists, Bangkok, Thailand, 22 – 26 May 2023
- RER6040 IAEA Virtual Regional Workshop on Advanced Treatment Planning for Head and Neck Cancer: From Contouring to Plan Evaluation, Vienna, Austria, 12 – 30 June 2023
- RER6042 Regional Workshop on Quality and Safety in Diagnostic and Interventional, in conjunction with the 10th EURASIAN Radiology Forum [in Russian], Astana, Kazakhstan, 26 – 29 June 2023
- RAF6055 Regional (AFRA) Training on how to Audit and Optimise Clinical Protocols on Common Cancers (English), Nairobi, Kenya, 26 – 30 June 2023
- RAF6055 Regional (AFRA) Training on how to Audit and Optimise Clinical Protocols on Common Cancers (French), Algiers, Algeria, TBC
- RLA6091 Regional Training Course on Quality Assurance and Dosimetry in Dental and Cone Beam CT, Havana, Cuba, July 2023
- Joint ICTP–IAEA Workshop on Quality Assurance, Quality Control and Optimization of Equipment and Procedures Used in Fluoroscopically Guided Interventional Radiology, Trieste, Italy, 9 – 13 October 2023
- RER6042 Regional Training Course on Basic Quality Control in Diagnostic Radiology [in Russian], Tashkent, Uzbekistan, 30 October – 3 November 2023
- RER6042 Regional Training Course on Performance Testing of Digital Detectors, Zagreb, Croatia, 6 – 10 November 2023
- Joint ICTP–IAEA Workshop on Artificial Intelligence in Ionizing Radiation for Medical Physicists, Trieste, Italy, 20 – 24 November 2023

Training courses and ESTRO Courses

- IAEA/ESTRO Training Course on Dosimetry Audit, London, United Kingdom, 17 – 21 April 2023
- E2-TR-1805156 Joint IAEA–Argonne National Laboratory Training Activity on Comprehensive Clinical Audits in Diagnostic Radiology under the Quality Assurance Audit for Diagnostic Radiology Improvement and Learning (QUAADRIL) Tool, Houston, Texas, United States of America, 24 – 28 April 2023
- RER6040 IAEA/ESTRO Training Course on Physics for Modern Radiotherapy, 22 – 26 May 2023 (virtual)
- RER6040 IAEA/ ESTRO Training Course on Advanced Skills in Modern Radiotherapy, Paris, France, 19 – 23 June 2023
- RER6040 IAEA/ESTRO Training Course on Basic Clinical Radiobiology, Porto, Portugal, 9 – 13 September 2023
- RER6036 Regional Training Course on Clinical Dosimetry in Modern Radiotherapy, Moscow, Russia, 17 – 21 October 2023 (in Russian)
- RER6036 Regional Training Course on Radiobiology for Radiation Oncologists and Medical Physicists (virtual), 23 October – 3 November 2023 (in Russian)
- RER6040 IAEA/ESTRO Training Course on Clinical Practice and Implementation of Image-guided Stereotactic Body Radiotherapy, Prague, Czech Republic, 9 – 11 November 2023
- RER6040 IAEA/ESTRO Training Course on Evidence Based Radiation Oncology, Budapest, Hungary, 12 – 16 November 2023
- RER6036 Regional Training Course on Physics for Conformal Radiotherapy: Advanced Technologies, Moscow, Russia, 13 – 24 November 2023 (in Russian)
- RER6040 IAEA/ESTRO Training Course on Best Practice in Radiation Oncology – Train the RTT (Radiation Therapists) Trainers – Part II, Vienna, Austria, 20 – 22 November 2023
- RER6036 Regional Training Course on Radiation Protection and Safety and Accident Prevention in Radiotherapy (virtual), 27 November – 1 December 2023 (in Russian)

DMRP Meetings and Consultancies

- Consultancy Meeting on Guidance Related to Quality Assurance and Optimization in Fluoroscopically-Guided Interventional Radiology, Vienna, Austria, 17 – 21 April 2023
- Consultancy Meeting on Developing Guidelines on Quality Assurance for Digital X ray Breast Imaging Modalities, Vienna, Austria, 22 – 26 May 2023
- Technical Meeting on Developments and Trends in Secondary Standards Dosimetry Laboratories and Quality Management Systems, Vienna, Austria, 29 May – 2 June 2023
- First Research Coordination Meeting on Audit System for Radiopharmaceutical Therapy (RPT), Vienna, Austria, 3rd Quarter 2023
- Second Research Coordination Meeting on Evaluation of the Dosimetry Needs and Practices for the Update of the Code of Practice for Dosimetry in Diagnostic Radiology (TRS-457), Vienna, Austria, 3rd Quarter 2023
- Consultancy Meeting to Advise on the Co-ordinated Research Project for the Evaluation on the Requirements for Medical Physicists Working in Radiopharmaceutical Therapies (RPT), Vienna, Austria, 16 – 20 October 2023
- Consultancy Meeting on Guidelines for Medical Physicists on Dose Management Systems, Vienna, Austria, 6 – 10 November 2023

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